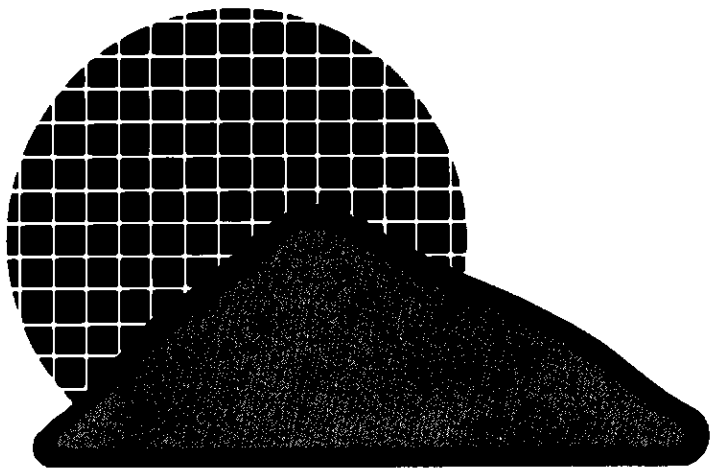
EK-DCTEM-UG-001

DCT11-EM Evaluation Module User's Guide



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DCT11-EM Evaluation Module User's Guide

Prepared by Educational Services
of
Digital Equipment Corporation

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CONTENTS

CONTENTS (Cont)

CONTENTS (Cont)

FIGURES

TABLES

PREFACE

This book explains how to use the DCT11-EM evaluation module. Although the book presents many topics in simplified form, some technical background is assumed on your part. It is assumed, for example, that you are familiar with the basics of microprocessor software and hardware. However, you need not be familiar with microprocessors manufactured by Digital Equipment Corporation.

To understand software details such as those contained in the monitor listing (Appendix A), you should be familiar with the MACRO-11 language. To understand hardware details, you should be able to read and interpret schematic diagrams and data sheets.

The book is organized as follows.

Chapter 1 is an introduction to the DCT11-EM and contains a specification summary for your reference.

Chapter 2 explains how to install and power up your DCT11-EM.

Chapter 3 shows you how to operate your DCT11-EM using the on-board keypad and switches.

Chapter 4 shows you how to operate your DCT11-EM using a console terminal.

Chapter 5 provides software information and describes the use of monitor subroutines.

Chapter 6 gives an overview of the DCT11-EM hardware and contains information you will find useful if you plan to design external circuitry.

Appendices A and B contain the DCT11-EM monitor listing and schematics, respectively. Appendix C contains a summary of error messages.

You will find that this book requires a high degree of interaction between you and the DCT11-EM. Chapters 3 and 4, in particular, are structured so that examples are an integral part of the text.

CHAPTER 1
OVERVIEW

1.1 INTRODUCTION

The DCT11-EM is a standalone, single-board computer. It is designed as a tool to introduce you to the DCT11-AA microprocessor CPU chip and the PDP-11 architecture. It contains supporting hardware and software which greatly simplify the task of evaluating the DCT11-AA for your application.

The DCT11-EM gives you considerable flexibility in designing your own software and hardware. You can write programs to run on the DCT11-EM which are substantially the same as those written in the versatile PDP-11 assembly language. You can also design your own hardware interfaces to use with the DCT11-EM. In fact, your hardware can connect directly to the DCT11-EM's internal data paths through an on-board, 60-pin male connector.

This chapter summarizes the features of the DCT11-EM. You will find more detail in the chapters that follow.

1.2 THE DCT11-EM AT A GLANCE

Central Processor

- DCT11-AA microprocessor
- 133 ns cycle time (standard)

Memory

- 4 K bytes of RAM, expandable to 8 K bytes
- 16 K bytes of EPROM which contains the DCT11-EM monitor

Input/Output

- Two serial ports, one for a console terminal and the other for an auxiliary RS232-C device
- One 8-bit parallel port
- One 60-pin connector for use by expansion hardware; allows access to DCT11-EM internal data paths

Host Communication

- Host computer can be connected to the auxiliary serial port for downline loading of programs
- Character format is asynchronous, 8 bits, ASCII, no parity, one stop bit
- Available baud rates are: 300, 600, 1200, 2400, 4800, 9600, 19200

Software

- Software is EPROM resident
- Keypad monitor for performing operations with the on-board keypad
- Console monitor for performing operations with a console terminal and with a host computer

On-Board Control Hardware

- 20-key keypad (4 × 5 array)
- HALT push-button switch

On-Board Displays

- Two rows of 6-digit octal LEDs
- User LED

Interrupts

- Four levels of interrupt priorities
- On-board interrupt push-button switch

Diagnostics

- Contained in EPROM, automatically run at power-up time

Documentation (provided with DCT11-EM)

- *DCT11-EM User's Guide*
- *DCT11-AA (MICRO/T-11) User's Guide*
- *DC319-AA DLART Data Sheet*

Physical

- Width: 20.3 cm (8 in)
- Length (including connectors): 27.9 cm (11 in)
- Height: 3.8 cm (1.5 in)
- Weight: 450 gm (15 oz)

Environment

- Noncaustic environment required
- Operating temperature: 10 to 40 degrees C
- Relative humidity: 10% to 90% (noncondensing)
- Altitude: Up to 2.4 km (8000 ft)

DC Power Requirements

- For keypad operation only:

  +5 V (±5%) @ 2 A

- For console terminal operation:

  +5 V (±5%) @ 2 A
  +12 V (±10%) @ 50 mA
  −12 V (±10%) @ 50 mA

CHAPTER 2
INSTALLATION

2.1 INTRODUCTION

DCT11-EM installation consists of attaching a power supply, powering up, and verifying that the board is operating properly.

2.2 POWER SUPPLY REQUIREMENTS

The DCT11-EM requires a +5 Vdc supply (±5%) capable of delivering up to 2 A. If you plan to use the console or auxiliary serial ports, you also need a +12 Vdc supply (±10%) and a −12 Vdc supply (±10%) each capable of delivering up to 50 mA.

WARNING

To protect yourself against injury from contact with circuits that carry high energy, we suggest your power supply outputs be limited to no more than 240 VA. This is in accordance with standards for data processing equipment.

CAUTION

We recommend that you fuse your power supply outputs at 5 A or less to provide overcurrent protection to circuits and remote wiring.

2.3 CONSTRUCTING A POWER SUPPLY CABLE

The DCT11-EM is packaged with a power supply connector and pins with which you can assemble a power supply cable. To do this, perform the following steps.

1. Select a 1 foot length of medium gauge (10 to 14 gauge) wire and strip the wire about 1/4 inch from each end. If you are using multiple-strand wire, twist the strands together at each stripped end.

2. Insert one end of the wire into a pin as shown in Figure 2-1. Crimp the pin to the wire with a pair of pliers or a crimping tool and solder the wire.

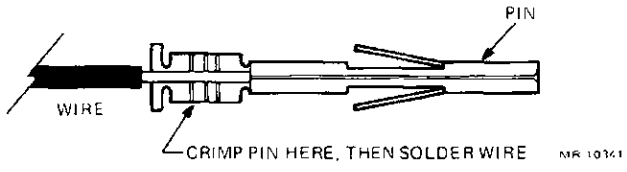


Figure 2-1 Attaching Pin to Wire

3. Insert the pin in the connector as shown in Figure 2-2.

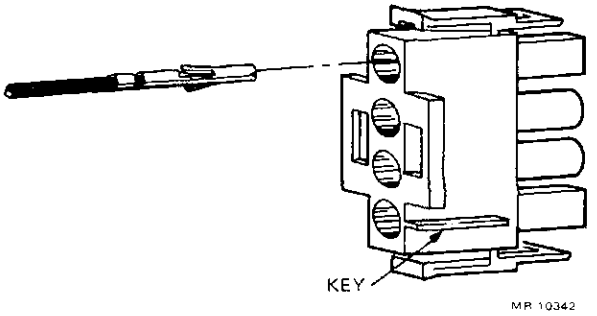


Figure 2-2 Inserting Pin into Connector

4. Repeat steps 1, 2, and 3 for each wire in your connector. (Use different colored wires for easy identification.)

5. Attach the wires to a power supply, making sure they correspond to the correct voltages as shown in Figure 2-3.

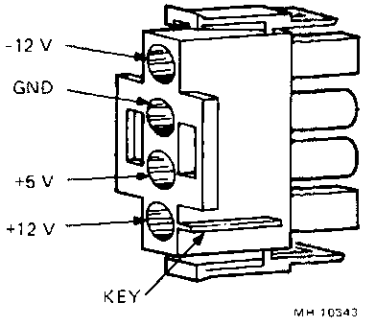


Figure 2-3 Power Supply Connector Pin Assignments

6. Turn on the power supply and use a voltmeter to check that the correct voltages appear at the connector pins.

7. Turn off the power supply and attach the connector to the DCT11-EM as shown in Figure 2-4.

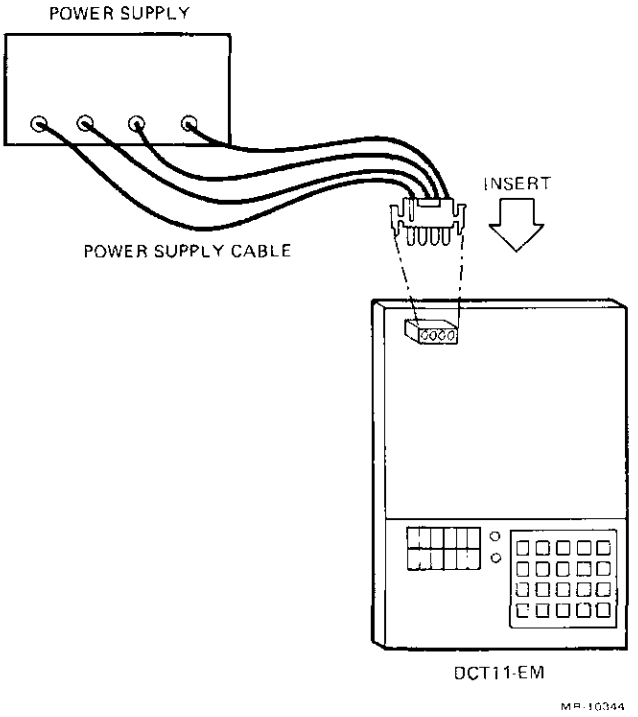


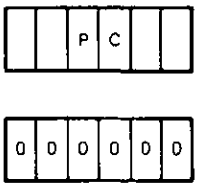
Figure 2-4 Power Supply Connector

You are now ready to power up your DCT11-EM.

2.4 POWERING UP AND VERIFYING CORRECT OPERATION

Make sure your DCT11-EM is on a nonmetallic surface and positioned so that it does not come in contact with any conducting objects. Then turn on your power supply.

When you apply power, the DCT11-EM runs its diagnostics automatically. The diagnostics: (1) perform checksum tests for the on-board RAM and PROM, and (2) write and read back data to and from the DLART. If the diagnostics run successfully, the LEDs display the following.



This shows that the keypad monitor is active and ready to accept your input. Further information on using the keypad is given in Chapter 3.

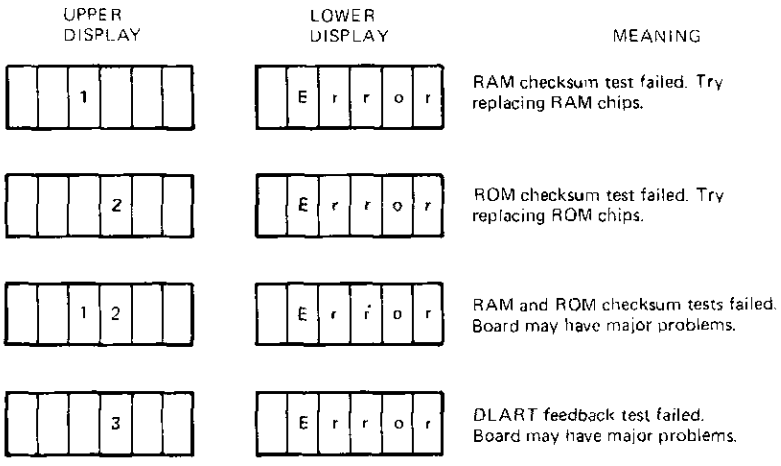
In addition to activating the keypad monitor, the DCT11-EM also sets these initial conditions:

- All user RAM is cleared
- The symbol table is cleared
- The stack pointer is set to 7400
- Both serial port baud rates are set to 9600.

You will learn more about what these initial conditions mean in later chapters.

If the two rows of LEDs are blank after you power up, your DCT11-EM probably has major problems.

The LEDs may display a flashing diagnostic error message after you power up. The meaning of the error messages is summarized below.



If you suspect your board has major problems, contact Digital Equipment Corporation or the authorized distributor from whom you purchased your DCT11-EM. The DCT11-EM is warranted against defects in workmanship for a period of ninety (90) days from the date of delivery.

2.5 JUMPERING

There are two metal posts located above the upper left corner of the DCT11-EM keypad. Install a jumper between these posts if you want to disable the generation of DCT11-AA microprocessor cycle slips. If you do this, you must also change the DCT11-AA's 7.5 MHz clock frequency to a frequency between 3 MHz and 6 MHz. To change the clock frequency, remove the 7.5 MHz crystal from the board and install a crystal of the desired frequency.

This is the only jumper that may be installed on the DCT11-EM.

CHAPTER 3
KEYPAD OPERATION

3.1 INTRODUCTION

This chapter explains how to operate the DCT11-EM using the DCT11-EM's on-board keypad and switches. When you complete this chapter, you will be able to do the following.

- Examine and alter the contents of registers in the DCT11-AA register file.
- Examine and alter the contents of memory locations.
- Enter and execute programs.
- Debug your programs through the use of single steps, breakpoints, and watchpoints.
- Perform halts and interrupts.
- Perform a number of other functions.

The DCT11-EM keypad, switches, and displays are arranged as shown in Figure 3-1.

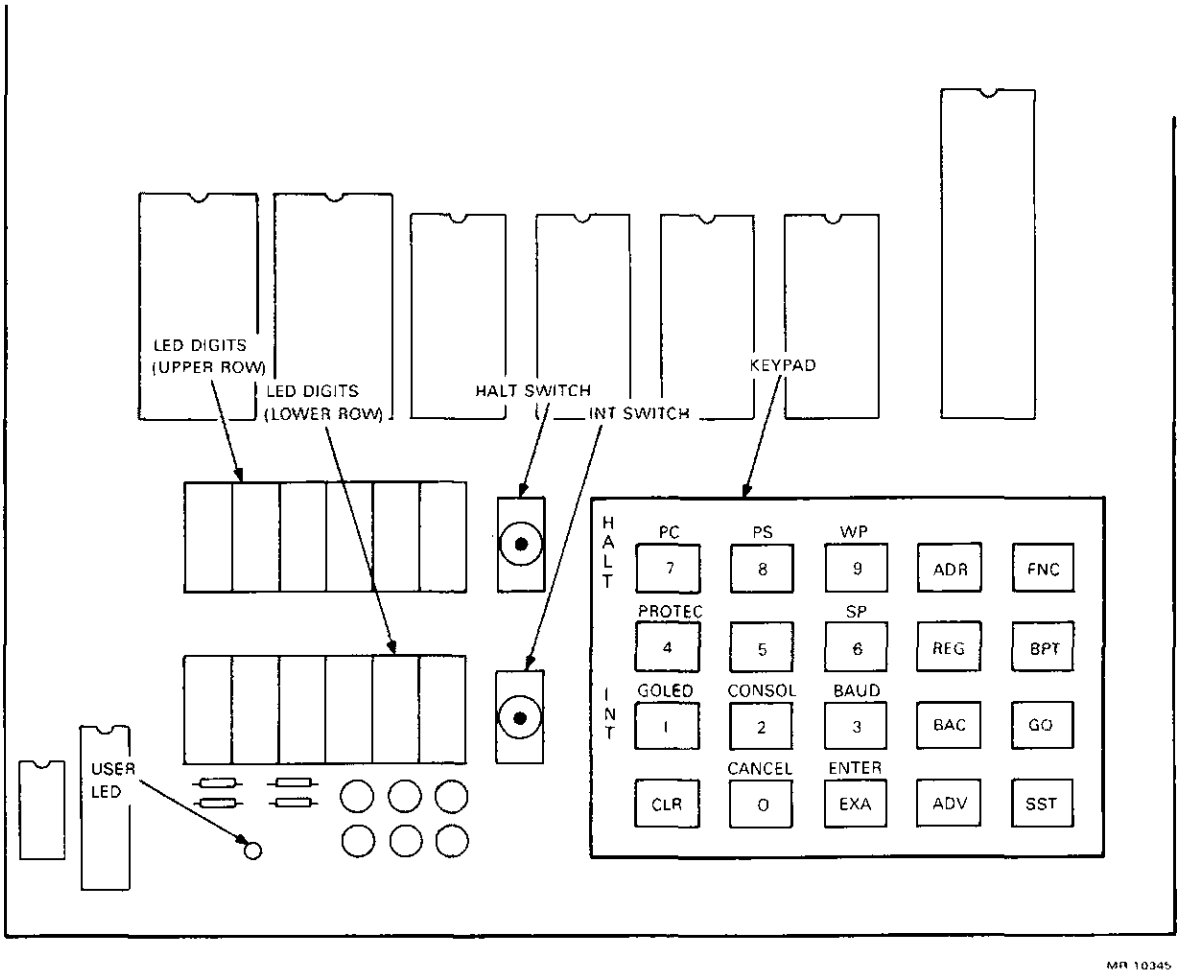


Figure 3-1 DCT11-EM Keypad, Switches, and Displays

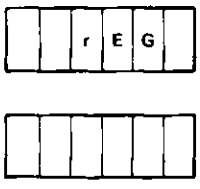
Figure 3-1 shows two rows of six LED digits which display data, addresses, and other information. Below the two rows of LED digits is a single LED (called the user LED) which you can use as an indicator in your programs. To the right of the LEDs are the HALT and INT push-button switches. These switches perform the functions their names imply; that is, they can halt and interrupt DCT11-EM operation. To the extreme right is a 4 × 5 array of switches called the keypad. The keypad is used to enter commands, instructions, and other information to the DCT11-EM. Pressing keys will generally cause responses to appear on the LED displays.

3.2 NUMBER SYSTEM

Information that is input or output via the keypad/LED combination must be represented in octal notation. Since the DCT11-AA is a 16-bit processor, the acceptable range of octal inputs and outputs is 000000 through 177777.

3.3 EXAMINING REGISTERS

To examine the contents of a DCT11-AA internal register, you must first place the DCT11-EM in register mode. Do this by pressing the REG key. The LEDs display:



Now you may examine a register by pressing any of the following keys:

0 through 9

or

CLR, which is equivalent to key 0.

In general, the name of the register being examined appears on the upper row of LEDs, and the contents of the register appears on the lower row of LEDs. The exception to this is when the watchpoint (WP) is examined. In that case, an address called the watchpoint (WP) address is displayed on the upper row of LEDs, and the WP contents are displayed on the lower row.

Keys 0 through 7 select R0 through R7, the eight registers in the DCT11-AA register file. Registers 6 and 7 are dedicated and are referred to as the stack pointer (SP) and program counter (PC), respectively.

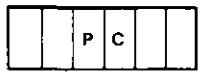
Key 8 selects the processor status (PS) word. Only the lower 8 bits of the PS word are meaningful. The PS word contains the current processor priority, the processor condition codes (N, Z, V, and C), and the T-bit.

Key 9 selects the watchpoint (WP). The WP is useful in connection with program debugging and is discussed in Paragraph 3.8.3.

NOTE

If you have just powered up your DCT11-EM or if you have halted its operation, it is not necessary to press the REG key to get into register mode.

The upper row of LEDs will display:



The lower row of LEDs will display the current value of the PC, and you can simply press one of the keys 0 through 9 or CLR to select a register.

Examining Registers – Example 1

You want to examine the contents of various registers. It is assumed that the registers still contain their initial (power-up) values.

KEY	UPPER DISPLAY	LOWER DISPLAY	COMMENTS
REG	r E G		Get into register mode.
0	r 0	0 0 0 0 0 0	
7	P C	0 0 0 0 0 0	
6	S P	0 0 6 5 0 0	
CLR	r 0	0 0 0 0 0 0	
8	P S	0 0 0 0 0 0	
9	0 0 0 0 0 0	0 0 0 0 0 0	

The ADV and BAC keys allow you to examine register contents sequentially. Pressing the ADV key allows you to examine registers in ascending order. You cannot advance beyond the WP. Pressing the BAC key allows you to examine registers in descending order. You cannot back up beyond R0.

If you want to examine registers nonsequentially after you have pressed ADV or BAC, you must first press the REG key to reinitialize register mode. Otherwise, you will alter the contents of the register you are currently examining.

Examining Registers – Example 2

You want to examine more registers. You begin by examining them sequentially. It is assumed that the registers still contain their initial (power-up) values.

KEY	UPPER DISPLAY	LOWER DISPLAY	COMMENTS
REG	r E G		Get into register mode.
ADV	r 0	0 0 0 0 0 0	
ADV	r 1	0 0 0 0 0 0	
ADV	r 2	0 0 0 0 0 0	
BAC	r 1	0 0 0 0 0 0	
BAC	r 0	0 0 0 0 0 0	
4	r 0	0 0 0 0 0 4	You wanted to examine R4 but you altered R0 instead.
CLR	r 0	0 0 0 0 0 0	Clear the incorrect entry.
REG	r E G		This is how to examine R4.
4	r 4	0 0 0 0 0 0	
BAC	r 3	0 0 0 0 0 0	Now you're sequentially examining again.

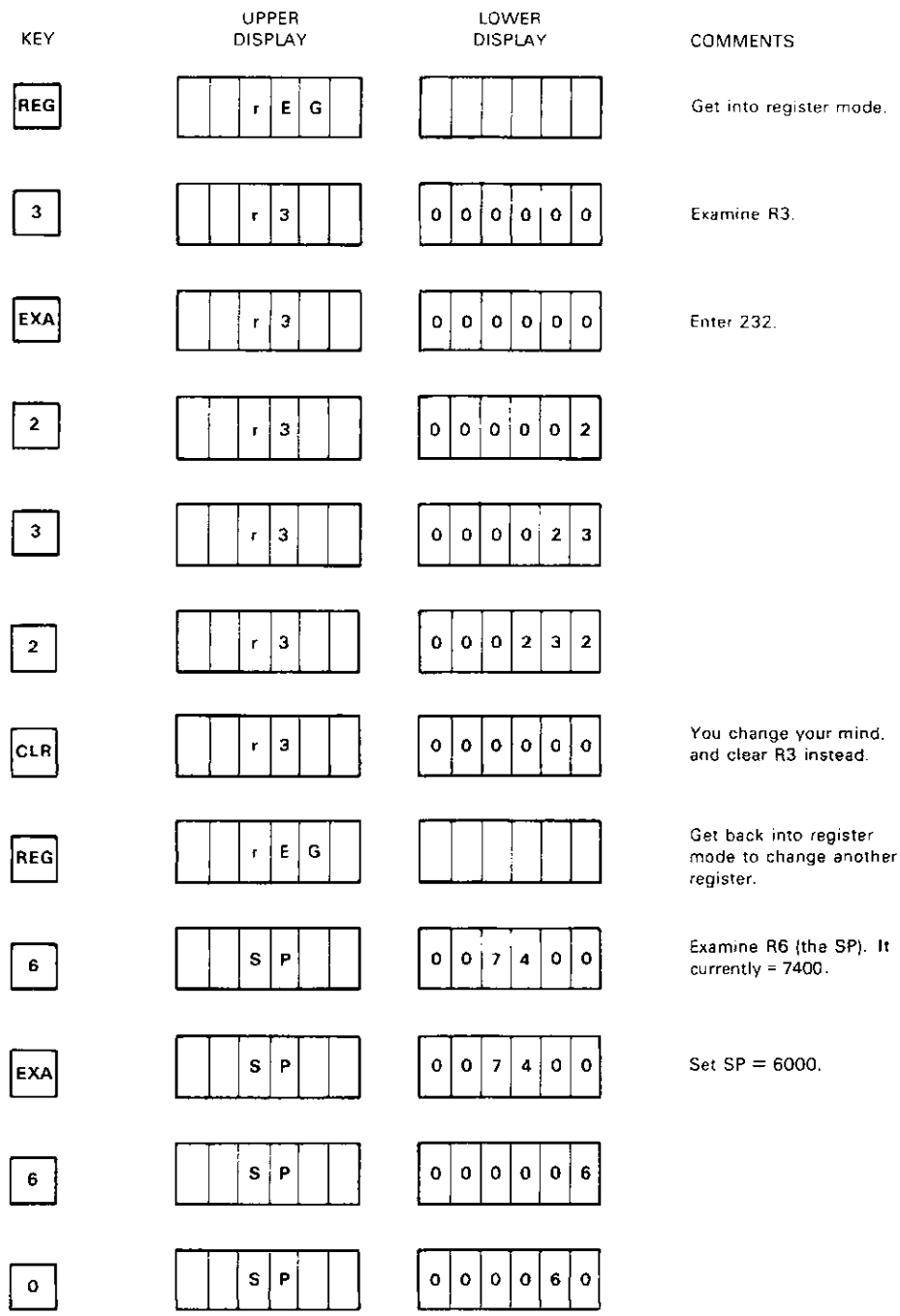
3.4 ALTERING REGISTERS

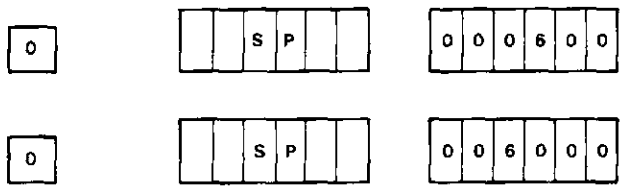
To alter the contents of a DCT11-AA internal register, you must first examine the register as described in Paragraph 3.3. To review, this means you must place the DCT11-EM in register mode by pressing the REG key and examine the desired register by pressing one of the keys 0 through 9. Once you have done this, press the EXA key and alter the contents of the selected register by pressing keys 0 through 7 in the desired order.

The previous contents of the register will be cleared and you will see the new contents being shifted in from the right side of the lower row of LEDs as you press keys.

If you wish to clear the contents of a register, press the CLR key after you have pressed the EXA key. Pressing the CLR key also clears a register while you are entering data.

Altering Registers – Example 1
You want to set register R3 to 000232 and the SP to 6000. It is assumed that the registers still contain their initial (power-up) values.



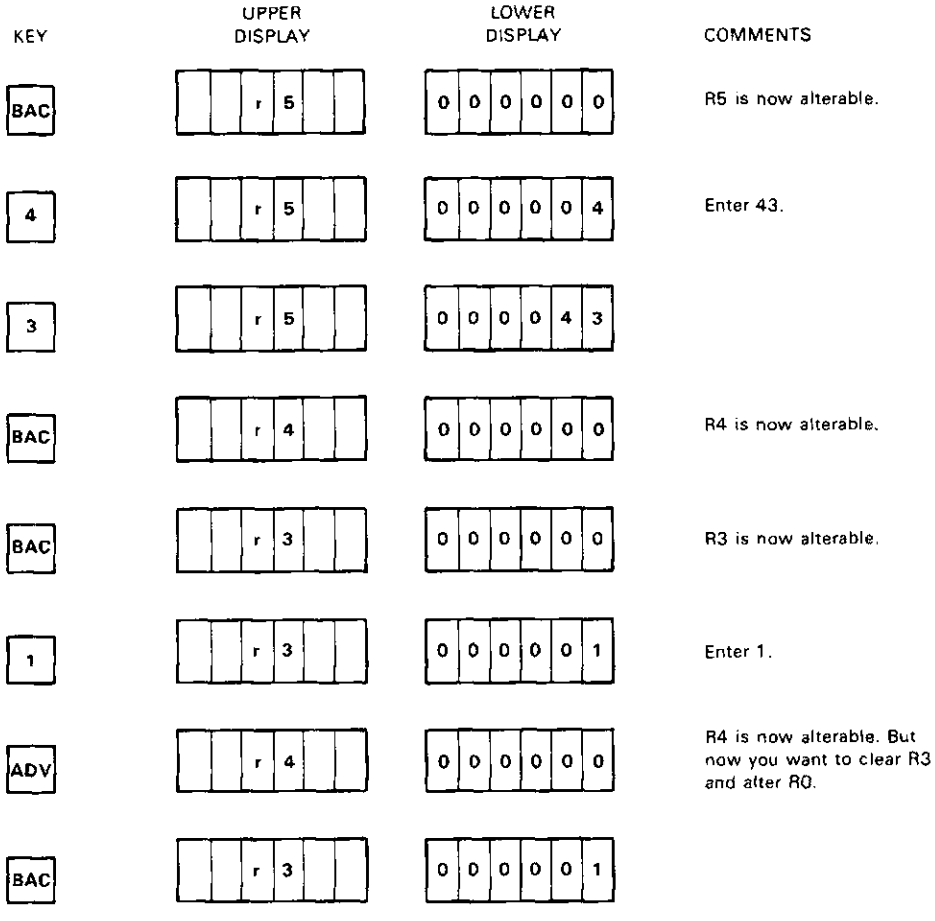


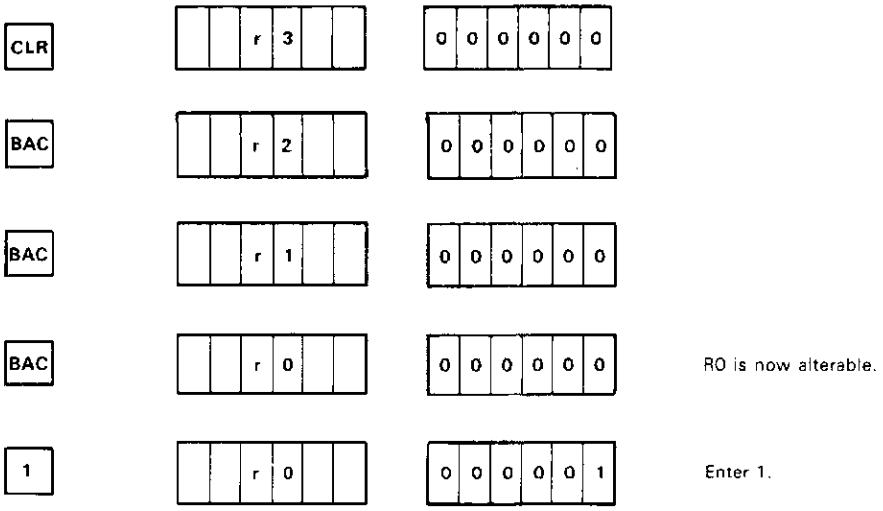
The ADV and BAC keys allow you to alter register contents sequentially. Pressing the ADV key allows you to alter registers in ascending order. You cannot advance beyond the WP. Pressing the BAC key allows you to alter registers in descending order. You cannot back up beyond R0.

Press the ADV or BAC keys until you arrive at the register you want to alter, then press the desired sequence of keys 0 through 7 to enter the data. If you want to clear the register, press CLR. If you want to alter registers nonsequentially after you have pressed the ADV or BAC keys, you must first press the REG key to reinitialize register mode. Then press 0 through 9 to select the desired register, followed by EXA, followed by the data you wish to enter.

It is generally easier to stay in sequential mode and step forward or backward to the desired register than to perform nonsequential alterations.

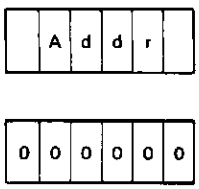
Altering Registers – Example 2
You have just completed example 1 and now want to sequentially change some registers.



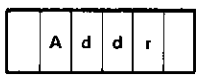


3.5 EXAMINING MEMORY LOCATIONS

To examine a memory location, you must first place the DCT11-EM in address mode. Do this by pressing the ADR key. The first time you do this, the LEDs display:



Subsequently, when you press the ADR key, the upper row of LEDs displays:



and the lower row of LEDs displays the most recently examined address.

Enter the address of the memory location you wish to examine by pressing the appropriate sequence of keys 0 through 7 .

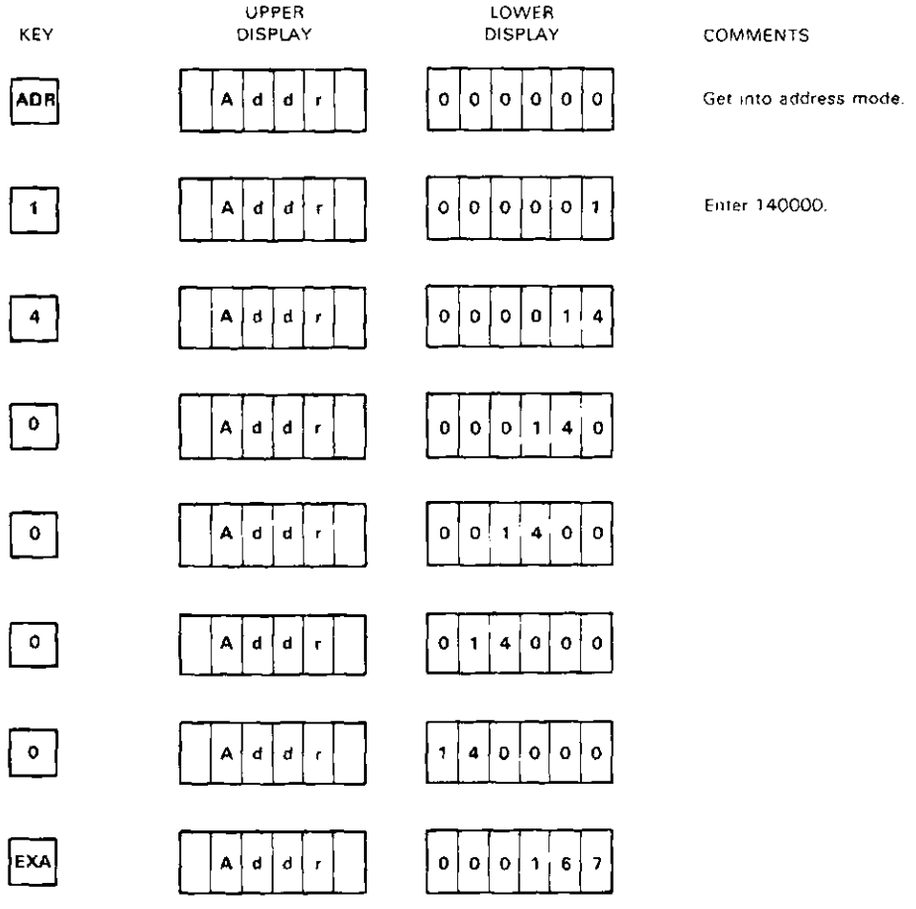
The previous address will be cleared and you will see the address you are entering being shifted in from the right side of the lower row of LEDs as you press keys.

If you make a mistake entering your address, you can press the CLR key to clear your entry and try again.

Once you are satisfied with the address you have entered, press the EXA key. The address of the location you are examining (the address you just entered) appears on the upper row of LEDs, and the contents of this location appear on the lower row of LEDs. Only even addresses can be examined. If you enter an odd address, it is rounded down when you press the EXA key.

Examining Memory Locations – Example 1

You have just powered up your DCT11-EM and want to examine some memory locations. There is a program that resides in the DCT11-EM called the monitor which begins at address 140000. You will learn more about the monitor later, but for now, all we want to do is examine some of its locations.



The ADV and BAC keys allow you to examine memory locations sequentially. Pressing the ADV key allows you to examine memory locations in ascending order. Advancing beyond address 177776 results in examining locations starting at 000000. Pressing the BAC key allows you to alter registers in descending order. Backing up beyond 000000 results in examining locations starting at 177776.

If you want to examine memory locations nonsequentially after you have pressed ADV or BAC, you must first press the ADR key to reinitialize address mode. Otherwise, you will change the contents of the memory location you are currently examining.

Examining Memory Locations – Example 2

You have just finished example 1 and now want to examine more locations in the monitor. You start by examining them sequentially.

KEY	UPPER DISPLAY	LOWER DISPLAY	COMMENTS
ADV	140002	015330	
ADV	140004	000167	
ADV	140006	176742	
BAC	140004	000167	
ADR	Addr	140004	Reinitialize address mode for nonsequential examine.
1	Addr	000001	You try to examine 140101.
4	Addr	000014	
0	Addr	000140	
1	Addr	001401	
0	Addr	014010	
1	Addr	140101	
EXA	140100	000167	The address is rounded down and you examine 140100.
BAC	140076	173306	Now you're sequentially examining again.

3.6 ALTERING MEMORY LOCATIONS

To alter the contents of a memory location, you must first examine the memory location as described in Paragraph 3.5. To review, this means you must place the DCT11-EM in address mode by pressing the ADR key and examine the desired location by pressing the appropriate sequence of keys 0 through 7. Then press the EXA key.

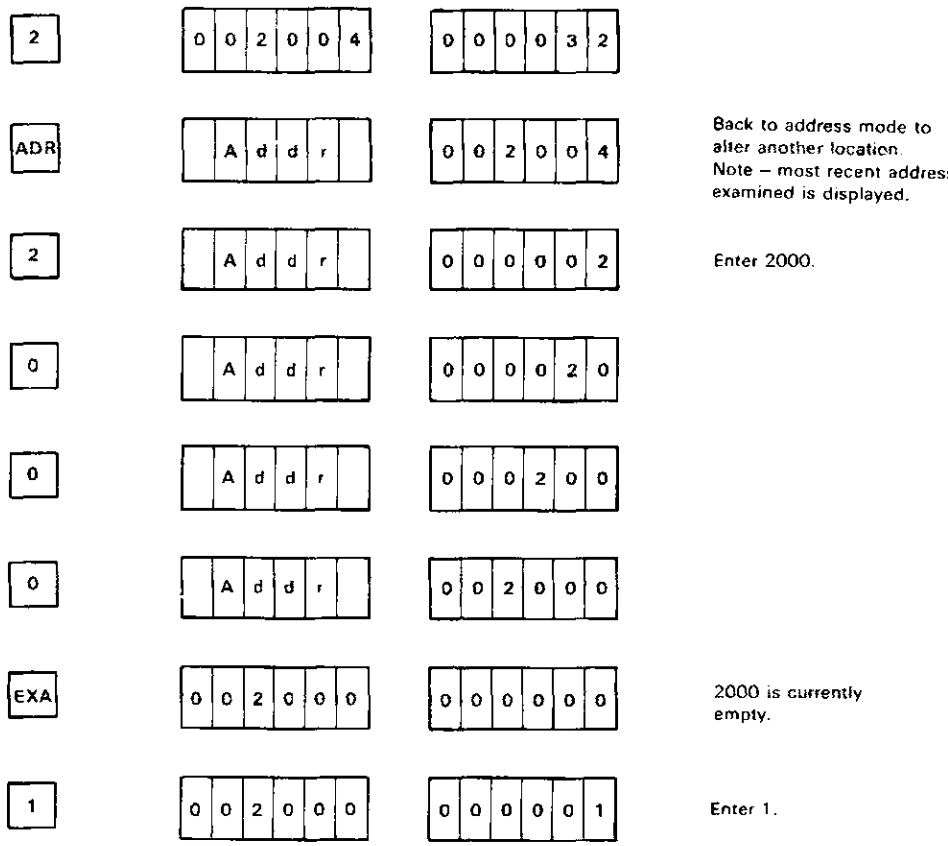
The contents of the location you are examining can now be changed by pressing keys 0 through 7 in the desired sequence. The previous contents of the location will be cleared and you will see the new contents being shifted in from the right side of the lower row of LEDs as you press keys.

Pressing the CLR key will clear the location before or during data entry.

Altering Memory Locations – Example 1

You have just powered up your DCT11-EM and want to alter some memory locations. Locations 2000 through 2006 are in the user RAM area and will be used in the following examples. Later on, you will learn more about the availability of DCT11-EM memory and address space, but for now the discussion will be limited to these locations only.

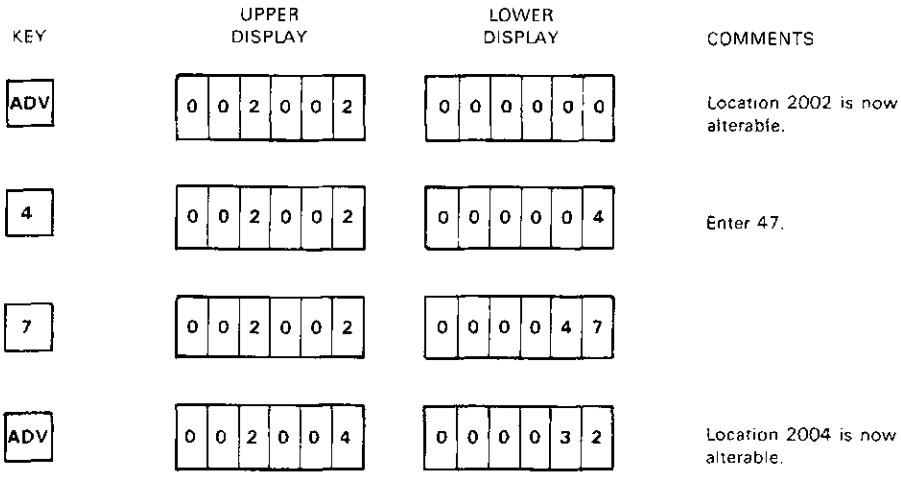
KEY	UPPER DISPLAY	LOWER DISPLAY	COMMENTS
ADR	Addr	000000	Get into address mode.
2	Addr	000002	Enter 2004
1	Addr	000021	You made a mistake and entered 1 instead of 0.
CLR	Addr	000000	Clear entry.
2	Addr	000002	Try again – enter 2004.
0	Addr	000020	
0	Addr	000200	
4	Addr	002004	
EXA	002004	000000	2004 is currently empty.
3	002004	000003	Enter 32.

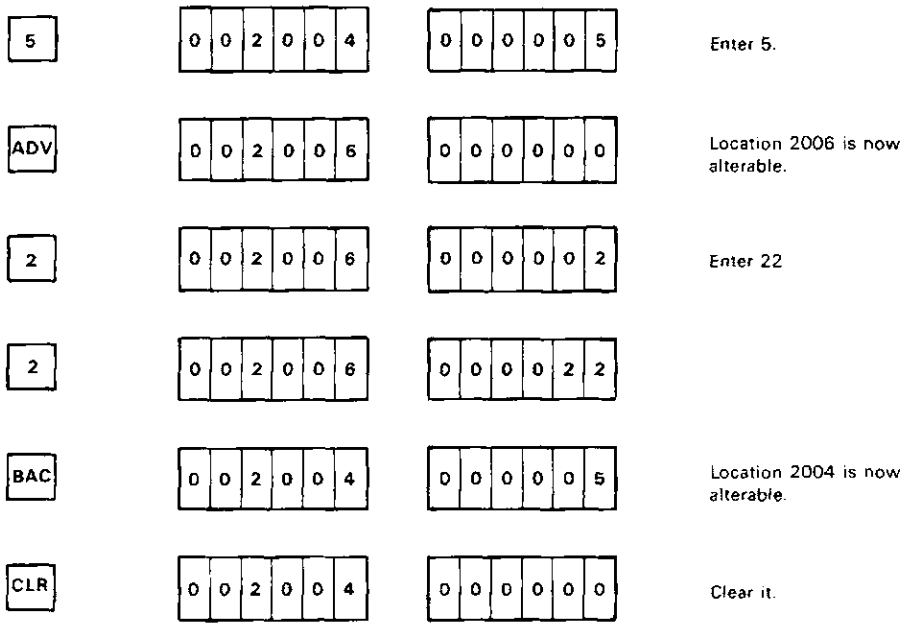


The ADV and BAC keys allow you to alter memory locations sequentially. Pressing the ADV key allows you to alter memory locations in ascending order. Pressing the BAC key allows you to alter memory locations in descending order.

Press the ADV or BAC keys until you arrive at the memory location you want to alter and press the desired sequence of keys 0 through 7 to enter the data. If you want to clear the memory location, press CLR.

Altering Memory Locations – Example 2
You have just completed example 1 and now want to sequentially alter memory locations.





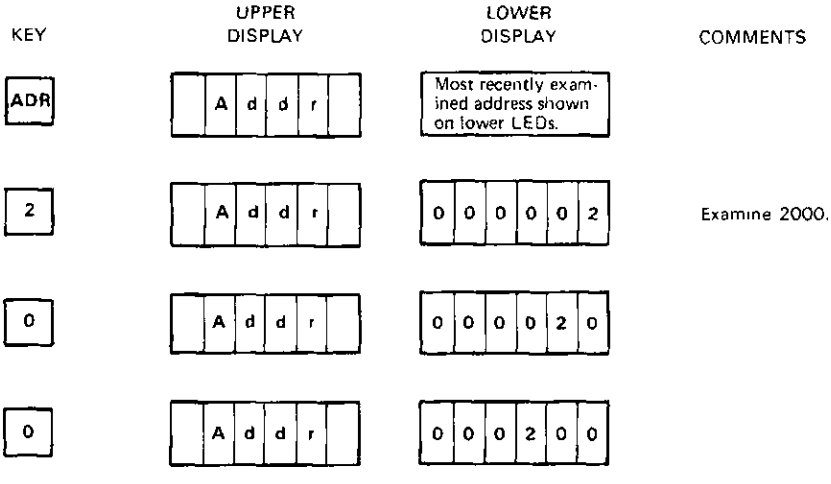
3.7 ENTERING AND EXECUTING A SIMPLE PROGRAM

In this paragraph, we will tie together the material presented thus far by entering and running a simple program. It is assumed you are familiar with an assembly language instruction set. A full description of the instruction set used in the following example is found in Chapter 6 of the *DCT11-AA User's Guide* (EK-DCT11-UG).

The following program takes a number in register R1, adds it to a number in register R2, and puts the result in register R3.

Octal Code	Instruction	Comments
010103	MOV R1,R3	Get first term.
060203	ADD R2,R3	Add second term.
000000	HALT	Halt program execution.

We will place this program in user RAM, starting at address 2000.



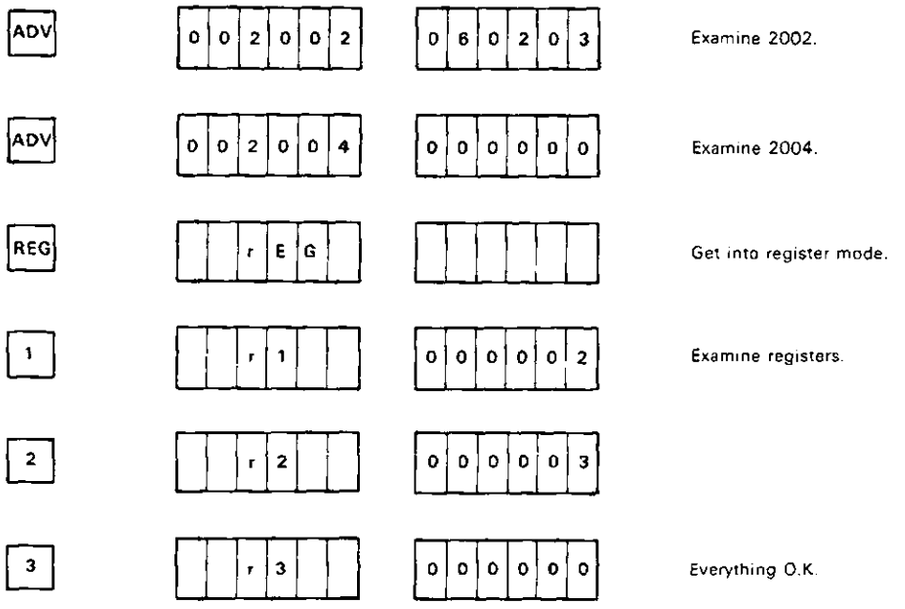
0	Addr	002000	
EXA	002000	Current contents of location 2000 are shown on lower LEDs.	
1	002000	000001	Enter first instruction. You don't need to enter leading zeroes.
0	002000	000010	
1	002000	000101	
0	002000	001010	
3	002000	010103	
ADV	002002	Current contents of 2002 are shown on lower LEDs.	Examine next address.
6	002002	000006	Enter second instruction.
0	002002	000060	
2	002002	000602	
0	002002	006020	
3	002002	060203	
ADV	002004	Current contents of 2004 are shown on lower LEDs.	Examine next address.
CLR	002004	000000	Enter third instruction. HALT is entered by clearing the location.

Now place some numbers in R1 and R2 that the program can work with. Also make sure R3 is cleared.

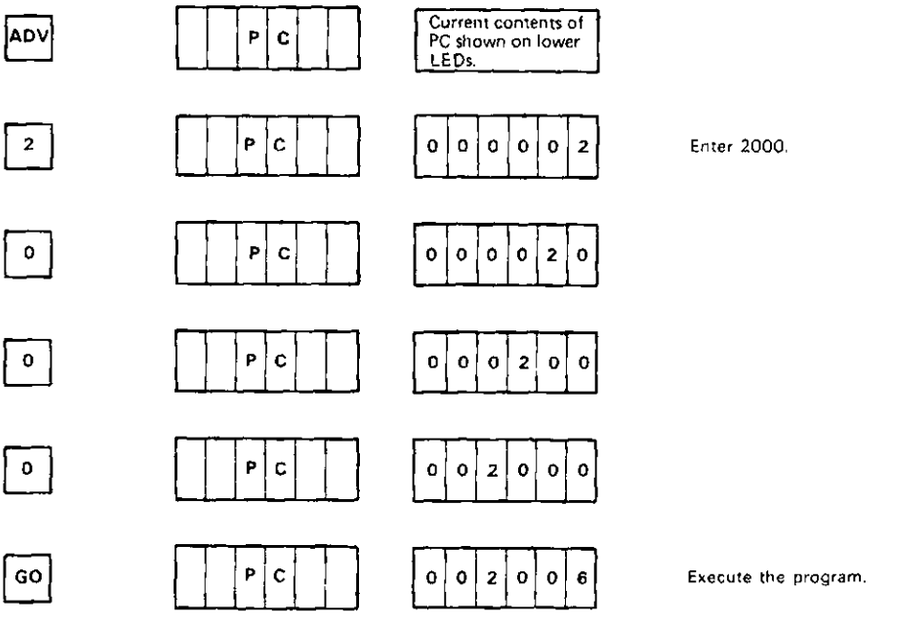
REG	r E G		Get into register mode.
1	r 1	Current contents of R1 shown on lower LEDs.	
EXA	r 1	Current contents of R1 remain on lower LEDs.	
2	r 1	0 0 0 0 0 2	Enter 2.
ADV	r 2	Current contents of R2 shown on lower LEDs.	
3	r 2	0 0 0 0 0 3	Enter 3.
ADV	r 3	Current contents of R3 shown on lower LEDs.	
CLR	r 3	0 0 0 0 0 0	Clear R3.

Now go back and check what you have just entered.

ADR	A d d r	0 0 2 0 0 4	Get into address mode.
2	A d d r	0 0 2 0 0 2	Examine 2000.
0	A d d r	0 0 0 0 2 0	
0	A d d r	0 0 0 2 0 0	
0	A d d r	0 0 2 0 0 0	
EXA	0 0 2 0 0 0	0 1 0 1 0 3	

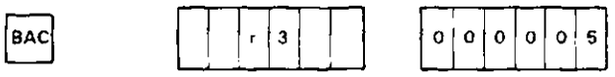


Now run the program. Set the PC to the starting address of the program (2000) and press the GO key to begin program execution. Since you are currently in register mode, press the ADV key until you get to the PC.



The program is now halted. The current PC (2006) is displayed on the lower row of LEDs.

Check R3 to find out if the program executed properly. Since you are in register mode, press the BAC key until you get to R3:



and the result is correct.

3.8 WORKING WITH A LONGER PROGRAM

Consider a program that calculates the sum of all the numbers from 0 to n, where you specify n. That is, the program determines:

$$\sum_{X=0}^{n} X$$

You place the value of n in R0, and the program deposits the sum it calculates in memory location 2044.

Use the keypad to enter the following summation program starting at location 2000.

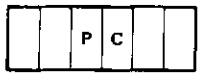
Location	Octal Code	Instruction	Comments
2000	005001	CLR R1	Set R1 = 0.
2002	020001	CMP R0,R1	R0 contains n.
2004	003413	BLE 2034	Illegal input (n $\leq$ 0)?
2006	005037	CLR @#2044	No, start operation by clearing 2044.
2010	002044		
2012	010037	MOV R0,@#2044	Place first value of n in 2044.
2014	002044		
2016	005300	DEC R0	n = n−1
2020	060037	ADD R0,@#2044	Add next value (n−1) to 2044.
2022	002044		
2024	102404	BVS 2036	Overflow?
2026	020001	CMP R0,R1	No overflow.
2030	003372	BGT 2016	Continue operation if n > 0.
2032	000000	HALT	Operation complete if n = 0.
2034	005000	CLR R0	Illegal input. Clear R0, 2044.
2036	005037	CLR @#2044	Overflow. Clear 2044.
2040	002044		
2042	000000	HALT	Illegal input or overflow occurred.
2044	xxxxxx		Initial contents of 2044 irrelevant.

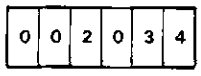
To test the operation of the program, deposit a value of 10 (octal) into R0. The program should sum 10 + 7 + 6 + 5 + 4 + 3 + 2 + 1 (octal) in memory location 2044 to produce 44 (octal). Note that this is equivalent to having a value of 8 (decimal) in R0 and letting the program sum 8 + 7 + 6 + 5 + 4 + 3 + 2 + 1 (decimal) to produce 36 (decimal).

Set R0 = 10
SP = 7400
PC = 2000

Press the GO key.

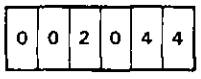
The result should be:

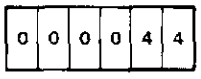




The program halted at location 2032. Now examine location 2044.

The result should be:





3.8.1 Using the Single-Step Function

The single-step function is a powerful program analysis tool. It allows you to execute your program one instruction at a time. At the end of each instruction, you may examine various registers and memory locations to determine how the program has affected them.

To perform the single-step function, press the SST key.

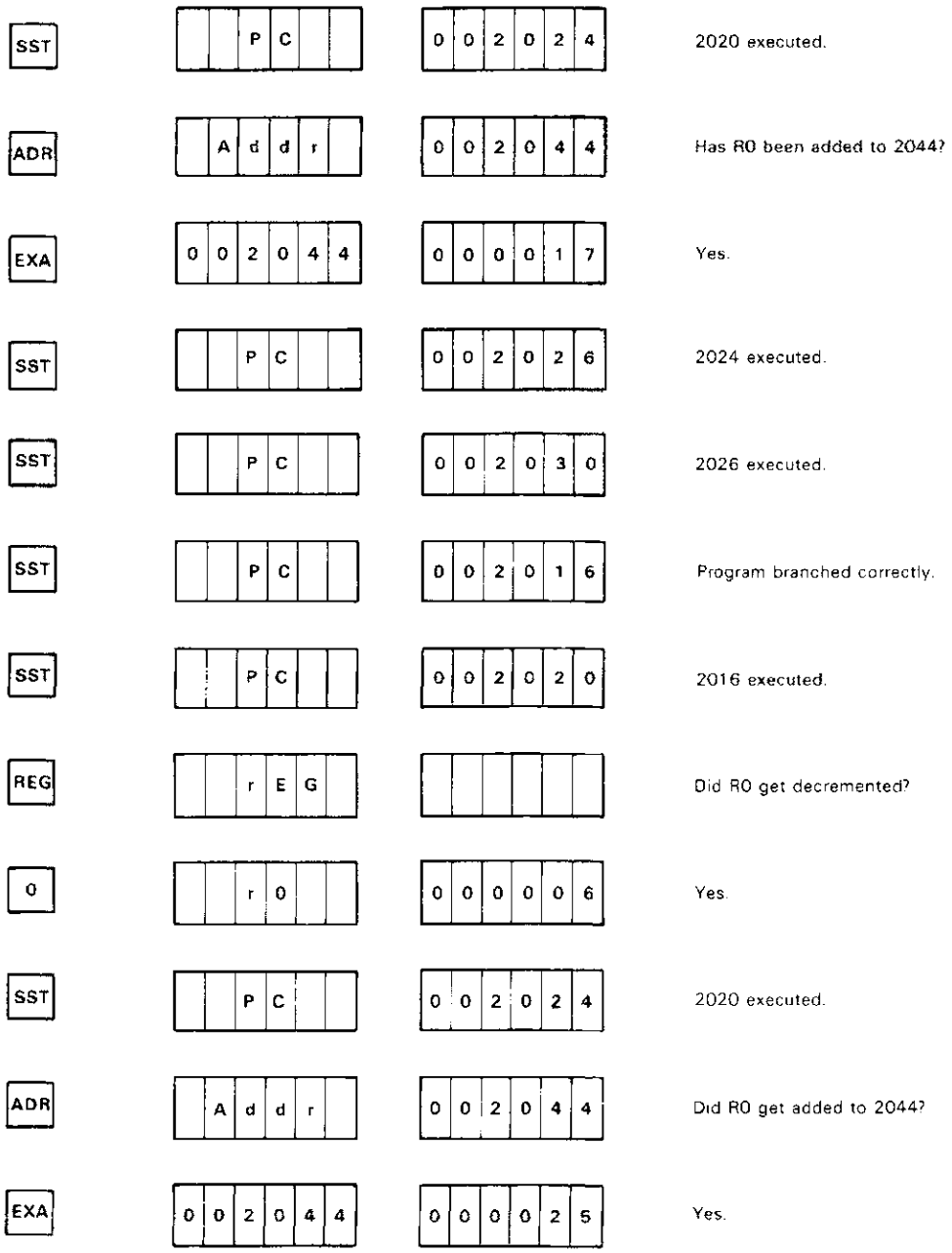
Result: the instruction currently pointed to by the PC is executed.

Let us now single step through the preceding summation program. First set up your initial conditions:

Set R0 = 10
SP = 7400
PC = 2000

Then key in the following.

KEY	UPPER DISPLAY	LOWER DISPLAY	COMMENTS
SST	PC	002002	2000 executed.
SST	PC	002004	2002 executed.
SST	PC	002006	2004 executed.
SST	PC	002012	2006 executed.
SST	PC	002016	2012 executed.
ADR	Addr	Most recently examined address shown on lower LEDs.	Has R0 been moved to 2044?
2	Addr	000002	
0	Addr	000020	
4	Addr	000204	
4	Addr	002044	
EXA	002044	000010	Yes.
SST	PC	002020	2016 executed.
REG	rEG		Did R0 get decremented?
0	r0	000007	Yes.



You can continue executing the program one instruction at a time by repetitively pressing the SST key.

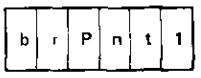
3.8.2 Using Breakpoints

The use of breakpoints is another means of analyzing and debugging your programs. Breakpoints cause your program to halt whenever they are encountered. When the program is halted, you can then examine various registers and memory locations to determine how the program has affected them.

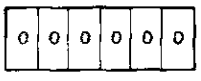
If there were no debugging aids, you would have to insert breakpoint (BPT) instructions in your program and write a breakpoint trap handling routine if you desired breakpoints. The DCT11-EM, however, *does* contain debugging aids and provides a convenient means of inserting up to four breakpoints via the keypad. Do not attempt to set breakpoints by inserting BPT instructions in your program. If you do this, you will get an error message when you try to execute the program (see Appendix C).

To insert breakpoints, press the BPT key.

The upper row of LEDs displays:



and the lower row of LEDs displays the current address of breakpoint 1. If breakpoint 1 is not currently set, the lower row of LEDs displays:



You can then press the appropriate sequence of keys 0 through 7 to enter the address of breakpoint 1.

You can set up to four breakpoints in this way. Use the ADV and BAC keys to examine breakpoints 1 through 4 and press the appropriate sequence of keys 0 through 7 to enter an address for each breakpoint.

If you press BAC while you are examining breakpoint 1, you are examining something called the watchpoint address. The use of the watchpoint is explained in Paragraph 3.8.3.

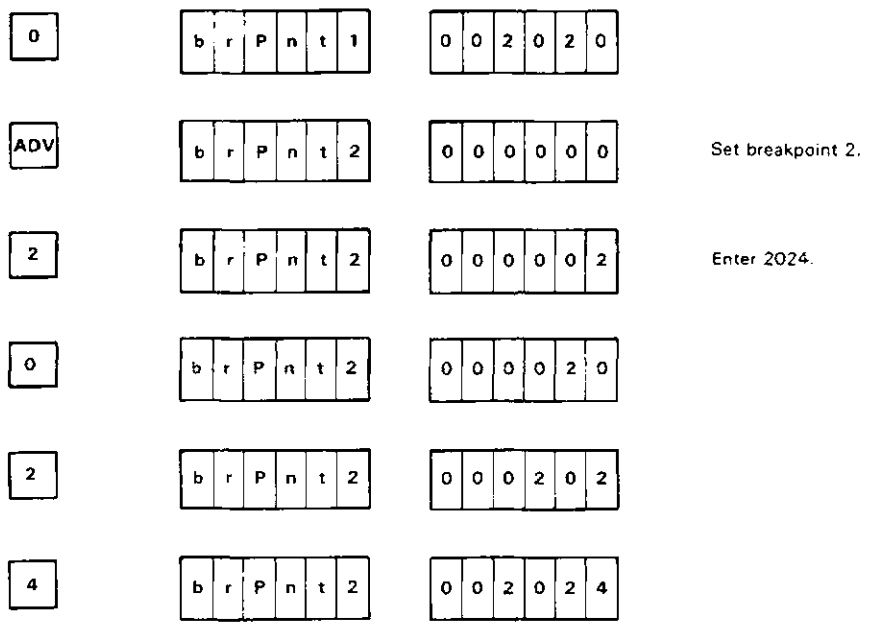
Breakpoints are recognized only if you use the GO key or the "Go With LEDs" special function (Paragraph 3.12.2) to execute your program from the keypad. Breakpoints are disabled when you single step through a program.

When you execute a program with breakpoints in it (by pressing the GO key, for example), your program halts at the address of your first breakpoint without executing the instruction at that address. The instruction at the breakpoint address is executed when you resume program execution (e.g., by pressing the GO or SST keys).

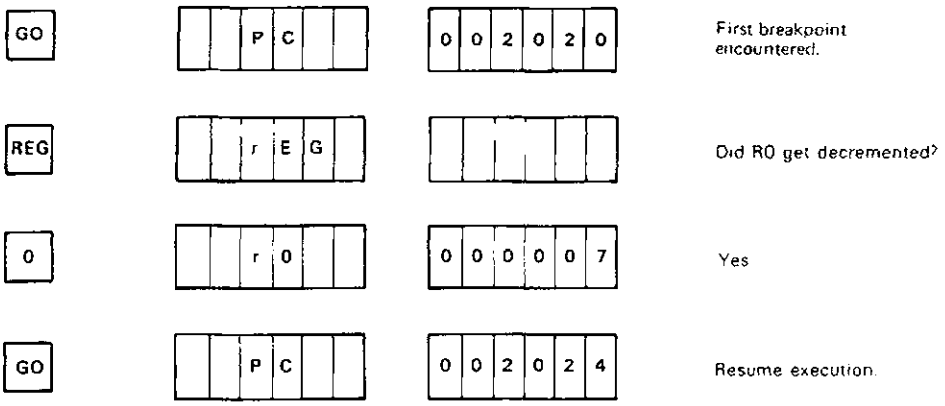
Using Breakpoints – Example

We want to set two breakpoints in the summation program shown in Paragraph 3.8. Set the first breakpoint at address 2020 to make sure R0 has been decremented properly. Then set the second breakpoint at address 2024 to check the results of the cumulative addition.

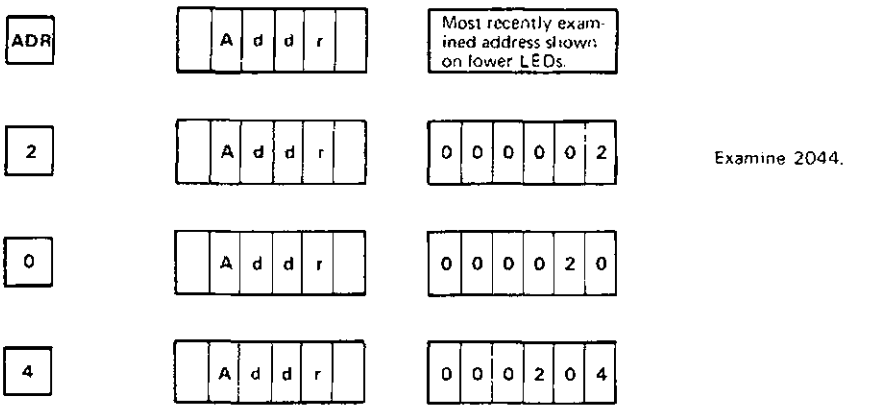
KEY	UPPER DISPLAY	LOWER DISPLAY	COMMENTS
BPT	b r P n t 1	0 0 0 0 0 0	Assume no breakpoints have been previously set.
2	b r P n t 1	0 0 0 0 0 2	Enter 2020.
0	b r P n t 1	0 0 0 0 2 0	
2	b r P n t 1	0 0 0 2 0 2	

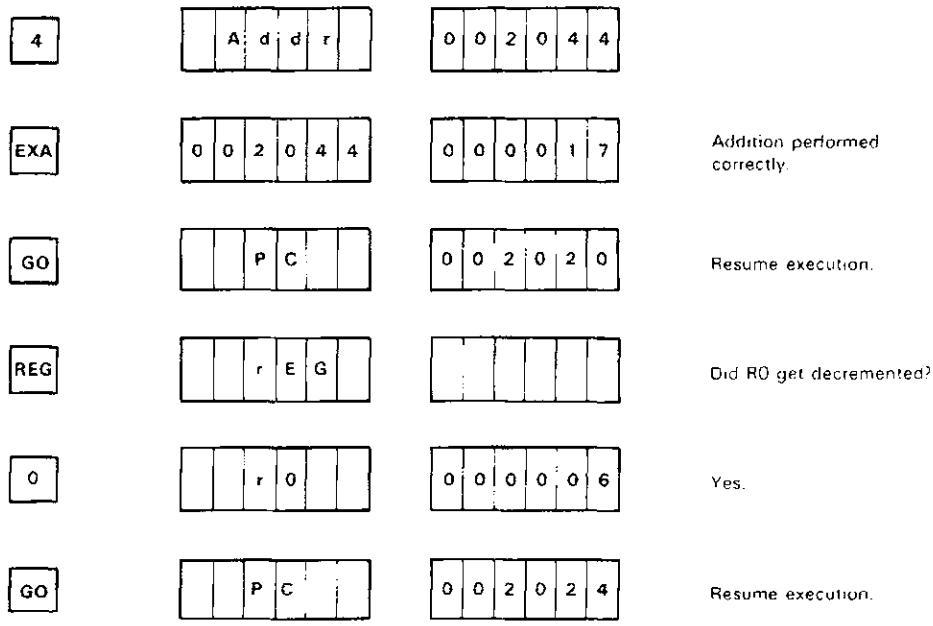


Set your initial conditions as before (R0 = 10, SP = 7400, PC = 2000) and execute the program.



Examine address 2044 to see if the first addition was performed correctly.



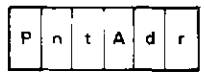


3.8.3 Using the Watchpoint

In Paragraph 3.3 we identified the watchpoint (WP) and showed how it could be examined. In this section, you will learn how to use the WP for program analysis and debugging.

The watchpoint is a convenient means of monitoring and altering a memory location. Once you set the watchpoint address to the address of a memory location, you can examine and alter that location just as you would a register. To set a watchpoint address, press the BPT key, then the BAC key.

The upper row of LEDs displays:



and the lower row of LEDs displays the current WP address.

If the WP is not set, the lower row of LEDs displays:

You may now enter the new WP address by pressing the desired sequence of keys 0 through 7. You can clear the WP by setting its address to zero.

Using the Watchpoint – Example 1

In our summation program in Paragraph 3.8, we used location 2044 to deposit our accumulated result. Since we would like to examine (and possibly alter) this location frequently, we set our watchpoint address at 2044.

KEY	UPPER DISPLAY	LOWER DISPLAY	COMMENTS
BPT	brPnt1	002002	Current value of BP1 displayed on lower LEDS.
BAC	PntAdr	000000	
2	PntAdr	000002	Enter watchpoint address of 2044.
0	PntAdr	000020	
4	PntAdr	000204	
4	PntAdr	002044	

Now we can examine and alter the contents of location 2044 just as we would a register. If you run the summation program in Paragraph 3.8 and want to inspect the result, do the following.

REG	rEG		Get into register mode.
9	002044	Current contents of 2044 shown on lower LEDs.	Examine WP.
EXA	002044	Current contents of 2004 shown on lower LEDs.	
CLR	002044	000000	Clear it.

You have just cleared the contents of location 2044.

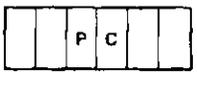
The watchpoint can be used in conjunction with the single-step function to continuously monitor the contents of a memory location. When this is done, the contents of the watchpoint appear on the upper row of LEDs, and the current PC appears on the lower row of LEDs.

Using the Watchpoint – Example 2
You are still working with the summation program in Paragraph 3.8. You have established a watchpoint at location 2044, as shown in the previous example, and want to continuously monitor the contents of this location as you single step through the program.

Set your initial conditions as before (R0 = 10, SP = 7400, PC = 2000) and key in the following.

KEY	UPPER DISPLAY	LOWER DISPLAY	COMMENTS
SST	0 0 0 0 0 0	0 0 2 0 0 2	2000 executed; 2044 contents shown on upper LEDs.
SST	0 0 0 0 0 0	0 0 2 0 0 4	2002 executed.
SST	0 0 0 0 0 0	0 0 2 0 0 6	2004 executed.
SST	0 0 0 0 0 0	0 0 2 0 1 2	2006 executed.
SST	0 0 0 0 1 0	0 0 2 0 1 6	2012 executed. 2044 has changed.
SST	0 0 0 0 1 0	0 0 2 0 2 0	2016 executed.
SST	0 0 0 0 1 7	0 0 2 0 2 4	2020 executed. 2044 has changed.

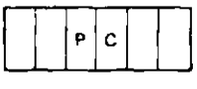
And so on. When you finish executing the program (e.g., after you have executed instruction 2032 in the example above), the upper row of LEDs displays:



and the lower row of LEDs displays the current PC.

3.9 USING THE HALT SWITCH

Pressing the HALT switch causes you to unconditionally halt the operation of your program and return control to the DCT11-EM keypad. When you press the HALT switch, the upper row of LEDs displays:



and the lower row of LEDs displays the current PC.

You can use the HALT switch, for example, to escape from an infinite loop your program is executing or to inhibit hardware problems which are interrupting the proper operation of the DCT11-EM.

After pressing HALT, you are in register mode and can readily examine the contents of the DCT11-EM registers as described in Paragraph 3.3.

3.10 THE INT SWITCH

Pressing the INT switch causes you to generate a power-fail (PF) nonmaskable interrupt. Pressing this switch will have no effect on the operation of the DCT11-EM unless you specifically write a program that recognizes input from it. The program in the following example shows you how to use this switch to experiment with interrupts. Also refer to Chapter 6 for more information on interrupts.

Using the INT Switch – Example

This program simply loops on itself at location 1510 until you press the INT switch. Then the current PC and PS are pushed onto the hardware stack and the DCT11-EM goes to locations 24 and 26 for its new PC and PS, respectively. Location 24 is called the power-fail vector and usually points to a power-fail service routine. The first line of your program, however, changes location 24 to point to your own "power-fail service routine." This routine, which you specify to start at location 1514, is not a power-fail service routine at all, but a routine that sets R0 to the number of times (in octal) that the interrupt switch has been pressed.

Enter the following.

Location	Octal Code	Instruction	Comments
1500	012737	MOV #1514,@#24	
1502	001514		Set power-fail vector to "service routine."
1504	000024		
1506	005000	CLR R0	Initialize R0.
1510	000777	BR 1510	Await interrupt.
1512	000000	HALT	
1514	005200	INC R0	Start of "service routine."
1516	000002	RTI	Restore old PC and PS.

Start the program at 1500 and press the INT switch a number of times. The upper and lower row of LEDs will be blank while you are pressing the INT switch. Each time you press INT, you execute the "service routine" which increments R0. When the routine is done, it returns to 1510 to await another INT switch press. Press the HALT switch to suspend operation and examine R0.

3.11 THE USER LED

The user LED is a general-purpose indicator lamp that your program can use to indicate the status of some condition. You can turn on the user LED by writing 000011 to port C of the 8255A parallel port chip (see Paragraph 6.5.1). Port C of the 8255A chip has an address of 177444. Writing 000010 to port C of the 8255A chip turns off the user LED once it has been turned on by your program.

User LED – Example
The following is a short program that turns the user LED on and off. Use the keypad to enter this program starting at location 1000.

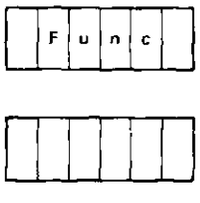
Location	Octal Code	Instruction	Comments
1000	012737	MOV #11,@#177444	Write 11 to port C.
1002	000011		
1004	177444		
1006	012700	MOV #100000,R0	Put a large number in R0.
1010	100000		
1012	077001	SOB R0,1012	Loop for a while.
1014	012737	MOV #10,@#177444	Write 10 to port C.
1016	000010		
1020	177444		
1022	012700	MOV #100000,R0	Put a large number in R0.
1024	100000		
1026	077001	SOB R0,1026	Loop for a while.
1030	000137	JMP @#1000	Loop infinitely.
1032	001000		

3.12 PERFORMING KEYPAD SPECIAL FUNCTIONS

There are five types of special functions you can perform through the use of the DCT11-EM keypad.

Function Number	Function Name
0	Cancel breakpoints
1	Go with LEDs
2	Start console
3	Set baud rates
4	Release protection

To perform one of these special functions, you must first place the DCT11-EM in function mode. To do this, press the FNC key. The LEDs display:

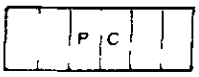


and you can now select a function by pressing any of the keys 0 through 4 or CLR, which is equivalent to 0. When you have done this, the number of the selected function appears on the bottom row of LEDs. The selected special function is then activated by pressing the EXA key.

The following paragraphs describe the operation of these special functions.

3.12.1 Function 0 – Cancel Breakpoints

Function 0 clears all four breakpoint addresses and the watchpoint address. When function 0 is activated, the upper row of LEDs displays:



and the lower row of LEDs displays the current value of the PC. The DCT11-EM is left in register mode.

Function 0 – Example

You are debugging a program you just entered and want to clear all the breakpoints and watchpoints associated with an old program.

KEY	UPPER DISPLAY	LOWER DISPLAY	COMMENTS
FNC	F u n c		Get into function mode.
0	F u n c	0	Select function 0.
EXA	P C	Current PC shown on lower LEDs.	
BPT	b r P n t 1	0 0 0 0 0 0	Verify breakpoint 1 cleared.
BAC	P n t A d r	0 0 0 0 0 0	Verify watchpoint address cleared.
ADV or BPT	b r P n t 1	0 0 0 0 0 0	Breakpoint 1 again.
ADV	b r P n t 2	0 0 0 0 0 0	Verify breakpoint 2 cleared.

3.12.2 Function 1 – Go With LEDs

Within the DCT11-EM are a number of routines your program can call to display values on the LEDs (see Paragraph 5.3.1). For these routines to operate correctly, you must explicitly turn on the LEDs before you call a routine. One way to turn on the LEDs is to include a MOV #7,@#177444 instruction in your program (see Paragraph 5.3.1.1). Another way is to execute your program by activating function 1 rather than by pressing the GO key. Activating function 1 turns on the LEDs and starts your program.

3.12.3 Function 2 – Start Console

If you connect a console terminal to your DCT11-EM, you will use function 2 frequently. Activating function 2 starts a program called the console monitor. The console monitor resides in the on-board PROMs and allows you to enter, execute, and debug programs through the use of a console terminal rather than the keypad. The console monitor also allows you to perform other operations and is described in more detail in Chapter 4.

Before activating function 2, connect a console terminal to the DCT11-EM and select an appropriate baud rate by activating function 3 (see Paragraph 3.12.4).

When function 2 is activated, the upper and lower LEDs are blank and the message:

```
TEM CONSOLE MONITOR V1.0
TEM>
```

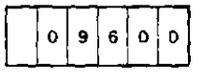
appears on the console terminal.

3.12.4 Function 3 – Set Baud Rates

The DCT11-EM has two serial ports: a console terminal port and an auxiliary serial port. Activating function 3 allows you to select baud rates for these ports. When the DCT11-EM is powered up, it automatically sets both baud rates to 9600.

When you first activate function 3, the upper row of LEDs displays:

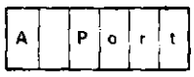
and the lower row of LEDs displays:



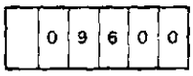
This tells us that the console terminal port is currently set at 9600 baud. Note that the baud rate is displayed as a decimal number.

Pressing the ADV and BAC keys steps you backward and forward among the various baud rate values available for the console terminal port. The available baud rates for the console terminal port are: 300, 600, 1200, 2400, 4800, 9600, and 19200.

You can now set the baud rate of the auxiliary serial port by pressing the EXA key. The first time you do this, the upper row of LEDs displays:



and the lower row of LEDs displays:



This tells us that the auxiliary serial port is currently set at 9600 baud. Repetitively pressing any of the keys CLR, 0 through 9, ADV, or BAC causes you to alternate between two available baud rates. The two available baud rates for the auxiliary serial port are: the current baud rate of the console terminal port and one-fourth the current baud rate of the console terminal port. Pressing EXA again puts you into register mode.

Function 3 – Example

You want to use function 3 to experiment with setting baud rates for the console terminal serial port and the auxiliary serial port. You have not altered these baud rates since powering up.

KEY	UPPER DISPLAY	LOWER DISPLAY	COMMENTS
FNC	Func		Get into function mode.
3	Func	3	Select function 3.
EXA	Consol	09600	Baud rate for console terminal port = 9600.
ADV	Consol	19200	
BAC	Consol	09600	
BAC	Consol	04800	
BAC	Consol	02400	
BAC	Consol	01200	
EXA	A.Port	01200	Band rate for auxiliary port = terminal port.
0	A.Port	00300	300 = one fourth of 1200.
8	A.Port	01200	Back to 1200.
ADV	A.Port	00300	Back to 300.
EXA	PC	Current PC shown on lower LEDs.	Now in register mode. Console port = 1200 Auxiliary port = 300.

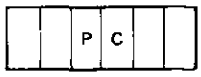
3.12.5 Function 4 – Release Protection

There is an area of RAM that the DCT11-EM normally prevents you from directly altering from the keypad. This area is called the keypad monitor scratchpad and occupies the memory space from addresses 7400 to 7777. Refer to Paragraphs 5.2 and 5.4.1 for more information about the keypad monitor and this protected area.

Additionally, if you have a console terminal connected to your DCT11-EM, there are two other areas of RAM that are protected. These areas are the console monitor scratchpad and the symbol table. They occupy the memory space from addresses 6500 to 7377. Again, more information is provided in Chapter 5. Activating function 4 releases the protection associated with these memory spaces. Note that "protection" refers to protection from direct alteration via the keypad or console terminal. Programs that you write can and will alter these locations. Therefore, when you write your programs make sure these spaces are not inadvertantly violated.

Protection is restored when you press the HALT switch, when a HALT instruction is encountered, or whenever you restart the DCT11-EM.

When you activate function 4, the upper row of LEDs displays:



and the lower row of LEDs displays the current value of the PC.

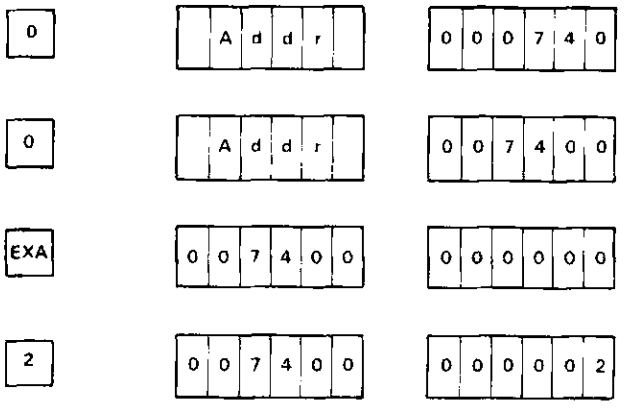
Function 4 – Example

You want to alter location 7400, a normally protected location.

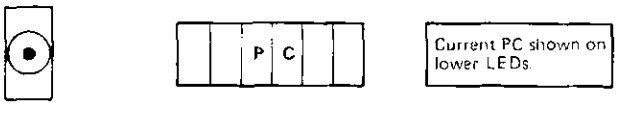
KEY	UPPER DISPLAY	LOWER DISPLAY	COMMENTS
FNC	F u n c		Get into function mode.
4	F u n c	4	Select function 4.
EXA	P C	Current PC shown on lower LEDs'	Protection off.

Alter the location.

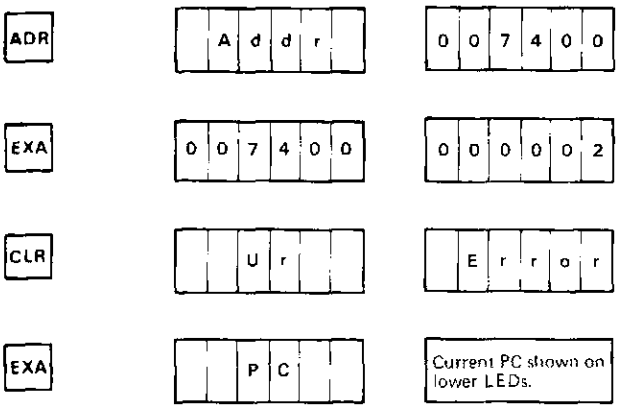
ADR	A d d r	Most recently examined address shown on lower LEDs.	
7	A d d r	0 0 0 0 0 7	Alter 7400
4	A d d r	0 0 0 0 7 4	



Restore protection by pressing the HALT switch.



Now try to alter location 7400.



See Appendix C for more information on error messages.

3.13 KEYPAD COMMAND SUMMARY

OPERATION	PRESS	ENTER	PRESS	ENTER	REFERENCE
ALTER MEMORY	ADR	LOCATION ADDRESS	EXA	NEW CONTENTS	3.6
ALTER REGISTER	REG	REGISTER NUMBER	EXA	NEW CONTENTS	3.4
CANCEL BREAKPOINTS	FNC	0	EXA		3.12.1
EXAMINE MEMORY	ADR	LOCATION ADDRESS	EXA		3.5
EXAMINE REGISTER	REG	REGISTER NUMBER			3.3
EXECUTE PROGRAM	GO				3.7
GO WITH LEDs	FNC	1	EXA		3.12.2
RELEASE PROTECTION	FNC	4	EXA		3.12.5
SET BAUD RATES	FNC	3	EXA		3.12.4
SET BREAKPOINT	BPT	BREAKPOINT ADDRESS			3.8.2
SET WATCHPOINT	BPT		BAC	WATCHPOINT ADDRESS	3.8.3
SINGLE STEP	SST				3.8.1
START CONSOLE	FNC	2	EXA		3.12.3

CHAPTER 4
CONSOLE OPERATION

4.1 INTRODUCTION

This chapter explains how to operate the DCT11-EM using a console terminal. Using a console terminal simplifies program development because it gives you access to the DCT11-EM's symbolic assembler/disassembler. In addition, a console terminal allows you to perform several functions not accessible with the keypad, such as the ability to load programs from a host computer.

When you complete this chapter, you will be able to use a console terminal to:

- Examine and alter the contents of registers in the DCT11-AA register file
- Examine and alter the contents of memory locations
- Enter and execute programs
- Debug your programs through the use of single steps, breakpoints, and watchpoints
- Load programs from a host computer
- Perform a variety of other console functions.

You can connect an RS232-C compatible console terminal to your DCT11-EM as shown in Figure 4-1.

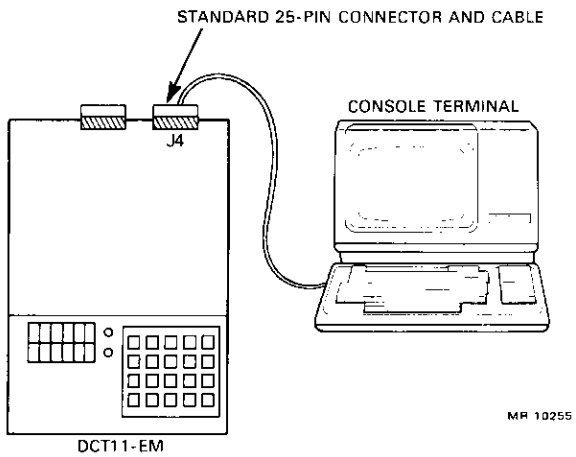


Figure 4-1 Connecting a Console Terminal to the DCT11-EM

No other wiring or jumpering is required. Use the DCT11-EM keypad to set the correct baud rate by activating function 3 (see Paragraph 3.12.4). Also, make sure your console terminal is set up to transmit and receive characters in the following format: asynchronous, ASCII, 8 bits (eighth bit is always space), no parity, one stop bit.

Then activate function 2 as described in Paragraph 3.12.3. The terminal displays:

```
TEM CONSOLE MONITOR V1.0
TEM>
```

and the console monitor is ready to accept your input.

The following default conditions are set when the console monitor is started:

1. The stack pointer is set to 6500
2. The PASS2, NOHOST, INSTRU, SYMBOL, and VTOFF operating modes are set.

More information about the stack pointer is given in Paragraph 5.2.1. The operating modes are described in detail elsewhere in this chapter and are summarized in Paragraph 4.18.

4.2 TRANSFERRING CONTROL BETWEEN THE CONSOLE TERMINAL AND THE KEYPAD

Either the console or the keypad can control the DCT11-EM, but not both at the same time.

From the keypad, your primary means of transferring control to the console is by activating function 2 (see Paragraph 3.12.3). You can regain keypad control by pressing the HALT switch. When you press the HALT switch, DCT11-EM operation is stopped and the LEDs display the current PC.

From the console, you can transfer control back to the keypad by typing in the EXIT command or by executing a HALT instruction.

4.3 GENERAL RULES FOR CONSOLE INPUT

Information you input via the console terminal is typically in the form of commands, instructions, or data.

In general, your input should conform with the following guidelines.

1. Your input line must not exceed 96 characters in length. If you exceed this limit, the console terminal does not accept further input until you type in a CTRL/C or CTRL/Y. Then, you must reinput the line.

2. Any number of commands and instructions can be strung together on a line as long as the line does not exceed 96 characters.

3. Commands or instructions strung together on a line should be separated with a space or a comma. Extra separation characters (space, tab, line feed, form feed) between commands or instructions on a line are ignored.

4. If a command or an instruction in a one-line string causes an error, the commands or instructions following it are ignored.

5. Extra separation characters (space, tab, line feed, form feed) inserted between parts of a command or instruction are ignored.

6. Information preceded by a semicolon on a line is interpreted as a comment and is ignored by the DCT11-EM.

7. Pressing the DELETE key deletes characters on a line. As characters are deleted, they are echoed (preceded by a slash character) on the console terminal if you are in VTOFF mode. The console monitor defaults to VTOFF mode when it is started or restarted. Type in the VTON command if you are using a video terminal as a console device. VTON mode eliminates the echoing of deleted characters. Typing in VTOFF returns you to VTOFF mode from VTON mode.

8. A line is terminated by pressing the RETURN key. Characters on a line are ignored until you press RETURN. In all the examples in this chapter, a RETURN is used to end your input line unless otherwise noted.

A summary of the various forms of acceptable console input is given in Paragraph 4.18. Information about specific commands and instruction formats is given elsewhere in this chapter.

4.4 CONSOLE CONTROL COMMANDS

The DCT11-EM recognizes several control commands that allow you to easily perform a variety of operations from the console terminal. These commands and their typical uses are listed in Table 4-1.

Table 4-1 Control Command Summary

Command	Meaning	Typical Use
CTRL/U CTRL/X	Delete line.	You made several typing errors in your input line. You want to cancel the line and try again.
CTRL/R	Display line.	You used the DELETE key several times while typing your input line. You want to see a clean version of the line you are editing.
CTRL/S	Suspend execution.	You want to suspend the operation of the console monitor or the execution of a currently running program.
CTRL/Q	Resume execution.	You have previously used the CTRL/S command and want to resume operation.
CTRL/C CTRL/Y	Abort operation.	You want to abort the current operation of the DCT11-EM and input a new line.
CTRL/O	Ignore host message.	You are in HOST mode (see Paragraph 4.17.1) and want to ignore information currently being sent by your host computer.
CTRL/A	Select option.	You are in TALK or LOAD modes (see Paragraphs 4.17.3 and 4.17.4) and want to select one of these four options: exit, resume, send break, send CTRL/A.

4.5 EXPRESSIONS

Several commands and instructions accept expressions as parameters. This paragraph familiarizes you with expressions and provides the rules for their definition.

If you wish to ignore the use of expressions for the moment, you can advance to the paragraph that describes the command or function you are interested in. You can return to this paragraph when you need more detail on how to define an expression for a particular command or instruction.

An expression is simply a user-definable combination of one or more components called terms that represents a 16-bit number. There are three types of terms allowable in a DCT11-EM expression:

- Numeric
- Literal
- Symbolic

Numeric terms are either octal or decimal numbers. Octal numbers can be any sequence of the digits 0 through 7. Decimal numbers can be any sequence of the digits 0 through 9 followed by a decimal point (.). Do not attempt to define decimal fractions.

Examples of Numeric Terms

```
100702
377
39874.
```

A literal term is an ASCII character you use as data. Precede an ASCII character with an apostrophe (') to form a literal term.

Examples of Literal Terms

```
'E
'*
'4
```

Symbolic terms are values symbolized by names which are defined according to the rules in Paragraph 4.13.

Examples of Symbolic Terms

```
R1
P$PORC
SUM
```

Terms are joined together in an expression by binary operators. (The word binary in this case means that at least two terms are involved.) The DCT11-EM allows six types of binary operators:

```
+ (addition)
- (subtraction)
* (multiplication)
/ (division)
& (logical AND)
! (logical OR)
```

The unary (one term) operators, + (plus sign) and − (minus sign), can only be used at the beginning of an expression (or parenthesized term). Multiple unary operators are not valid.

Expressions are evaluated from left to right with no operator hierarchy rules. Two types of brackets can be used to nest expressions up to seven levels deep. Use angle brackets (< >) as you would arithmetic parentheses and use square brackets ([]) if you want the DCT11-EM to substitute the enclosed information with the contents of the memory word it addresses. Note that if the information in square brackets represents an odd address, it is first rounded down.

A quick way to evaluate the octal value of an expression is to type in the expression followed by a question mark. This command has the form:

expression?

Expressions – Examples
The following are examples of valid DCT11-EM expressions. You can verify the octal values of these expressions by using the question mark command.

Expression	Octal Value
65209	177271
7077+189.+'E	007501
−2*<300/25>+70	000046
120.*<−8.>	176100
177777&25+3	000030

4.6 EXAMINING REGISTERS

There are two ways to examine registers. One way is to type in the appropriate register symbol followed by a question mark. This command has the general format:

register symbol?

where the register symbol (R0, R1, etc.) is as defined in Paragraph 4.13.1.

Another way to examine registers is to type in the SHOWRE command. The SHOWRE command displays the values of all the registers and the PS in ascending order. If a watchpoint has been set, it is also displayed. Paragraph 4.14.1, which describes program debugging, gives you an illustration of the SHOWRE command.

4.7 ALTERING REGISTERS

Registers are altered by using an equal sign to set the register to the desired value. The general format for this is:

register symbol=expression

where the register symbol (R0, R1, etc.) is as defined in Paragraph 4.13.1 and the register is set to the value of the expression. (See Paragraph 4.5 for expression formats and conventions.)

Altering Registers – Example
Alter and examine the values of R0 and the SP.

```
TEM> R0=65.
TEM> SP=6500
TEM> R0? SP?
000101
006500
TEM>
```

4.8 EXAMINING AND ALTERING MEMORY LOCATIONS – INTRODUCTORY CONCEPTS

There are several ways to examine and alter memory locations. Before discussing the specific techniques, there are some introductory concepts you should be familiar with.

4.8.1 The Address Pointer

The address pointer specifies your current *open location,* i.e., the address of the location currently available to you for alteration. It is important to keep track of the address pointer because it determines where in memory you deposit information. As you will discover later, most commands which alter and examine memory locations are closely linked to the value of the address pointer. This paragraph gives an overview of how the address pointer can be affected.

Since the DCT11-EM recognizes a period (.) as the symbol for the address pointer, you can manipulate the value of the address pointer just as you would any other symbol (see Paragraph 4.13.2). For example, to set the value of the address pointer use an equal sign:

.=expression

where the value of the address pointer is determined by the expression (see Paragraph 4.5). To determine the current value of the address pointer, use a question mark:

.?

Another way to set the address pointer is to use the backslash (\) character. The general format for a backslash command is:

expression\

where the value of the address pointer is determined by the expression. This command also displays the memory location specified by the expression (see Paragraph 4.9).

There are two other commands which affect the address pointer. These commands are the caret (^) command and the RETURN (or null line input) command. The effects of these commands depend upon which output format mode the DCT11-EM is in (see Paragraph 4.8.2). A description of their effects is given in Paragraphs 4.9 and 4.10.

When you type in a program, the DCT11-EM automatically increments the address pointer for each instruction or data object you input. Note that whenever you power up, the address pointer is initialized to zero.

Do not confuse the address pointer with the PC (program counter). They are unrelated. As you type in a program, the address pointer is incremented, but the PC is unaffected. And the execution of a program will affect the PC but not necessarily the address pointer.

4.8.2 Output Formatting Modes

When you examine memory locations, the values the DCT11-EM displays on the console depend upon your current output formatting mode. There are five output formatting modes: INSTRU, WORD, BYTE, SYMBOL, and ABSOLU.

The INSTRU (or instruction disassembly) mode causes memory locations to be displayed as disassembled DCT11-AA instructions. INSTRU is one of the modes that the DCT11-EM is initalized to when you power up.

The WORD and BYTE modes cause memory locations to be displayed octally. Set the WORD mode (by typing in the WORD command) if you want the values of memory locations to be displayed as 16-bit words. Set the BYTE mode (by typing in the BYTE command) if you want the values of memory locations to be displayed as individual bytes. If you are in WORD or BYTE mode, type in the INSTRU command to return to instruction disassembly mode. Notice that the INSTRU, WORD, and BYTE commands are mutually exclusive. To summarize:

Mode	Memory Locations Are Displayed As
INSTRU	Disassembled DCT11-AA instructions
BYTE	8-bit octal bytes
WORD	16-bit octal words

Odd addresses (i.e., upper bytes) can only be examined in BYTE mode. If you try to examine an odd address in INSTRU or WORD mode, an error message results.

The SYMBOL and ABSOLU modes determine how the symbols you have defined in your program are to be displayed. You will usually use SYMBOL and ABSOLU in conjunction with instruction disassembly (INSTRU) mode.

If your program contains user-defined symbols (see Paragraph 4.13), these symbols will be displayed only if you are in SYMBOL mode. SYMBOL is one of the modes the DCT11-EM is initialized to when you power up.

If you want user-defined symbols to be displayed as octal values, type in the ABSOLU command to set the ABSOLU mode. Typing in SYMBOL restores the SYMBOL mode. Note that SYMBOL and ABSOLU are mutually exclusive. To summarize:

Mode	User-Defined Symbols Are Displayed As
SYMBOL	Symbols
ABSOLU	Octal values

4.9 EXAMINING MEMORY LOCATIONS

This paragraph summarizes the commands with which you can examine memory locations. The examples in this paragraph are intended to give you a general idea of what to expect when you use these commands in different output formatting modes.

One way to examine a memory location is to type in the desired memory location followed by a backslash. The general format for this command is:

```
expression\
```

where the memory location you examine is determined by the value of the expression (see Paragraph 4.5). The backslash command also sets the address pointer, so a location examined with a backslash becomes the current open location.

Examining Memory Locations – Example 1
Use the backslash command to examine a memory location. Try this in different output formatting modes. You have not altered any memory locations from their initial (power-up) values.

```
TEM> WORD
TEM> 2000\
002000: 000000
TEM> 100\
000100: 135676
TEM> BYTE
TEM> 100\
000100: 276
TEM> INSTRU
TEM> 140000\
140000: JMP   155334
140004:
TEM>
```

Examining Memory Locations – Example 2
You use the backslash command to try to examine location 1001 without first typing in the BYTE command. This causes an error message to be generated.

```
TEM> INSTRU
TEM> 1001\
001001:
\\\
ODD ADDRESS
TEM>
```

Another way to examine memory locations is to simply press the RETURN key. When you press the RETURN key as a command input, the result depends on both your output formatting mode and the value of the address pointer. If you are in INSTRU mode, RETURN displays the next eight instructions relative to the address pointer. In WORD mode, the contents of the next eight words relative to the address pointer are displayed. In BYTE mode, the contents of the next eight bytes relative to the address pointer are displayed. Note that the RETURN command is ignored when you are loading a program from a host computer (see Paragraph 4.17).

Examining Memory Locations – Example 3

You want to examine memory locations by pressing the RETURN key. You have not altered these locations since you have powered up. Start with location 1000.

```
TEM> INSTRU
TEM> 1000\
001000: HALT
001002:
TEM>
001000: HALT
001002: HALT
001004: HALT
001006: HALT
001010: HALT
001012: HALT
001014: HALT
001016: HALT
001020:
TEM> WORD
TEM>
001000: 000000    000000  000000  000000  000000  000000  000000  000000
TEM>
001020: 000000    000000  000000  000000  000000  000000  000000  000000
TEM> BYTE
TEM>
001020: 000       000     000     000     000     000     000     000
TEM>
001030: 000       000     000     000     000     000     000     000
TEM>
```

A one-line string of bytes or words is numbered from left to right.

Note that consecutive RETURN keypresses increment the address pointer but nonconsecutive ones do not. For example, in WORD mode you incremented the address pointer from 1000 to 1020 by pressing RETURN twice in a row. In BYTE mode you incremented the address pointer from 1020 to 1030 by pressing RETURN twice in a row. Pressing RETURN only once (as you did in INSTRU mode) had no effect on the address pointer.

A way to examine a range of memory locations is to use the underscore (_) character. The general format for this command is:

```
expression1_expression2
```

where the beginning of the range is determined by the value of expression1 and the end of the range is determined by the value of expression2. See Paragraph 4.5 for expression formats.

Expression1 should be less than expression2. If it is not, only one location is displayed: the beginning of range location.

The use of the underscore command has no effect on the address pointer.

Examining Memory Locations – Example 4
You want to examine groups of memory locations by using the underscore command. Try this command in INSTRU, WORD, and BYTE modes. These memory locations have not been altered since you have powered up.

```
TEM> INSTRU
TEM> 2000\
002000: HALT
002002:
TEM> 1004_1012
001004: HALT
001006: HALT
001010: HALT
001012: HALT
001014:
TEM> WORD
TEM> 1002_1006
001002: 000000      000000    000000
TEM> BYTE
TEM> 1005_1020
001005: 000         000       000       000       000       000       000       000
001015: 000         000       000       000
TEM> INSTRU
TEM>
002000: HALT
002002: HALT
002004: HALT
002006: HALT
002010: HALT
002012: HALT
002014: HALT
002016: HALT
002020:
TEM>
```

Notice that the address pointer value of 2000 which was set at the beginning of the example is still 2000 at the end of the example.

4.10 ALTERING MEMORY LOCATIONS

You can deposit data into a memory location by setting the address pointer to the address of the location you wish to alter and typing in the information. The address pointer is automatically incremented as you deposit instructions and data to consecutive memory locations (as when you type in a program, for example).

If you make an error during data entry, you can use the caret (^) command to decrement the address pointer and retype the input line. In INSTRU and WORD modes, the address pointer is decremented by one word for each caret command, and in BYTE mode it is decremented by one byte for each caret command.

Altering Memory Locations – Example 1
You type in a short program starting at address 1000. You make an error while typing in the program and use the caret (^) command to help you correct the error. You then examine the program. The program adds R1 to R2 and places the result in R3. The final line restarts the console monitor so that you will get a TEM> prompt after you execute the program.

```
                                        Comments
TEM> INSTRU
TEM> .=1000
TEM> MOV R1,R3
TEM> ADD R2,R4                          ;you really wanted to type ADD R2,R3
TEM> ^                                  ;decrement address pointer by one word
TEM> ADD R2,R3                          ;type in correct line
TEM> JMP @#140010                       ;continue typing in program
TEM> 1000\                              ;now examine your program
001000: MOV             R1,R3
001002:
TEM>
001000: MOV             R1,R3
001002: ADD             R2,R3
001004: JMP             @#140010
001010: HALT
001012: HALT
001014: HALT
001016: HALT
001020:
001022:
TEM>
```

Altering Memory Locations – Example 2
You type in some data starting at location 2000. You type several values on a line, remembering to include separation characters (in this case, spaces) between them. You then examine the data you have typed in.

```
                                        Comments
TEM> .=2000
TEM> 1 2 3 4                            ;type in four data values
TEM> .?                                 ;the address pointer is incremented
002010
TEM> .=2000                             ;reinitialize the address pointer
TEM> WORD
TEM> .__.+10                            ;examine the data
002000: 000001  000002  000003  000004  000000
TEM>
```

4.11 INSTRUCTION FORMAT

This paragraph provides some guidelines for formatting instructions for input to the DCT11-EM. A complete description of the instruction set is found in the *DCT11-AA User's Guide* (EK-DCT11-UG).

An acceptable instruction consists of the instruction mnemonic followed by the appropriate string of operands (if any). A separation character (space, tab, feed) must be used to separate a mnemonic from its first operand (if any). A comma must appear between two operands in a two-operand instruction.

Expressions can be used as operands, if desired. Refer to Paragraph 4.5 for expression formats.

If you wish, you may enter your instructions in octal format, rather than in assembly language format. Refer to Chapter 6 of the *DCT11-AA User's Guide* for information on constructing octal equivalents of instructions.

4.12 TYPING IN A PROGRAM

Set the address pointer to 2000 and type in the summation program from Paragraph 3.8 as shown below.

```
TEM> .=2000
TEM> CLR R1
TEM> CMP R0,R1
TEM> BLE 2034
TEM> CLR @#2044
TEM> MOV R0,@#2044
TEM> DEC R0
TEM> ADD R0,@#2044
TEM> BVS 2036
TEM> CMP R0,R1
TEM> BGT 2016
TEM> HALT
TEM> CLR R0
TEM> CLR @#2044
TEM> HALT
TEM>
```

Now verify you have typed in the program correctly by setting the address pointer to 2000 and repeatedly pressing the RETURN key. If you are in INSTRU mode, the following will be displayed.

```
TEM> .=2000
TEM>
002000: CLR         R1
002002: CMP         R0,R1
002004: BLE         002034
002006: CLR         @#002044
002012: MOV         R0,@#002044
002016: DEC         R0
002020: ADD         R0,@#002044
002024: BVS         002036
002026:
TEM>
002026: CMP         R0,R1
002030: BGT         002016
002032: HALT
002034: CLR         R0
002036: CLR         @#002044
002042: HALT
002044: HALT
002046: HALT
002050:
TEM>
```

The address pointer is automatically incremented each time you type in an instruction.

You may want to use symbolic names to represent values such as 2044 (the location of the accumulated sum) to increase the readability of the program. The next few paragraphs tell you how to define and manipulate symbols.

If you want to execute the program and learn how to use the DCT11-EM's console debugging facilities, advance to Paragraph 4.14.

4.13 USING SYMBOLS

The DCT11-EM allows you to define symbols in your programs. This paragraph describes the formats required for DCT11-EM symbols and explains the use of the commands which allow you to define and manipulate symbols.

4.13.1 Symbol Names

The following characters may be used in symbol names.

A through Z
0 through 9
. (Period)
$ (Dollar sign)

A symbol name must not begin with 0 through 9, however.

A symbol name may have any length; however, only the first six characters are stored by the DCT11-EM. Thus, to avoid ambiguities, make the first six characters of your symbol names unique.

The following predefined symbol names are reserved.

R0	Register 0
R1	Register 1
R2	Register 2
R3	Register 3
R4	Register 4
R5	Register 5
SP	Stack pointer (register 6)
PC	Program counter (register 7)
PS	Processor status word
WP	Watchpoint address
.	Address pointer
B1	Breakpoint 1
B2	Breakpoint 2
B3	Breakpoint 3
B4	Breakpoint 4

These predefined symbols must not be used as user-defined symbol names, although they can be used as arguments in expressions, instructions, or commands.

DCT11-EM directives, commands, and DCT11-AA instruction mnemonics (e.g., MOV, ADD, JMP) are also reserved and must not be used as symbol names.

4.13.2 Commands That Define And Manipulate Symbols

There are two ways you can define a symbol. One way is to use the equal sign (=) to equate a symbol to a specific value. The general format of this is:

```
symbol=expression
```

where the value of the symbol is determined by the expression.

The other way of defining a symbol is to use a colon (:). The colon defines a symbol as the label of the current address. The general format of this is:

```
symbol:
```

where the value of the symbol is defined as the value of the address pointer.

Once you have defined a symbol, you cannot redefine it unless you first delete it. Symbol deletion is accomplished with the DELETE command. This command has the general format:

```
DELETE symbol
```

where the name of the symbol you wish to delete follows the command. The DELETE command causes the DCT11-EM to display the symbol and its value as it performs the deletion.

Predefined symbols (see Paragraph 4.13.1) cannot be deleted with the DELETE command. Predefined symbols can be redefined, however, by using the equal sign.

When you define a symbol, it is stored in an area called the user symbol table. There is sufficient space in the user symbol table to store up to 66 symbols. If you try to define more than 66 symbols, you will cause an error message to be generated.

If you want to display your user symbol table, type in the SHOWSY command. The symbols are displayed in the order in which you defined them, starting with the most recently defined symbol.

If you want to delete your entire symbol table, type in the CLEAR command. The CLEAR command is typically used at the beginning of a long program or a program you are loading in from a host computer (see Paragraph 4.17). CLEAR gives the program plenty of room in the symbol table for symbols and avoids conflicts between symbol names in the program and any symbol names you may have previously defined.

If you want to display the value of an individual symbol, type in the symbol followed by a question mark (?). The general format for this is:

```
symbol?
```

Defining and Manipulating Symbols – Example 1
You set the address pointer to 1000 and define the symbols FIRST, SECOND, and THIRD. You experiment with displaying and deleting these symbols.

```
TEM> CLEAR
TEM> .=1000
TEM> FIRST:
TEM> SECOND=FIRST+100
TEM> THIRD=SECOND+300
TEM> SHOWSY
THIRD = 001400
SECOND= 001100
FIRST = 001000
TEM> DELETE FIRST
FIRST = 001000
TEM> SHOWSY
THIRD = 001400
SECOND= 001100
TEM> CLEAR
TEM> SHOWSY
TEM>
```

SECOND is set equal to 1100 because FIRST equals 1000 at the time of definition. If you delete FIRST after you delete SECOND SECOND will be unaffected.

4.14 EXECUTING AND DEBUGGING PROGRAMS

Refer to the summation program you typed in (Paragraph 4.12). You will make some minor changes to this program and use the DCT11-EM's debugging facilities to observe its operation.

First, replace memory location numbers with symbolic names (see Paragraph 4.13).

```
TEM> ILLIN=2034
TEM> SUM=2044
TEM> OVFLO=2036
TEM> LOOP=2016
TEM>
```

Instead of having the program HALT when it completes execution (which returns control to the keypad), you want it to restart the console monitor and give you a TEM> prompt. You do this by placing a JMP @#140010 instruction at location 2032 which restarts the console monitor when executed.

```
TEM> .=2032
TEM> JMP @#140010
TEM>
```

Now set your initial conditions as follows.

```
TEM> R0=100
TEM> PC=2000
TEM> SP=6500
TEM>
```

Then execute the program by typing in the GO command.

```
TEM> GO
TEM>
```

To check the result, examine SUM.

```
TEM> SUM\
SUM   : 004040
TEM>
```

This is the correct sum in octal of the numbers from 0 to 100 (octal).

4.14.1 Using The Watchpoint

The DCT11-EM recognizes WP as the symbol for the watchpoint. Set the watchpoint address by using the equal sign command. The general format for this is:

```
WP=expression
```

where the watchpoint address is determined by the value of the expression.

For example, to monitor the accumulated sum in your program, set your watchpoint at the location SUM.

```
TEM>WP=SUM
TEM>
```

Now reset your initial conditions (set R0=100) and execute the program. After you receive the TEM> prompt, use the SHOWRE command to examine your registers.

```
TEM> SHOWRE
R0      = 000000
R1      = 000000
R2      = 000000
R3      = 000000
R4      = 000000
R5      = 000000
SP      = 006500
PC      = 002000
PS      = 000004
SUM      : 004040
TEM>
```

Notice your watchpoint appears as well. Another way to examine the watchpoint is to use the question mark command. WP? displays numerically the watchpoint address. [WP]? displays numerically the watchpoint contents.

```
TEM> WP?
002044
TEM> [WP]?
004040
TEM>
```

The watchpoint can be cleared by setting it to zero or by typing in the CANCEL command, which not only clears the watchpoint but the breakpoints as well.

4.14.2 Using the Single-Step Function

Single stepping is accomplished by typing in the STEP command. STEP executes the instruction at the current PC and displays: (1) the new values of your registers and watchpoint, and (2) the next instruction to be executed.

To experiment with the STEP command, reset the initial conditions for your program (set R0=100) and type in STEP. You can then continue single stepping by repeatedly pressing the RETURN key.

```
TEM> STEP
R0     = 000100
R1     = 000000
R2     = 000000
R3     = 000000
R4     = 000000
R5     = 000000
SP     = 006500
PC     = 002002
PS     = 000024
SUM    : 004040
002002 : CMP   R0,R1
002004 :
TEM>
R0     = 000100
R1     = 000000
R2     = 000000
R3     = 000000
R4     = 000000
R5     = 000000
SP     = 006500
PC     = 002004
PS     = 000020
SUM    : 004040
002004 : BLE   ILLIN
002006 :
TEM>
R0     = 000100
R1     = 000000
R2     = 000000
R3     = 000000
R4     = 000000
R5     = 000000
SP     = 006500
PC     = 002006
PS     = 000020
SUM    : 004040
002006 : CLR   @#SUM
002012 :
TEM>
R0     = 000100
R1     = 000000
R2     = 000000
R3     = 000000
R4     = 000000
R5     = 000000
```

```
SP     = 006500
PC     = 002012
PS     = 000024
SUM    : 000000
002012 : MOV   R0,@#SUM
LOOP   :
TEM>
R0     = 000100
R1     = 000000
R2     = 000000
R3     = 000000
R4     = 000000
R5     = 000000
SP     = 006500
PC     = LOOP
PS     = 000020
SUM    : 000100
LOOP   : DEC   R0
002020 :
TEM>
R0     = 000077
R1     = 000000
R2     = 000000
R3     = 000000
R4     = 000000
R5     = 000000
SP     = 006500
PC     = 002020
PS     = 000020
SUM    : 000100
002020 : ADD   R0,@#SUM
002024 :
TEM>
R0     = 000077
R1     = 000000
R2     = 000000
R3     = 000000
R4     = 000000
R5     = 000000
SP     = 006500
PC     = 002024
PS     = 000020
SUM    : 000177
002024 : BVS   OVFLO
002026 :
TEM>
```

The program is functioning properly; R0 is getting decremented and added to SUM.

4.14.3 Using Breakpoints

The use of breakpoints with a console terminal is similar to the use of breakpoints with the keypad (see Paragraph 3.8.2).

The DCT11-EM recognizes B1, B2, B3, and B4 as the symbols for the four breakpoints. Set a breakpoint by using the equal sign command. The general format for this is:

```
breakpoint symbol=expression
```

where the breakpoint is determined by the value of the expression.

For example, to set breakpoints at locations 2020 and 2024 in the summation program (as you did with the keypad), type in:

```
TEM> B1=2020
TEM> B2=2024
TEM>
```

Now reset your initial conditions (set R0=100, PC=2000) and execute the program.

```
TEM> GO
BREAK POINT ENCOUNTERED
002020: ADD   R0,@#SUM
002024:
TEM>
```

You get a message which indicates that your first breakpoint (B1) was encountered by the console monitor. To determine the current state of your program, type in the SHOWRE command.

```
TEM> SHOWRE
R0  = 000077
R1  = 000000
R2  = 000000
R3  = 000000
R4  = 000000
R5  = 000000
SP  = 006500
PC  = 002020
PS  = 000000
SUM : 000100
TEM>
```

You see that R0 has been correctly decremented. When you type in GO again:

```
TEM> GO
BREAK POINT ENCOUNTERED
002024: BVS   OVFLO
002026:
TEM>
```

the console message appears (this time because of B2), and you again examine the state of your program.

```
TEM> SHOWRE
R0   = 000077
R1   = 000000
R2   = 000000
R3   = 000000
R4   = 000000
R5   = 000000
SP   = 006500
PC   = 002024
PS   = 000000
SUM  : 000177
TEM>
```

You see that the first addition was performed correctly. You can continue to observe the operation of the program by typing in the GO and SHOWRE sequence as just shown.

To examine a breakpoint, type in B1?, B2?, B3?, or B4?. Breakpoints can be cleared by setting them to zero or by typing in the CANCEL command, which not only clears the breakpoints but the watchpoint as well.

4.15 DCT11-EM DIRECTIVES

As a convenience for users who are familiar with assemblers (and in particular the PDP-11 MACRO-11 assembler), the DCT11-EM recognizes several directives which are similar to those used in the MACRO-11 language. These directives are listed in Table 4-2 with a brief explanation of their operation. For detailed information about how to use these directives in your programs, refer to the *PDP-11 MACRO-11 Language Reference Manual* (AA-5075A-TC).

Table 4-2 DCT11-EM Directives

Directive Form	Operation
ASCII /string/	Generates a block of data containing the ASCII equivalent of the character string (enclosed in delimiting characters), one character per byte. The delimiting characters can be slashes or any other visible character. The ASCII code for each character is stored in successive bytes of memory starting at the location indicated by the current address pointer. The address pointer is advanced by the length (in characters) of the enclosed string.
BLKB expr	Reserves a block of storage space whose length in bytes is determined by the specified expression. The current address pointer is advanced by the value of the expression.
BLKW expr	Reserves a block of storage space whose length in words is determined by the specified expression. The current address pointer is advanced by two times the value of the expression.
BYTE expr1, expr2, . . .	Generates successive bytes of data; each byte contains the value of the corresponding specified expression. The lower eight bits of each expression are stored in successive bytes of memory, starting at the location indicated by the current address pointer. The address pointer is advanced by the number of expressions given. The last expression must not be followed by a comma.
EVEN	Ensures that the current address pointer contains an even address by adding 1 if it is odd.
WORD expr1, expr2, . . .	Generates successive words of data; each word contains the value of the corresponding specified expression. The value of each expression is stored in successive words of memory starting at the location indicated by the current address pointer. The address pointer is advanced by two times the number of expressions given. The last expression must not be followed by a comma.

4.16 MISCELLANEOUS CONSOLE FUNCTIONS

The DCT11-EM has a HELP facility which displays all the commands available to you. To invoke this facility, type in HELP.

You can display the current operating modes of the DCT11-EM by typing in the SHOWMO command. When you first power up, typing in the SHOWMO command displays the default operating modes:

```
PASS2  NOHOST  INSTRU  SYMBOL  VTOFF
```

The operating modes that can be displayed are: PASS1, PASS2, HOST, NOHOST, INSTRU, WORD, BYTE, SYMBOL, ABSOLU, VTON, and VTOFF. See the command summary in Paragraph 4.18 for brief descriptions of these modes. The command summary also contains references to paragraphs that explain the modes in detail.

The DCT11-EM has a REPEAT function which allows you to repeatedly input a line of commands or instructions. The form of this command is:

```
REPEAT expression,input line
```

where the input line is executed the number of times specified by the value of the expression. One application of the REPEAT command is to fill memory. For example, the REPEAT 1000,NOP command will fill 1000 (octal) locations with NOP instructions. The REPEAT command also lets you single step without having to press the RETURN key repeatedly (see Paragraph 4.14.2). The REPEAT 7, STEP command, for example, single steps through your program seven times.

Repeat Command – Example
A third application of the REPEAT command is to move blocks of memory. You must specify the beginning and ending addresses of the range to be moved (the source range) and the beginning address of the destination range. The general format for a command sequence which moves a block of memory is:

```
TEM> .=destination
TEM> REPEAT <end-start>/2+1,[.+start-destination]
```

where start and end are the beginning and ending addresses (respectively) of the source range, and destination is the beginning address of the destination range. Both ranges must begin at even addresses, and only words of memory can be transferred.

For example, if you want to move the contents of locations 1000 through 1010 to 2030 through 2040, type in the following.

```
TEM> .=2030
TEM> REPEAT <1010-1000>/2+1,[.+1000-2030]
```

4.17 LOADING THE DCT11-EM FROM A HOST COMPUTER

This paragraph describes how to load information (usually a program) from a host computer into your DCT11-EM. Two broad areas are covered. First, you are familiarized with the console monitor commands that initiate and control the host loading process. Second, you are shown how to prepare a DCT11-EM loadable program on your host.

4.17.1 Configuring the DCT11-EM for Host Loading

Since host loading is accomplished through the use of console monitor commands, you must have your DCT11-EM connected to a console terminal.

Your host computer must have a serial communication line capable of sending data to the DCT11-EM in ASCII text format. Connect the serial line from the host to the DCT11-EM auxiliary serial port connector (J3) as shown in Figure 4-2.

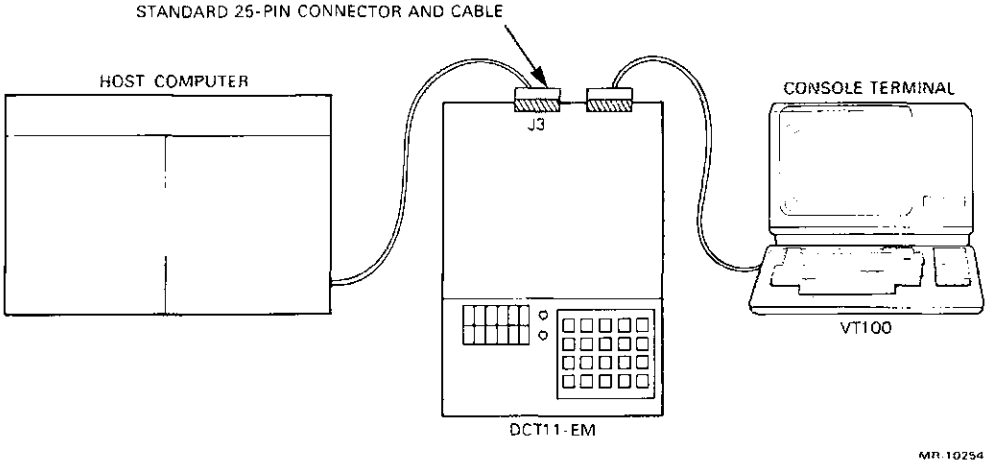


Figure 4-2 Connecting a Host Computer to the DCT11-EM

No other wiring or jumpering is required. Set the baud rate of your console terminal equal to the baud rate of your host line. Use the DCT11-EM keypad to set the same baud rate for the console serial port by activating function 3 as described in Paragraph 3.12.4. Also make sure you are set up to transmit and receive characters in the following format: asynchronous, ASCII, 8 bits (eighth bit is always space), no parity, one stop bit.

You need not set the baud rate of the auxiliary serial port. When you communicate with a host, the DCT11-EM automatically sets the baud rate of the auxiliary serial port equal to the baud rate of the console serial port.

Activate function 2 as described in Paragraph 3.12.3 to start the console monitor. When the console displays a prompt, type in:

```
TEM> HOST
```

The HOST command places you in HOST mode and is a prerequisite for performing any operation with a host computer.

HOST mode only allows you to receive messages from the host. If you want to communicate directly with the host, use the TALK command in addition to HOST. If you want to load information from the host, use the LOAD command in addition to HOST. The TALK and LOAD commands are explained in Paragraphs 4.17.3 and 4.17.4.

The NOHOST command cancels HOST mode.

4.17.2 The HOST Command

Typing in the HOST command has two effects:

1. It defines the auxiliary serial port as a host communication line.
2. It creates an input buffer to hold information received from the host.

A HOST> prompt precedes any messages you receive from your host while in HOST mode.

Host Mode – Example

You are in HOST mode and you receive a message from the host before you finish typing an input line. If you simply continue typing the line, the console monitor restores the interrupted line and appends your new material to it. Messages from the host are ignored as console input.

```
                                    Comments
TEM> HOST
TEM> MOV R0,R1
TEM> MOV R                          ;You were typing MOV R0,R2
HOST>
This is a message from the host...
TEM> MOV R0,R2                      ;You type 0,R2 and the previous line is restored.
TEM>
```

4.17.3 The TALK Command

Typing in the TALK command allows you to communicate directly with the host just as if the DCT11-EM were not there. It has the same effect as connecting the serial line from the host directly to your console terminal.

Typically, you might use the TALK mode to prepare a DCT11-EM loadable file with your host's editing facilities (see Paragraph 4.17.5).

The user LED is illuminated in TALK mode.

There are two ways to cancel TALK mode. One way is to press the BREAK key on the console. The DCT11-EM responds:

```
CONSOLE BREAK
TEM>
```

and you not only cancel TALK mode but HOST mode as well. The other way is to type in CTRL/A. The DCT11-EM responds:

```
E (EXIT), R (RESUME), B (SEND BREAK), ^ A (SEND ^A) ?
```

If you type in the letter E, TALK mode is canceled but HOST mode is not.

Note that typing in CTRL/A (^A) in TALK mode gives you three other options. You can send a break or CTRL/A character to the host by typing in B or CTRL/A, respectively. Typing in an R or any characters other than E, B, or CTRL/A, causes TALK mode to be resumed.

4.17.4 The LOAD Command

Use the LOAD command only after you have prepared a DCT11-EM loadable program on your host as explained in Paragraph 4.17.5.

Typing in the LOAD command allows you to communicate directly with the host just as the TALK command does. In LOAD mode, however, the DCT11-EM constantly monitors the characters received from the host and begins loading if it sees the .START directive.

To initiate host loading while in LOAD mode, therefore, simply enter a command (which depends on the particular host you are using) that types out your program on the console terminal. For example, if you were using a VAX/VMS host, you would use TYPE PROG.TXT to type out the file PROG.TXT on your terminal. Since your DCT11-EM loadable program always has the .START directive as its first line, typing the program causes the DCT11-EM to start loading.

NOTE

During the loading process, the DCT11-EM accepts input from both serial ports simultaneously. As a rule, do not press keys on the console terminal during loading since this interferes with your host's input. The only exception to this rule is the use of the CTRL/O command (see below).

Once loading begins, it continues until the .END directive is received or until an error in the incoming program is detected. In both cases, when loading stops, you are returned to HOST mode. If loading stops as a result of an error in your program, the portion of the program that follows the error will be displayed on your console terminal as a "message" from the host.

If loading is terminated by an error in your program, you can suppress further display of the program by typing in the CTRL/O command. CTRL/O causes the DCT11-EM to ignore messages from the host until you press the RETURN key. If you want to terminate output from the host, enter CTRL/O followed by the TALK command followed by the appropriate interrupt control sequence your host recognizes (such as CTRL/Y or CTRL/C).

Note that the user LED is illuminated in LOAD mode. Also note that pressing BREAK or typing in CTRL/A has the same effect in LOAD mode as in TALK mode.

4.17.5 Preparing DCT11-EM Loadable Programs on a Host

In general, you will find it convenient to use your host's editing facilities to create programs. This is particularly true if the programs are long or require extensive alteration. In order to prepare a program the DCT11-EM will accept, keep the following in mind.

Make sure the .START directive precedes your program. The DCT11-EM will not be able to load your program unless it first sees the .START directive.

Next, realize that when your program is loaded into the DCT11-EM, the DCT11-EM will behave as if each line of your program were being entered by you directly from the console terminal. This means that the rules and conventions of console monitor input apply also to each line of the program you create on your host. The one exception is that the null line command (i.e., pressing RETURN to examine successive memory locations) is disabled during host loading.

If your program contains undefined symbols or expressions (for example, a "forward reference"), prepare your program as two identical segments. Precede the first segment with the PASS1 command and the second segment with the PASS2 command. The idea behind the PASS1 and PASS2 commands is as follows.

Normally, the DCT11-EM does not allow you to input undefined symbols. This mode of operation is called the PASS2 mode (PASS2 is one of the power-up default modes of the DCT11-EM). The use of undefined symbols in your programs, however, is commonly desirable. For example, consider the following program segment.

```
CMP #177700,R1
BNE .+14
INC R2
CMP R2,#200
BLO .+4
CLR R2
MOV R2,R3
```

In this example, you are branching to a defined location (i.e., the location that contains the MOV R2,R3 instruction), but are doing so in a cumbersome way. You need to perform a calculation for each branching instruction. An easier way to write this program segment would be:

```
        CMP #177700,R1
        BNE THERE
        INC R2
        CMP R2,#200
        BLO THERE
        CLR R2
THERE:  MOV R2,R3
```

But if the DCT11-EM is in a mode in which it rejects undefined symbols, an error results when you try to input BNE THERE.

The DCT11-EM solves this problem by having a mode of operation in which undefined symbols are tolerated called the PASS1 mode.

In the PASS1 mode, the DCT11-EM substitutes the value zero for each undefined symbol encountered in expressions except when the undefined symbol is the operand of a branch instruction. In that case, the value of the current address pointer is substituted for the value of the branch operand. If an undefined symbol is later defined through the use of an equal sign (=) or colon (:), the symbol is entered into the symbol table with its proper value.

NOTE

Undefined expressions involving the address pointer are never tolerated, not even in PASS1. For example if A, B, and C are undefined, the following are unacceptable:

```
.=A
.BLKB B
.BLKW C
```

Make sure the .END directive terminates your program.

A DCT11-EM Loadable Program – Example 1

Use your host's editing facilities to create the summation program presented in Paragraph 3.8. Comments from the original program are shown in lowercase, and comments added for the benefit of the example are shown in uppercase.

```
.START          ;THIS LINE MUST APPEAR FIRST.
. = 2000        ;ENTER THE PROGRAM STARTING AT LOCATION 2000.
CLR R1          ;Set R1 = 0.
CMP R0,R1       ;R0 contains n.
BLE 2034        ;Illegal input (n ≤ 0)?
CLR @#2044      ;No, start operation by clearing 2044.
MOV R0,@#2044   ;Place first value of n in 2044.
DEC R0          ;n = n−1
ADD R0,@#2044   ;Add next value (n−1) to 2044.
BVS 2036        ;Overflow?
CMP R0,R1       ;No.
BGT 2016        ;Continue operation if n > 0.
HALT            ;Operation complete if n = 0.
CLR R0          ;Yes, illegal input. Clear R0, 2044.
CLR @#2044      ;Yes, overflow. Clear 2044 only.
HALT            ;Illegal input or overflow occurred.
.END            ;STOP HOST LOADING.
```

A DCT11-EM Loadable Program – Example 2

In this example, the summation program above is changed slightly such that forward references to the symbols ILLIN and OVFLO are made. Since these symbols are undefined when first referenced, you must create the program in two segments to make it acceptable to the DCT11-EM.

```
.START                          ;THIS LINE MUST APPEAR FIRST.
CLEAR                           ;DELETE ALL PREVIOUSLY DEFINED
                                ;SYMBOLS.
PASS1                           ;PERFORM FIRST PASS INPUT OF PROGRAM.
                                ;ALLOW UNDEFINED SYMBOLS AND SET
                                ;THEIR VALUES TO ZERO.
. = 2000                        ;INPUT THE PROGRAM STARTING AT
                                ;LOCATION 2000.
BEGIN:  CLR R1                  ;Set R1 = 0.
        CMP R0,R1               ;R0 contains n.
        BLE ILLIN               ;Illegal input (n ≤ 0)?
        CLR @#2044              ;No, start operation by clearing 2044.
        MOV R0,@#2044           ;Place first value of n in 2044.
LOOP:   DEC R0                  ;n = n-1
        ADD R0,@#2044           ;Add next value (n-1) to 2044.
        BVS OVFLO               ;Overflow?
        CMP R0,R1               ;No.
        BGT LOOP                ;Continue operation if n > 0.
        HALT                    ;Operation complete if n = 0.
ILLIN:  CLR R0                  ;Yes, illegal input. Clear R0, 2044.
OVFLO:  CLR @#2044              ;Yes, overflow. Clear 2044 only.
        HALT                    ;Illegal input or overflow occurred.
PASS2                           ;PERFORM SECOND PASS ENTRY OF
                                ;PROGRAM.
                                ;SYMBOLS ARE NO LONGER UNDEFINED AND
                                ;ARE ASSIGNED CORRECT VALUES.
                                ;UNRESOLVED ADDRESSES ARE RESOLVED.
. = 2000                        ;INPUT THE PROGRAM AGAIN STARTING AT
                                ;LOCATION 2000.
BEGIN:  CLR R1                  ;Set R1 = 0.
        CMP R0,R1               ;R0 contains n.
        BLE ILLIN               ;Illegal input (n ≤ 0)?
        CLR @#2044              ;No, start operation by clearing 2044.
        MOV R0,@#2044           ;Place first value of n in 2044.
LOOP:   DEC R0                  ;n = n-1
        ADD R0,@#2044           ;Add next value (n-1) to 2044.
        BVS OVFLO               ;Overflow?
        CMP R0,R1               ;No.
        BGT LOOP                ;Continue operation if n > 0.
        HALT                    ;Operation complete if n = 0.
ILLIN:  CLR R0                  ;Yes, illegal input. Clear R0, 2044.
OVFLO:  CLR @#2044              ;Yes, overflow. Clear 2044 only.
        HALT                    ;Illegal input or overflow occurred.
.END                            ;STOP HOST LOADING.
```

4.17.6 An Illustration of the Host Loading Process

This paragraph steps you through a session with the DCT11-EM during which you load the summation program you created on your host (see example 1, Paragraph 4.17.5).

Assuming you are in NOHOST mode, the first step is to get into LOAD mode by typing in:

```
TEM> HOST LOAD
```

Press RETURN until your host responds with its usual prompting character(s).

Then direct your host to type or otherwise display on the console terminal the program you wish to load. This command might be in the form:

```
TYPE SUMM
```

where TYPE is the the command your host recognizes to display the program and SUMM is the name you gave the program. When the host starts typing the program, the following appears on your console terminal. (This program does not contain any undefined symbols and requires only one pass.)

```
      .START
TEM>                          ;THIS LINE MUST APPEAR FIRST.
TEM> CLEAR                        ;DELETE ALL PREVIOUSLY DEFINED
TEM>                              ;SYMBOLS.
TEM> . = 2000                     ;ENTER THE PROGRAM STARTING AT
TEM>                              ;LOCATION 2000.
TEM> CLR R1                       ;Set R1 = 0.
TEM> CMP R0,R1                    ;R0 contains n.
TEM> BLE 2034                     ;Illegal input (n ≤ 0)?
TEM> CLR @#2044                   ;No, start operation by clearing 2044.
TEM> MOV R0,@#2044                ;Place first value of n in 2044.
TEM> DEC R0                       ;n = n-1
TEM> ADD R0,@#2044                ;Add next value (n-1) to 2044.
TEM> BVS 2036                     ;Overflow?
TEM> CMP R0,R1                    ;No.
TEM> BGT 2016                     ;Continue operation if n > 0.
TEM> HALT                         ;Operation complete if n = 0.
TEM> CLR R0                       ;Yes, illegal input. Clear R0, 2044.
TEM> CLR @#2044                   ;Yes, overflow. Clear 2044 only.
TEM> HALT                         ;Illegal input or overflow occurred.
TEM> .END                         ;STOP HOST LOADING.
HOST>
<your host's prompt appears on the last line>
```

The DCT11-EM successfully loaded your program and you are now back in HOST mode. The console monitor can now respond to your input. If you type in 2000, you can examine the program you just loaded by pressing RETURN repeatedly.

If your program is successfully being loaded into the DCT11-EM, each line is preceded by the TEM> prompt. If a program line causes a console error message, loading stops but typing continues (without the TEM> prompt).

4.18 CONSOLE COMMAND SUMMARY

General Form	Operation
expr	Deposit the expression in RAM unless the expression is part of another command. Advance the address pointer accordingly.
instr	Assemble and deposit the instruction at the location indicated by the address pointer. Advance the address pointer accordingly.
expr1_expr2	Display the contents of the locations from expr1 through expr2. If expr1 is greater than expr2, only expr1 contents displayed.
expr?	Display numerically the value of the expression.
expr\	Set the address pointer to the value of the expression. Display the contents of the location specified by the expression.
null line	Display, relative to the address pointer, the next eight instructions if in INSTRU mode, the next eight words if in WORD mode, or the next eight bytes if in BYTE mode. If single stepping, single step again.
symbol=expr	Define the symbol to be equal to the expression.
symbol:	Define the symbol to be equal to the current value of the address pointer.
^	Decrement the address pointer by one byte if you are in BYTE mode or by one word if you are in WORD or INSTRU mode.

Form	Paragraph Reference	Operation
ABSOLU	4.8.2	Sets the ABSOLU mode. Causes user-defined symbols in programs to be displayed as numeric values.
.ASCII /string/	4.15	Generates a block of data containing the ASCII equivalent of the character string (enclosed in delimiting characters), one character per byte.
.BLKB expr	4.15	Reserves a block of storage space whose length in bytes is determined by the specified expression.
.BLKW expr	4.15	Reserves a block of storage space whose length in words is determined by the specified expression.

.BYTE expr1, expr2, . . .	4.15	Generates successive bytes of data; each byte contains the value of the corresponding specified expression.
BYTE	4.8.2	Sets the BYTE mode for memory examination and alteration operations. Causes memory to be displayed as three digit bytes.
CANCEL	4.14.1 4.14.3	Clears all four breakpoints and the watchpoint.
CLEAR	4.13.2	Clears the user symbol table.
DELETE symbol	4.13.2	Deletes user-defined symbol from the user symbol table.
.END	4.17.4	Used at the end of programs that are to be loaded into the DCT11-EM from a host. Causes the DCT11-EM to terminate host loading if in LOAD mode.
.EVEN	4.15	Ensures that the current address pointer contains an even address by adding 1 if it is odd.
EXIT	4.2	Transfers console control to the keypad.
GO	4.14	Executes the user program at the current PC value.
HELP	4.16	Displays a table of commands.
HOST	4.17.1	Sets the HOST mode. Allows the DCT11-EM to receive messages from a host.
INSTRU	4.8.2	Sets the INSTRU mode. Data is displayed as DCT11-AA assembly language instructions. Is set by default when the DCT11-EM is powered up.
LOAD	4.17.1	Sets the LOAD mode. Establishes host communication. Allows the DCT11-EM to begin loading if it encounters the .START command.
NOHOST	4.17.1	Clears the HOST mode. Is set by default when the DCT11-EM is powered up.
PASS1	4.17.5	Sets the PASS1 mode. Allows the use of undefined symbols.
PASS2	4.17.5	Sets the PASS2 mode. Requires all symbols to be defined. Is set by default when the DCT11-EM is powered up.

REPEAT expr,cmd	4.16	Repeatedly performs the specified command(s) by the number of times specified by the expression.
SHOWMO	4.16	Displays the current operating modes of the DCT11-EM.
SHOWRE	4.6	Displays the contents of user registers and the watchpoint if the watchpoint is set.
SHOWSY	4.13.2	Displays the contents of the user symbol table.
START	4.17.5	Used at the beginning of programs that are to be loaded into the DCT11-EM from a host. Causes the DCT11-EM to start host loading if in LOAD mode.
STEP	4.14.2	Executes one instruction of a user program at the current value of the PC. Displays the contents of user registers and the watchpoint if the watchpoint is set. Displays the next instruction to be executed.
SYMBOL	4.8.2	Sets the SYMBOL mode. Causes user-defined symbols in programs to be displayed as symbols rather than as numeric values. Is set by default when the DCT11-EM is powered up.
TALK	4.17.1	Sets the TALK mode. Establishes host communication. Allows you to communicate directly with a host as if the DCT11-EM were not there. Typically used for program development on a host.
VTOFF	4.3	Sets the VTOFF mode. Causes deleted characters to be echoed (preceded by a slash) on the console terminal when you press the DELETE key. Is set by default when the DCT11-EM is powered up.
VTON	4.3	Sets the VTON mode. Characters you delete by pressing the DELETE key are not echoed in this mode. Typically used if you have a video terminal for a console.
.WORD expr1, expr2, · · ·	4.15	Generates successive words of data; each word contains the value of the corresponding specified expression.

4.19 CONTROL COMMAND SUMMARY

Command	Meaning	Typical Use
CTRL/U CTRL/X	Delete line.	You made several typing errors in your input line. You want to cancel the line and try again.
CTRL/R	Display line.	You used the DELETE key several times while typing your input line. You want to see a clean version of the line you are editing.
CTRL/S	Suspend execution.	You want to suspend the operation of the console monitor or the execution of a currently running program.
CTRL/Q	Resume execution.	You have previously used the CTRL/S command and want to resume operation.
CTRL/C	Abort operation.	You want to abort the current CTRL/Y operation of the DCT11-EM and input a new line.
CTRL/O	Ignore host message.	You are in HOST mode (see Paragraph 4.17.1) and want to ignore information currently being sent by your host computer.
CTRL/A	Select option.	You are in TALK or LOAD modes (see Paragraphs 4.17.3 and 4.17.4) and want to select one of these four options: exit, resume, send break, send CTRL/A.

CHAPTER 5
SOFTWARE

5.1 INTRODUCTION

This chapter provides some information about the DCT11-EM monitor and introduces you to monitor subroutines you can use in your programs. The chapter also describes how address space is allocated in the DCT11-EM and shows you which areas are available and unavailable for use.

This material is summary in nature. More detailed information can be found in the DCT11-EM monitor listing (see Appendix A) and in the DCT11-EM schematics (see Appendix B).

5.2 THE MONITOR

The monitor is a PROM resident program that controls the operation of the DCT11-EM. Its main purpose is to provide an environment in which you can develop and run programs. The portion of the monitor that allows you to operate the DCT11-EM with the keypad is called the keypad monitor and the portion that lets you use a console terminal is called the console monitor. When you learned how to operate the DCT11-EM with the keypad and console in Chapters 3 and 4, you were really learning how to get the monitor to do things for you.

When you execute a program, the monitor relinquishes control of the DCT11-EM to your program. Control is returned to the monitor (i.e., the monitor is restarted) by any of the following ways:

1. Pressing the HALT switch
2. Executing a HALT instruction
3. Encountering a breakpoint or executing a BPT instruction
4. Attempting to execute an illegal instruction
5. Performing a single step
6. Sending a BREAK from a console terminal
7. Executing a JMP @#140010 instruction
8. Sending a CTRL/C or CTRL/Y command from a console terminal

The first two ways (1 and 2) always return control to the keypad monitor. The remaining ways (3 through 8) return control to the keypad monitor if you are using the keypad or the console monitor if you are using a console terminal. When control is returned to the keypad monitor, the PC is displayed on the LEDs and you are in register mode. (If a flashing error message appears on the LEDs, press the HALT switch or any key to display the PC.) When control is returned to the console monitor, a TEM> prompt is displayed on your console terminal. Refer to Appendix A for details about how the HALT and BPT instructions interact with the monitor. Also refer to Appendix A for information on the effects of setting the T-bit.

When you return control to the monitor, the DCT11-EM registers contain the values they had at the time your program stopped with the following exceptions.

1. If you execute a JMP @#140010 instruction, the PC is restored to the value it had when your program started. This allows easy restarting of the program.

2. If you type CTRL/C or CTRL/Y from a console terminal, all the DCT11-EM registers are restored to the values they had when your program started.

3. If you encounter a breakpoint, the stack pointer is set to the value it had just before the breakpoint occurred.

5.2.1 The Stack Pointer

The monitor initializes your stack pointer to 7400 when you power up. The monitor also checks to make sure your stack pointer is in the range 4 through 7400, inclusive (for the keypad monitor), or 4 through 6500, inclusive (for the console monitor), before it allows your program to execute. It is up to you, however, to make sure the stack pointer has a reasonable value before you attempt to run a program.

For example, it is a good idea to make sure your stack pointer and the information you push onto the stack do not overlap your program. To decrease the chance of this happening, set the stack pointer well above the area in which your program resides.

5.3 MONITOR SUBROUTINES

Several portions of the DCT11-EM monitor are accessible to your programs as subroutines. If you want to use one of these subroutines in your program, simply include a JSR instruction in the form:

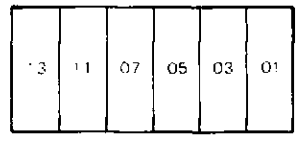
```
JSR PC,@#subroutine
```

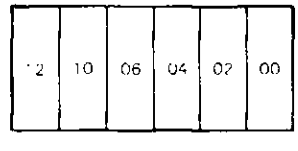
where subroutine refers to the address of the desired subroutine.

Subroutine mnemonics are defined within the monitor only, so make sure your program defines these mnemonics before it uses them as symbols.

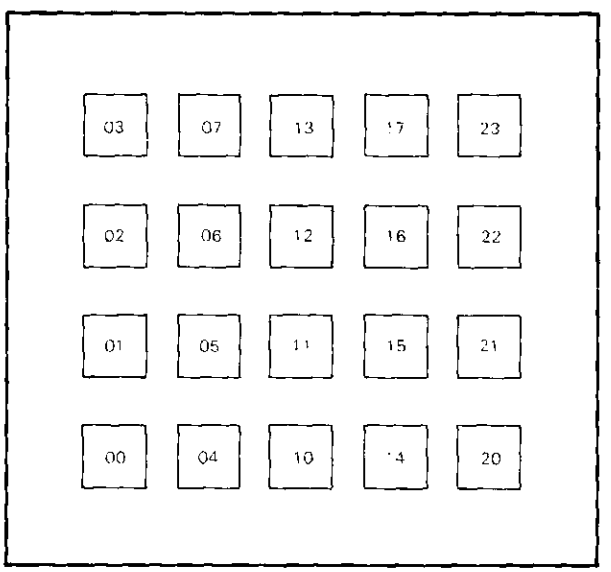
5.3.1 Keypad/LED Subroutines

Address	Mnemonic	Description
140014	DGDISP	Display Hex Digit Takes the value contained in the lower four bits of R0 and displays it as a hexadecimal number on the LED digit indexed by R1. Values of R1 correspond to LED digits as follows. Uses R0 and R1.





Address	Mnemonic	Description
140020	UPDISP	Display Octal Number on Upper LEDs Takes the value in R2 and displays it as a six-digit octal number on the upper row of LEDs. Uses R0 and R1.
140024	LODISP	Display Octal Number on Lower LEDs Takes the value in R2 and displays it as a six-digit octal number on the lower row of LEDs. Uses R0 and R1.
140030	DECDSP	Display Decimal Number Takes the value in R1 and displays it as a five-digit decimal number on the row of LEDs indexed by R2. R2 = 12 for the lower row, R2 = 13 for the upper row. Uses R0, R1, R2, and R3.
140034	UPBLNK	Clear Upper Row Blanks out the upper row of LEDs. Uses R0 and R1.
140040	LOBLNK	Clear Lower Row Blanks out the lower row of LEDs. Uses R0 and R1.
140044	GETKEY	Get Key Number Turns on LEDs and waits for a keypress. When a keypress occurs, takes the number of the key and stores it in R1. Keys are numbered as follows.



140050	BCDKEY	Convert Key Number to BCD Takes the key number in R1 and converts it to a BCD value for the keys 0 through 9. Returns 12 for the CLR key and 13 for the EXA key. Returns −1 (i.e., 177777) for any other key. Stores the result in R1.

Address	Mnemonic	Description
140054	GETNUM	Input Number From Keypad Displays the value in R2 as a six-digit octal number on the lower row of LEDs. Enables the user to modify the value of R2 using keys 0 through 7 and CLR. Stores modified value in R2 when the EXA key is pressed. Uses R0, R1, and R2.

5.3.1.1 Using the LEDs and Keypad – This paragraph contains some information you may find useful when writing programs that use the LEDs and keypad. This is intended as introductory material only. For further detail, refer to the monitor listing in Appendix A and the DCT11-EM schematics in Appendix B.

You can create your own characters to display on the LED digits. First, form bytes that represent the segment patterns of the characters you wish to display as shown in Figure 5-1.

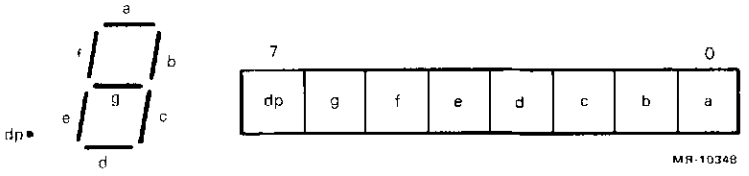


Figure 5-1 LED Segment Assignments

For example, 01110100 (or 164 octal) corresponds to the letter *h* and 01001111 (or 117 octal) corresponds to the numeral *3*.

Then, move the bytes containing the segment patterns to locations 7712 through 7725. These locations (collectively called SEGBUF) are used by the LED interrupt service routine in the monitor to display segment patterns on the LEDs. Each location (byte) corresponds to an LED digit as shown in Figure 5-2.

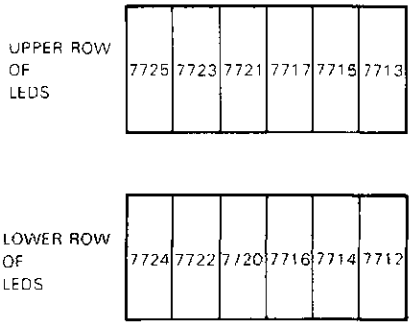


Figure 5-2 SEGBUF Assignments

For example, if you moved 164 (octal) to location 7721, 117 (octal) to location 7717, and 0 to all the other SEGBUF locations, you would display *h3* centered in the upper row of LEDs.

Finally, turn on the LEDs by writing 000007 to port C of the 8255A parallel port chip (address 177444). Make sure your program keeps the LEDs on long enough for you to see them. One way of leaving the LEDs on is to incorporate one or more delay loops in your program of the form:

```
CLR R5
SOB R5,.
```

The LED interrupt (INTA) is disabled (i.e., the LEDS are turned off) by writing 000010 to port C of the 8255A chip. This also disables the user LED.

To turn on the user LED (which, incidentally, also disables the LED digits), write 000011 to port C of the 8255A chip.

Examples of displaying values on the LEDs are provided in Paragraph 5.3.1.2. You can also create your own interrupt service routines to respond to keypresses. When a key is pressed, program control is transfered to the routine pointed to by 7676. If 7676 is zero, keypresses are ignored. The number of the key pressed is available to your routine through R1. See the description of the GETKEY subroutine in Paragraph 5.3.1 for key numbers.

In order for a keypress to be sensed, the LEDs must be enabled. This can be done by writing 000007 to location 177444 as explained above or by executing your program from the keypad with the "Go With LEDs" special function (see Paragraph 3.12.2).

At the end of your keypress service routine, include the sequence:

```
MOV (SP)+,R2
MOV (SP)+,R1
MOV (SP)+,R0
RTI
```

to restore the state of your interrupted program. As an example, here is a program which loops on itself and increments R3 each time a key is pressed. To check the operation of the program, start it at location 1000 and press keys. Press HALT and examine R3.

Address	Data	Symbolic Representation	Comments
1000	012737	MOV #7,@#177444	;enable keypad
1002	000007		
1004	177444		
1006	012737	MOV #1500,@#7676	;attach interrupt routine
1010	001500		
1012	007676		
1014	000774	BR 1006	;loop infinitely
1500	005203	INC R3	;interrupt service routine
1502	012602	MOV (SP)+,R2	
1504	012601	MOV (SP)+,R1	
1506	012600	MOV (SP)+,R0	
1510	000002	RTI	

5.3.1.2 Using Keypad/LED Subroutines – Example Programs – The following examples show you how to use keypad/LED subroutines.

Example 1 – Countdown Program This program decrements a number at a rate inversely proportional to the number's size. The program begins by displaying the word "EntEr" on the upper row of LEDs. You enter a number (which is displayed on the lower row of LEDs) and press the EXA key. The number is displayed as it is decremented. The program initializes itself at the end to allow you to enter another number.

There are undefined symbols in this program, so if you enter the symbolic version via the console terminal, make sure you incorporate the PASS1 and PASS2 commands as described in Paragraph 4.17.5.

Address	Data		Symbolic Representation	Comments
			SEGBUF = 7712	;LED segment buffer
			LODISP = 140024	;octal number on lower LEDs
			GETNUM = 140054	;input number from keypad
			. = 1000	;position program at location ;1000
1000	012701	TEST:	MOV #SEGBUF+1,R1	;point to rightmost
1002	007713			;digit of upper row of LEDs
1004	012700		MOV #6,R0	;set digit count = six digits
1006	000006			
1010	116021	TEST1:	MOVB ENTER-1(R0),(R1)+	;transfer character to
1012	001063			;digit in upper row of LEDs
1014	005201		INC R1	;advance pointer to next ;digit in upper row of LEDs
1016	077004		SOB R0,TEST1	;loop to transfer all six ;characters
1020	004737	TEST2:	JSR PC,@#GETNUM	;input an octal number from
1022	140054			;the keypad
1024	005702	TEST4:	TST R2	;reject zero as an input
1026	001774		BEQ TEST2	;if zero, get a new number
1030	012701		MOV #3,R1	;call delay routine three
1032	000003			;times
1034	004767	TEST3:	JSR PC,DELAY	;wait a while
1036	000012			
1040	077103		SOB R1,TEST3	
1042	005302		DEC R2	;decrement entered number
1044	004737		JSR PC,@#LODISP	;display new value
1046	140024			
1050	000765		BR TEST4	;see if we have zero yet
;DELAY loops a number of times inversely proportional to the size ;of R2. Thus there is a smaller delay when R2 is large.				
1052	012700	DELAY:	MOV #-1,R0	;set dividend
1054	177777			
1056	160200	DELAY 1:	SUB R2,R0	;divide by successive
1060	103376		BCC DELAY1	;subtraction; keep ;subtracting until ;underflow occurs
1062	000207		RTS PC	
; ENTER is a list of bytes corresponding to the segment patterns ; "EntEr".				
1064	052171	ENTER:	.BYTE 171,124,170,171,120,0	
1066	074570			
1070	000120			

Example 2 - Clock Program

This program displays a minutes and seconds clock on the lower row of LEDs. The values for minutes and seconds are obtained from a timer maintained by the monitor. You can use the INT switch to set minutes. Note that the upper row of LEDs and the left-most digit of the lower row display the current contents of the LED segment buffer for those digits.

All symbols referenced in this program are defined. The symbolic version of the program will run if entered as follows. As an exercise, try to modify the program so that the upper row of LEDs and the left-most digit of the lower row of LEDs are blank when the program is running.

Address	Data		Symbolic Representation	Comments
			PFVEC = 24	;INT switch vector
			TIME = 7730	;upper six bits count seconds
			SEGBUF = 7712	;LED segment buffer
			MINUTS = 776	;location to hold minutes count
			DECDSP = 140030	;display decimal number
			P$PORC = 177444	;LED/keypad I/O port on 8255A
			SETIME = 1200	;subroutine to set minutes
			= 1000	;position program at loc. 1000
1000	012706	CLOCK:	MOV #6500,SP	;initialize stack pointer
1002	006500			
1004	106427		MTPS #0	;set low priority
1006	000000			
1010	012737		MOV #SETIME,@#PFVEC	;connect minute set
1012	001200			;routine to INT switch
1014	000024			
1016	005037		CLR @#TIME	;clear seconds and second
1020	007730			;fractions
1022	005067		CLR MINUTS	;clear minutes
1024	177750			
1026	112737		MOVB #7,@#P$PORC	;turn on LEDS
1030	000007			
1032	177444			
1034	032737	LOOP:	BIT #1000,@#TIME	;wait for seconds to
1036	001000			;change
1040	007730			
1042	001774		BEQ LOOP	
1044	032737	LOOP1:	BIT #1000,@#TIME	
1046	001000			
1050	007730			
1052	001374		BNE LOOP1	
1054	013701	SHOWIT:	MOV @#TIME,R1	;show time
1056	007730			
1060	000301		SWAB R1	;get seconds
1062	006201		ASR R1	
1064	006201		ASR R1	
1066	042701		BIC #177700,R1	;mask out fractions of
1070	177700			;seconds
1072	001010		BNE .+22	;not a new minute (BNE CLK1)
1074	005267		INC MINUTS	;else count minutes

Address	Data		Symbolic Representation	Comments
1076	177676			
1100	026727		CMP MINUTS,#60.	;overflow?
1102	177672			
1104	000074			
1106	103402		BLO .+6	;no (BLO CLK1)
1110	005067		CLR MINUTS	
1112	177662			
1114	016702	CLK1:	MOV MINUTS,R2	;get minutes
1116	177656			
1120	012700		MOV #3,R0	;shift minutes over three
1122	000003			;digits
1124	006302	LOOP2:	ASL R2	;multiply R2 by 10 to shift
1126	010246		MOV R2,–(SP)	;one decimal digit to the left
1130	006302		ASL R2	
1132	006302		ASL R2	
1134	062602		ADD (SP)+,R2	
1136	077006		SOB R0,LOOP2	;loop three times to make × 1000
1140	060201		ADD R2,R1	;add minutes to seconds
1142	012702		MOV #10,R2	;index lower display
1144	000010			
1146	004767		JSR PC,@#DECDSP	;display time
1150	136656			
1152	112737		MOVB #100,@#SEGBUF+4	;display dash between
1154	000100			;minutes and seconds
1156	007716			
1160	000725		BR LOOP	
			. = 1200	
1200	005037	SETIME:	CLR @#TIME	;reset seconds to increment
1202	007730			;minutes
1204	012706		MOV #6500,SP	;reinitialize stack
1206	006500			
1210	106427		MTPS #0	;reinitialize priority
1212	000000			
1214	000717		BR SHOWIT	;display new time

As an exercise, try to modify the program so that the upper row of LEDs and the left-most digit of the lower row of LEDs are blank when the program is running.

5.3.2 Console Subroutines

Address	Mnemonic	Description
140060	GETLIN	Get Input Line Types an angle bracket and space (>) as prompting characters and awaits input from the console terminal. Echoes characters as they are typed in. Stores these characters (up to 96 per line) in a character buffer. Uses R0, R3.

Address	Mnemonic	Description
140070	GETCH	Get Character Retrieves the character indexed by R3 from the character buffer. R3 must have a value from 0 to 137 octal (95 decimal). Stores the character in the lower byte of R0 and increments R3. Lowercase characters are converted to uppercase. Sets the N condition code bit if the character is a separator (space, tab, feed). Sets the C condition code bit if the character has been converted from lowercase to uppercase. Uses R0, R3.
140100	GETCHC	Get Character, Preserve Case Retrieves a character with its case intact from the character buffer. Uses R3 as an index to the character. R3 must have a value from 0 to 137 octal (95 decimal). Stores the character in the lower byte of R0 and increments R3. Uses R0, R3.
140104	GETNXT	Get Character, Ignore Separators Retrieves the next character in the character buffer which is not a separator (space, tab, feed). Uses R3 as a starting point index. R3 must have a value from 0 to 137 octal (95 decimal). Stores the character in the lower byte of R0 and increments R3 in accordance with the number of separators encountered. Lowercase characters are converted to uppercase. Sets the C condition code bit if a character has been converted from lowercase to uppercase. Uses R0, R3.
140120	CRLF	Type Carriage Return, Line Feed Types a carriage return and line feed on the console.
140124	CHROUT	Type One or Two ASCII Characters Takes the value in the lower byte of R0 and types it as an ASCII character on the console. If the upper byte of R0 has a nonzero value, it is also typed as an ASCII character on the console. Uses R0.
140134	CHRO2	Send Byte to Auxiliary Port Takes the value in the lower byte of R0 and sends it to the auxiliary serial port. Uses R0.
140140	ASCOUT	Type One ASCII Character or String Takes the value in the lower byte of R0 and types it on the console either as an ASCII character or as an ASCII string of characters. ASCII strings that can be typed include <ESC>, <SP>, <DEL>, and ^A through ^_ where the caret denotes a control character. Uses R0.
140144	PRINTA	Type ASCII String Takes a string of bytes starting at the location pointed to by R1 and types them on the console as ASCII characters until until a byte whose value is zero is is encountered. Uses R0, R1.

Address	Mnemonic	Description
140160	TYPOCT	Type Octal Number Types the value in R1 on the console as a six-digit octal number if in the INSTRU or WORD output formatting modes. Types the lower byte of R1 on the console as a three-digit octal number if in BYTE mode. Uses R0, R1.
140164	TYPDEC	Type Decimal Number Types the value in R1 on the console as a signed five-digit decimal number followed by a period. Uses R0, R1.

5.3.2.1 Console Character Manipulation – The console subroutines just described provide most of the functions you will require to manipulate characters via the console. If you require other functions, refer to the monitor listing in Appendix A.

Keep the following in mind when using the GETCH, GETCHC, and GETNXT subroutines.

When you use these subroutines, characters you input via the console terminal are stored in a 96-character buffer maintained by the monitor called BUFFER. All three subroutines use R3 as a pointer to determine which character within BUFFER is retrieved. Since BUFFER is 96 characters in length, R3 can have a value from 0 through 137 (octal), inclusive. For your convenience, the subroutines automatically increment R3 to point to the next character to be retrieved.

5.3.2.2 Using Console Subroutines – Sample Program

```
;
; NIM for the TEM
;
; In this version of NIM, there are 21 sticks. The game requires 2
;players (the user and the TEM). The players take turns picking up
;1, 2, or 3 sticks. The object of the game is to leave 1 stick for
;the other player to pick up in the last turn. The algorithm used
;by the TEM ensures that it will win if it goes second, or if it goes
;first and the other player leaves it an opportunity to win.
;
; Operation of the game is explained by prompts. All responses by the
;user must be terminated with a carriage return. However, several
;responses may be typed together on a line, separated by commas, and
;will be taken as needed by upcoming prompts for input.
;
; There are undefined symbols in this program, so if you enter the
;symbolic version via the console terminal, make sure you incorporate
;the PASS1 and PASS2 commands as described in Paragraph 4.17.5.
```

```
;********** SYMBOL DEFINITIONS ***********

 CLEAR ;empty symbol table

MONITR  = 140010 ;reentry point for monitor
GETLIN  = 140060 ;get a line from the console
GETNXT  = 140104 ;get next significant character from BUFFER
CRLF    = 140120 ;send <CR>,<LF> to console
CHROUT  = 140124 ;send a character to console
PRINTA  = 140144 ;print an ASCII string
TYPDEC  = 140164 ;type a decimal number on the console

CR      = 15     ;<CR>
LF      = 12     ;<LF>
SPACE   = 40     ;space
STICKS  = 21.    ;initial number of sticks

;
;************ START OF PROGRAM ************
;

. = 1000

NIM:    MOV #GREET,R1
        JSR PC,@#PRINTA          ;print greeting message on console

NEWGAM: CLR R5                   ;show no sticks taken yet
                                 ;(number of sticks left = STICKS - R5)
        CLR R3
NEW1:   MOV #MEORU,R1
        JSR PC,@#PRINTA          ;ask who plays first
        JSR PC,@#GETLIN          ;wait for response from console
        JSR PC,@#GETNXT          ;get first meaningful character
        CMPB R0,#'M              ;m(e) means TEM goes first
        BEQ TEMGO
        CMPB R0,#'Y              ;y(ou) means user goes first
        BEQ USERGO
        CMPB R0,#'Q              ;q(uit) means return to monitor
        BNE NEW1                 ;If user has not entered a valid response,
        JMP @#MONITR             ;prompt for response again.
```

```
USERGO: MOV #LEFT1,R1
        JSR PC,@#PRINTA          ;print header for number of sticks left
        MOV #STICKS,R1
        SUB R5,R1                ;calculate number of sticks left
        MOV R1,R2                ;save a copy of result
        JSR PC,@#TYPDEC          ;type decimal value on the console
        MOV #LEFT2,R1
        JSR PC,@#PRINTA          ;finish message
        JSR PC,@#CRLF            ;start a new line
USER1:  MOV #400*SPACE+'/,R0     ;put in R0 the character pair "/"
        JSR PC,@#CHROUT          ;type a "stick" on the screen
        SOB R2,USER1             ;loop to type the appropriate number
                                 ;of sticks
        JSR PC,@#GETNXT          ;get next character
        CMPB R0,#',              ;is it a comma?
        BEQ NEXT                 ;yes, get next move from line.
USER2:  MOV #HOWMNY,R1
        JSR PC,@#PRINTA          ;ask how many sticks the user wants
        JSR PC,@#GETLIN          ;get a line
NEXT:   JSR PC,@#GETNXT          ;get first/next meaningful character
                                 ;on line
        CMPB R0,#'1
        BLO USER2                ;illegal response, throw away line and
                                 ;try again
        CMPB R0,#'3
        BHI USER2                ;illegal response
        SUB #'0,R0               ;convert digit in R0 into a number
        ADD R0,R5                ;add to sticks already taken away
        CMP R5,#STICKS-1         ;is only 1 stick left?
        BLO TEMGO                ;no, it's TEM's turn
        BHI USER4                ;user took too many sticks
        MOV #ILOSE,R1
        JSR PC,@#PRINTA          ;announce the loss
        JMP NEWGAM               ;ask about another game

USER4:  MOV #GOOFED,R1
        JSR PC,@#PRINTA          ;tell the idiot that he goofed up
        JMP NEWGAM               ;and ask about another game

TEMGO:  MOV #MYMOVE,R1
        JSR PC,@#PRINTA          ;type beginning of TEM's move on
                                 ;console
        MOV R5,R1                ;get number of sticks taken so far
        NEG R1                   ;implement algoritm to select move:
        BIC #177774,R1           ;if R5 MOD 4 = 0, take 2 sticks
        BNE TEM1                 ; R5 MOD 4 = 1, take 3 sticks
        MOV #2,R1                ; R5 MOD 4 = 2, take 2 sticks
```

```
TEM1:    ADD R1,R5                    ; R5 MOD 4 = 3, take 1 stick
         JSR PC,@#TYPDEC              ;show how many sticks TEM is taking
         MOV #MYMOV1,R1
         JSR PC,@#PRINTA              ;finish message
         CMP R5,#STICKS-1             ;is there only 1 stick left?
         BLO USERGO                   ;no, it's the user's turn
         MOV #IWIN,R1
         JSR PC,@#PRINTA              ;announce the victory
         JMP NEWGAM                   ;and ask about a new game

GREET:   .BYTE CR,LF
         .ASCII /NIM for the TEM/
         .BYTE CR,LF,0
MEORU:   .BYTE CR,LF
         .ASCII /Who goes first? Me (M) or you (Y)? (Q to quit)/
         .BYTE 0
LEFT1:   .BYTE CR,LF
         .ASCII /There are /
         .BYTE 0
LEFT2:   .ASCII / sticks left./
         .BYTE 0
HOWMNY:.BYTE CR,LF
         .ASCII /How many sticks will you take? (1, 2, or 3)/
         .BYTE 0
MYMOVE: .BYTE CR,LF
         .ASCII /I take /
         .BYTE 0
MYMOV1: .ASCII / stick(s)./
         .BYTE 0
ILOSE:   .BYTE CR,LF,LF
         .ASCII /You win!!! I demand a rematch!/
         .BYTE 0
IWIN:    .BYTE CR,LF,LF
         .ASCII /I win!!! Want to try again?/
         .BYTE 0
GOOFED:  .BYTE CR,LF,LF
         .ASCII /You goofed up! Can you get it right this time?/
         .BYTE 0
```

5.4 DCT11-EM ADDRESS SPACE

DCT11-EM address space is organized as shown in Figure 5-3. Functionally, the address space consists of: standard RAM space, expansion RAM space, monitor space, I/O space, space available for external hardware, and reserved space.

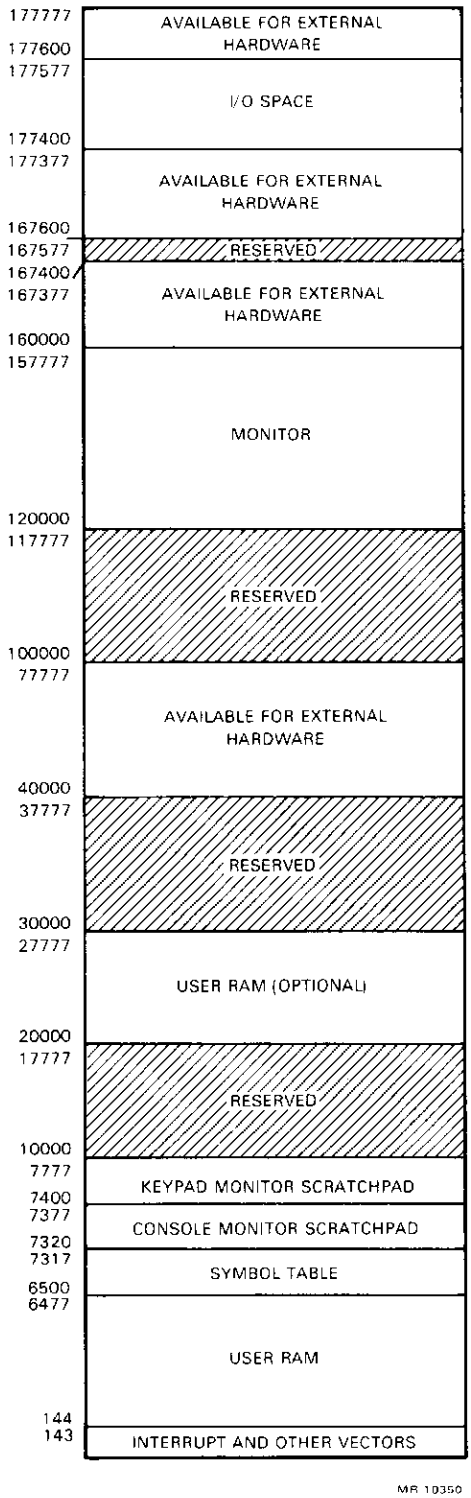


Figure 5-3 DCT11-EM Memory Map

5.4.1 Standard RAM Space

Addresses 000000 through 007777 are allocated to the RAM that comes standard with the DCT11-EM. This RAM space is utilized as follows.

Addresses	Use
000000–000143	Interrupt and Other Vectors. Contains vectors that point to service routines for various interrupt, trace, and trap conditions. See Chapter 6 for specific vector addresses.
000144–006477	User RAM Space. Space available for user programs.
006500–007317	Symbol Table (Console Monitor Only). Can contain up to 66 user defined symbols.
007320–007377	Console Monitor Scratchpad. Area for use by the console monitor.
007400–007777	Keypad Monitor Scratchpad. Area for use by the keypad monitor and console monitor.

If you are using only the keypad, the symbol table and console monitor scratchpad areas are available to you as user RAM.

The monitor ordinarily protects certain areas of RAM from direct alteration. If you are using the keypad only, the keypad monitor scratchpad is the only area of protected RAM. If you are using a console terminal, however, the symbol table, console monitor scratchpad, and keypad monitor scratchpad are all protected. You can remove protection by activating special function 4 from the keypad (see Paragraph 3.12.5).

Note that "protection" refers only to protection from direct alteration, such as examining a location from the keypad or console and then trying to change the location. An executing program can violate any RAM location. To avoid unpredictable results, therefore, make certain your programs do not inadvertantly write data into areas not available as user RAM.

5.4.2 Expansion RAM Space

If you insert two 2 K × 8 RAMs into the expansion sockets (see Paragraph 5.3), another portion of user RAM space at locations 020000 through 027777 becomes available to you.

5.4.3 Monitor Space

The monitor space is the space occupied by the keypad and console monitors which reside in two 8 K × 8 PROMs at locations 120000 through 157777.

5.4.4 I/O Space

Locations 177400 through 177577 are designated as space for the DCT11-EM's I/O chips. The 8255A parallel port, the 8251A auxiliary serial line, and the DC319 DLART console serial line all use this space. The I/O space consists of locations that can be written only and locations that can be written or read. Figure 5-4 provides a detailed breakdown of how the I/O space is used.

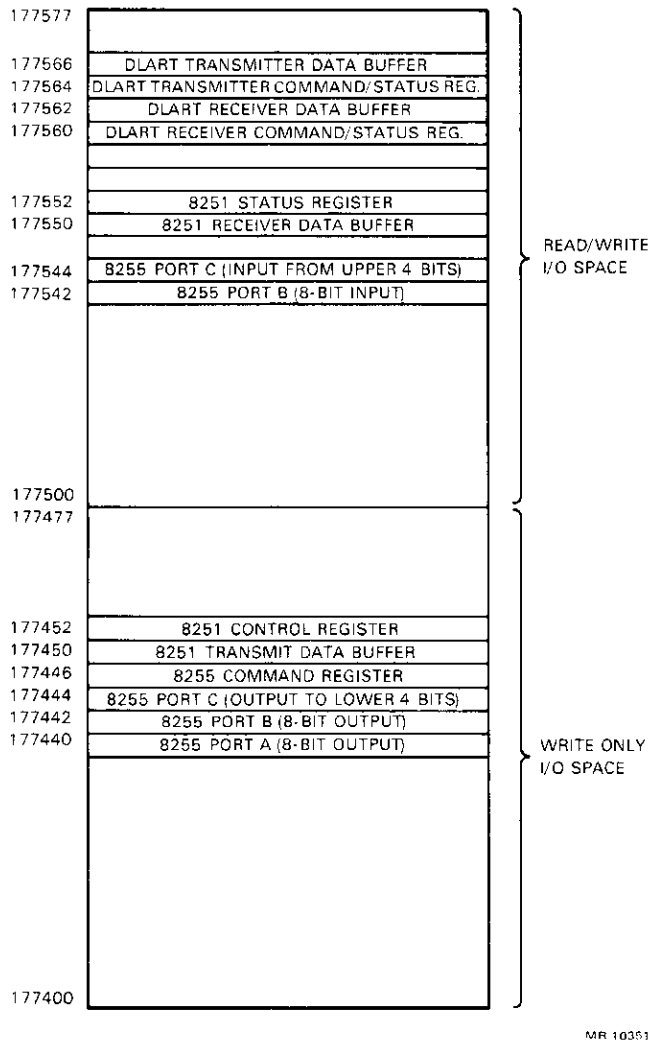


Figure 5-4 Map of I/O Space

5.4.5 Space Available For External Hardware

The following space is available to you for any expansion hardware you may wish to design:

040000–077777	167600–177377
160000–167377	177600–177777

An example of a piece of external hardware that could use this space is a RAM board which responds to addresses 040000 through 057777. Further information on hardware expansion is provided in Chapter 6.

5.4.6 Reserved Space

The shaded space in Figure 5-3 is reserved and unavailable for use. The addresses affected are:

010000–017777	100000–117777
030000–037777	167400–167577

CHAPTER 6
HARDWARE

6.1 INTRODUCTION

The DCT11-EM hardware is organized as shown in Figure 6-1. In general, the hardware consists of:

- The DCT11-AA microprocessor
- RAM
- Monitor EPROM
- Peripheral chips and drivers
- An internal data bus buffer
- User buffers
- Microprocessor control signal decoding logic
- Address latching and range decoding logic
- Peripheral chip address decoding logic
- Interrupt logic
- Timing logic
- Miscellaneous control logic
- Keypad/LEDs and supporting logic
- The HALT and INT push-button switches
- Connectors

The paragraphs that follow provide information on each of these. Refer to the DCT11-EM schematics in Appendix B for further details.

Paragraph 6.17 contains a design for an expansion memory board you can build.

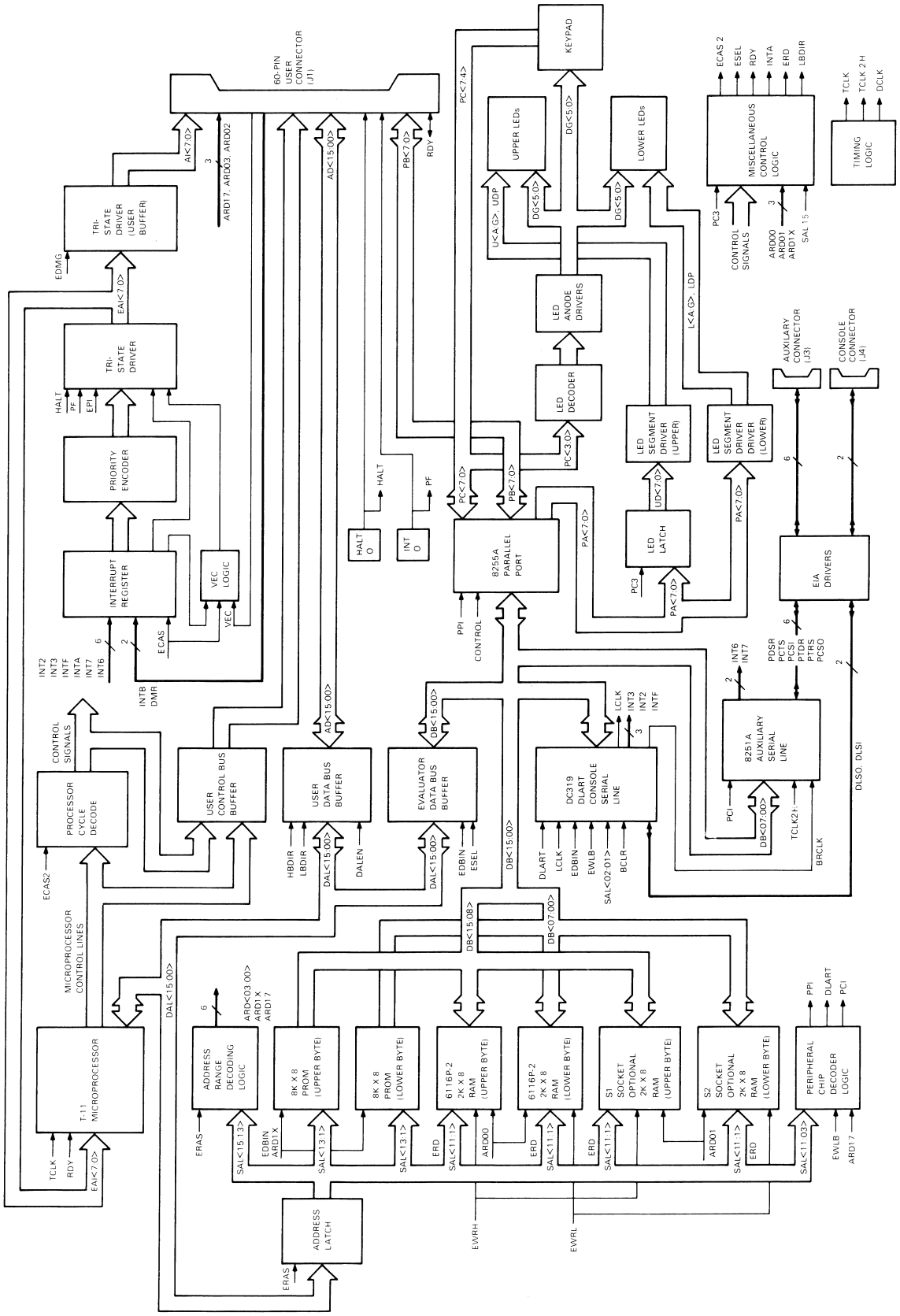


Figure 6-1 DCT11-EM System Block Diagram

6.2 DCT11-AA MICROPROCESSOR

The DCT11-AA microprocessor is the heart of the system. A detailed discussion of the operation and architecture of the DCT11-AA is beyond the scope of this book. Refer to the *DCT11-AA User's Guide* (EK-DCT11-UG) for this information.

At power-up or when a RESET instruction is executed, the DCT11-AA mode register bits are set to the following states and cannot be changed.

Mode Register Bits	State	Mode
<15:13>	000	Start address = 140000 Restart address = 140004
12	1	User
11	0	16-bit bus
10	1	4 K/16 K memory
9	0	Dynamic memory
8	0	Normal read/write
1	1	Standard microcycle
0	1	COUT = processor clock

This mode configuration has the following implications:

- Bit <11> = 1 – This allows you to use either 8-bit or 16-bit data paths in your expansion circuitry designs. If 8 bits, simply use the lower 8 bits of the 16-bit bus.
- Bits <10:09> = 10 – This allows you to use inexpensive 16 K dynamic RAMs for off-board memory expansion (see Paragraph 6.17).
- Bit <8> = 0 – This allows you to design expansion hardware with devices that respond to either normal or delayed read/write controls. If you use devices that respond to delayed read/write controls, include delay circuitry in your design.

NOTE

Do not use a RESET instruction in your program unless your program reconfigures (i.e., reinitializes) your peripheral chips. RESET causes the DCT11-AA to assert –BCLR which resets the peripheral chips.

6.3 RAM

There are two 2 K × 8 CMOS static RAM chips in the basic DCT11-EM which provide 4 K bytes of memory space. These RAMs respond to addresses 000000 through 007777. Even numbered or low bytes reside in one RAM, and odd numbered or high bytes reside in the other.

There are two expansion sockets on the board which can accommodate two additional 2 K × 8 static RAMs. The RAMs in these sockets respond to addresses 020000 through 027777. One RAM stores low bytes and the other stores high bytes.

Although the DCT11-AA generates refresh cycles as a result of being set to dynamic memory mode, this is for the benefit of off-board expansion with dynamic RAMs. The on-board static RAMs ignore the refresh cycles.

6.4 MONITOR EPROM

The DCT11-EM monitor is contained in two 8 K × 8 EPROM chips. The EPROMs respond to addresses 120000 through 157777.

Note that accesses to memory locations above 100000 cause a single cycle slip. This is not only for the benefit of the monitor EPROMs, but also for the peripheral chips and any slow expansion hardware which may be attached. Cycle slips are disabled if the jumper is installed (see Paragraph 2.5). If you install the jumper, make sure you also decrease the microprocessor's 7.5 MHz clock frequency to a value between 3 MHz and 6 MHz by changing the crystal.

6.5 PERIPHERAL CHIPS AND DRIVERS

The peripheral chips are the 8255A parallel port, the DC319-AA DLART console serial line, and the 8251A auxiliary serial line. The DLART and the 8251A have EIA drivers associated with them so that they can communicate with RS232-C devices. The locations reserved for use by the peripheral chips are listed in Table 6-1.

Table 6-1 Reserved I/O Locations for Peripheral Chips

Location Number	Location Type	Use
177566	Read/write	DLART transmitter data buffer
177564	Read/write	DLART transmitter command/status register
177562	Read/write	DLART receiver data buffer
177560	Read/write	DLART receiver command/status register
177552	Read/write	8251A status register
177550	Read/write	8251A receiver data buffer
177544	Read/write	8255A port C (input from upper 4 bits)
177542	Read/write	8255A port B (8-bit input)
177452	Write only	8251A control register
177450	Write only	8251A transmit data buffer
177446	Write only	8255A command register
177444	Write only	8255A port C (output to lower 4 bits)
177442	Write only	8255A port B (8-bit output)
177440	Write only	8255A port A (8-bit output)

6.5.1 Parallel Port (8255A)

The 8255A parallel port chip has two 8-bit ports and two 4-bit ports, all independently controllable. Port A (8 bits) is dedicated to supplying LED segment data to the LED segment drivers. Port A is configured as output only. Port B (8 bits) is initially configured as an input port and is available to your expansion hardware via the 60-pin connector. You can configure port B as either an input port or an output port. Port C is really two independent 4-bit ports. The upper four bits of port C are dedicated to sensing keypresses and are configured as input only. The lower four bits of port C are dedicated to turning on the LEDs and enabling the keypad. These lower four bits are configured as output only.

For detailed information on programming the 8255A, refer to the Intel Component Data Catalog (available from Intel Corp., 3065 Bowers Ave., Santa Clara, CA 95051). The order number is 210298-001.

6.5.2 DLART Console Serial Line

The DLART (DC319-AA) is an asynchronous receiver/transmitter which the DCT11-EM uses to communicate with a console terminal.

The DLART can generate receiver, transmitter, and break detection interrupt requests. See Paragraph 6.11 for more information on interrupts.

The 800 Hz clock output of the DLART is used to generate the INTA interrupt request which causes the LEDs and keypad to be activated. Again, see Paragraph 6.11.

Detailed information on programming the DLART is contained in the *DLART Data Sheet* (ED-23181).

6.5.3 Auxiliary Serial Line (8251A)

The 8251A auxiliary serial line chip is a universal synchronous/asynchronous receiver/transmitter (USART) which the DCT11-EM uses for general purpose asynchronous serial communications. Typically, the auxiliary serial line is used for communicating with a host computer.

The auxiliary serial line features modem control. The Data Carrier Detect and the SYNDET functions of the 8251A, however, are not used in the DCT11-EM.

For detailed information on programming the 8251A, refer to the Intel Component Data Catalog (available from Intel Corp., 3065 Bowers Ave., Santa Clara, CA 95051). The order number is 210298-001.

6.6 INTERNAL DATA BUS BUFFER

The internal data bus buffer is not accessible to you directly but is the buffer through which most of the data in the DCT11-EM passes. It buffers DAL<15:00>, the microprocessor's primary data bus.

6.7 USER BUFFERS

The DCT11-EM has three user buffers. One buffer provides access to DAL<15:00>, the main internal data bus. Another buffer provides access to AI<7:0>, the microprocessor's address interrupt lines. The third buffer provides access to various DCT11-EM control signals. These buffers are directly accessible through the 60-pin connector. See Paragraph 6.16 for the names of the specific buffered signals available.

6.8 PROCESSOR CYCLE DECODING

There is some decoding logic that takes microprocessor control signals and combines them to direct the operation of various chips within the DCT11-EM. Some of these decoded signals are available to you through one of the user buffers. See Paragraph 6.16 for the names of these buffered control signals.

6.9 ADDRESS LATCHING AND RANGE DECODING

Memory addresses are latched from DAL<15:00> when the microprocessor asserts ERAS L. As shown in Figure 6-1, the upper three bits of the latched address are converted (decoded) to signals which enable pairs of on-board ROMs or RAMs.

Decoded address range signals are also available to your expansion hardware via the 60-pin connector. These signals are ARD02 L, ARD03 L, and ARD17 L. Figure 6-2 illustrates the address ranges to which these signals correspond.

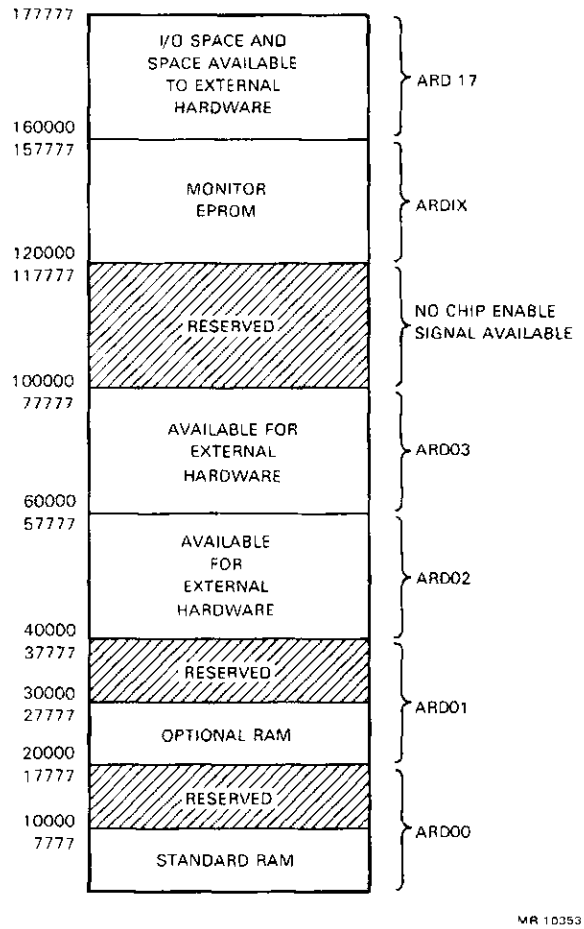


Figure 6-2 Address Range Decoding

6.10 PERIPHERAL CHIP ADDRESS DECODING

The peripheral chip decoding logic is similar in function to the address range decoding logic (see Paragraph 6.9). The difference is that this logic generates peripheral chip enable signals instead of memory chip enable signals. Peripheral chips are enabled according to the addressing scheme shown in Paragraph 6.5. The peripheral chip decoding signals are internal to the DCT11-EM and are unavailable for expansion hardware.

6.11 INTERRUPTS AND TRAPS

Interrupt vectors are located as shown in Table 6-2.

Interrupts are encoded and sent to the DCT11-AA for handling. The DCT11-AA also handles DMA requests and external vector requests via the interrupt logic.

Some of the interrupt vectors above point to a "null" service routine. That is, they simply point to an RTI instruction. These include the power-fail, DLART transmitter, external, and 8251A transmitter interrupts. If you do not write your own service routines and change the interrupt vectors accordingly, these interrupts will have no effect.

Table 6-2 Interrupt Vector Locations

Interrupt Vector Address	Priority	Type of Interrupt
-	-	HALT switch and HALT instruction
000024	-	Nonmaskable power fail interrupt (caused by pressing INT switch)
000060	4	DLART receiver (INT3)
000064	4	DLART transmitter (INT2)
000100	6	External interrupt (INTB)
000104	6	Keypad/LED scanning (INTA)
000120	5	8251A receiver (INT7)
000124	5	8251A transmitter (INT6)
000140	7	DLART receiver break (INTF)

Other vectors include the following.

Vector Address	Description
000010	Illegal instruction trap
000014	Breakpoint and trace service

6.12 TIMING

Fundamental timing signals are generated by:

1. A 7.5 MHz crystal oscillator which drives the DCT11-AA microprocessor
2. A 614.4 KHz clock which drives the DLART.

The 7.5 MHz signal is also divided down to 1.875 MHz to drive the 8251A auxiliary serial line. These signals are unavailable for external use.

6.13 MISCELLANEOUS CONTROL LOGIC

There are pieces of logic spread throughout the DCT11-EM that generate miscellaneous control signals. The only signal that the miscellaneous control logic makes available to you is the signal RDY L, which, when asserted, causes a single cycle slip. Note that the installation of the jumper disables the on-board generation of RDY L.

6.14 KEYPAD/LEDS

The keypad/LEDs combination communicates with the rest of the DCT11-EM through the 8255A parallel port peripheral chip (see Paragraph 6.5.1). Note that the lower four bits of port C are decoded and are used to drive the LED anodes and keypad simultaneously. These lines are asserted sequentially in response to the INTA interrupt request.

6.15 HALT AND INT SWITCHES

The operaton of the HALT and INT switches is explained in Paragraphs 3.9 and 3.10, respectively. To summarize, pressing the HALT switch asserts the HALT signal which restarts the keypad monitor and unconditionally stops whatever operation was in progress. Pressing the INT switch asserts the PF signal which causes a power-fail interrupt. Power-fail interrupts have no effect unless you write a service routine (vectored by location 24) to handle the interrupts.

Both HALT and PF are available to you via the 60-pin expansion connector.

6.16 CONNECTORS

There are four male connectors on the DCT11-EM as follows.

Connector	Number of Pins	Function
J1	60	Connector for expansion hardware
J2	4	Power supply connector
J3	25	Auxiliary serial line
J4	25	Console serial line

J1, J3, and J4 are all standard size connectors. J2 is the connector you assembled when you installed the DCT11-EM.

The pin assignments of these connectors are listed in Table 6-3.

Table 6-3 DCT11-EM Connector Pin Assignments

60-Pin Connector for Expansion Hardware (J1) (see Figure 6-3)

Pin Number	Signal Name	Description
1	AD00 H	AD<15:00> is the buffered version of DAL<15:00>, the bidirectional multiplexed data/address lines of the DCT11-AA.
2	AD01 H	
3	AD02 H	
4	AD03 H	
5	AD04 H	
6	AD05 H	
7	AD06 H	
8	AD07 H	
9	AD08 H	
10	AD09 H	
11	AD10 H	
12	AD11 H	
13	AD12 H	
14	AD13 H	
15	AD14 H	
16	AD15 H	
17	AI0 H	AI<7:0> is the buffered version of the DCT11-AA's AI<7:0> address interrupt lines. Output only. During DMA transactions, these lines are set to the high impedance state.
18	AI1 H	
19	AI2 H	
20	AI3 H	
21	AI4 H	
22	AI5 H	
23	AI6 H	
24	AI7 H	
25	GND	
26	RESET L	Buffered control signal. Output only. Corresponds to the DCT11-AA's –BCLR signal.
27	PB0 H	PB<7:0> are the bidirectional port B lines of the 8255A parallel port chip.
28	PB1 H	
29	PB2 H	
30	PB3 H	
31	PB4 H	
32	PB5 H	
33	PB6 H	
34	PB7 H	
35	HALT L	Asserted when HALT switch is pressed. Open collector.

Table 6-3 DCT11-EM Connector Pin Assignments (Cont)

60-Pin Connector for Expansion Hardware (J1) (see Figure 6-3)

Pin Number	Signal Name	Description
36	PF L	Asserted when INT switch is pressed. Open collector.
37	DMR L	External DMA request line. Input only.
38	INTB L	External interrupt request line. Input only.
39	VEC L	External vector request line. Input only.
40	PI H	Buffered control signal. Corresponds to the DCT11-AA's PI signal. Output only.
41	GND	
42	ARD02 H	Decoding signal for the address range 040000–057777. Output only.
43	ARD03 H	Decoding signal for the address range 060000–077777. Output only.
44	ARD17 L	Decoding signal for the address range 160000–177777. Output only.
45	IACK L	Buffered control signal. Interrupt acknowledge. Output only.
46	DMG L	Buffered control signal. DMA acknowledge. Output only.
47	SEL1 H	Buffered control signal. Corresponds to DCT11-AA's SEL1 signal. Output only.
48	SEL0 H	Buffered control signal. Corresponds to DCT11-AA's SEL0 signal. Output only.
49	WLB L	Buffered control signal. Corresponds to DCT11-AA's R/–WLB signal. Set to high impedance state during DMA. Input or output.
50	WHB L	Buffered control signal. Corresponds to DCT11-AA's R/–WHB signal. Set to high impedance state during DMA. Input or output.
51	GND	
52	RAS L	Buffered control signal. Corresponds to DCT11-AA's –RAS signal. Output only.
53	GND	
54	CAS L	Buffered control signal. Corresponds to DCT11-AA's –CAS signal. Output only.
55	GND	
56	DBIN L	Buffered control signal. Read enable line. Output only.
57	GND	
58	COUT H	Buffered control signal. Corresponds to DCT11-AA's COUT signal. Output only.
59	GND	
60	RDY L	Causes single cycle slip when asserted. Open collector.

Table 6-3 DCT11-EM Connector Pin Assignments (Cont)

Power Supply Connector (J2)

Pin Number	Signal Name	Description
1	+12VDC	Power signal
2	+5VDC	Power signal
3	GND	
4	−12VDC	Power signal

Auxiliary Serial Line Connector (J3)

Pin Number	Signal Name	Description
1	FGND	Frame ground
2	PCSO	Serial data out
3	PCSI	Serial data in
4	PRTS	Request to send
5	PCTS	Clear to send
6	PDSR	Data set ready
7	GND	Signal ground
8	–	Not used
9	–	Not used
10	–	Not used
11	–	Not used
12	–	Not used
13	–	Not used
14	–	Not used
15	–	Not used
16	–	Not used
17	–	Not used
18	–	Not used
19	–	Not used
20	PDTR	Data terminal ready
21	–	Not used
22	–	Not used
23	–	Not used
24	–	Not used
25	–	Not used

Table 6-3 DCT11-EM Connector Pin Assignments (Cont)

Console Serial Line Connector (J4)

Pin Number	Signal Name	Description
1	FGND	Frame ground
2	DLSO	Serial data out
3	DLSI	Serial data in
4	RTS	Request to send (always ON)
5	–	Not used
6	–	Not used
7	GND	Signal ground
8	–	Not used
9	–	Not used
10	–	Not used
11	–	Not used
12	–	Not used
13	–	Not used
14	–	Not used
15	–	Not used
16	–	Not used
17	–	Not used
18	–	Not used
19	–	Not used
20	DTR	Data terminal ready (always ON)
21	–	Not used
22	–	Not used
23	–	Not used
24	–	Not used
25	–	Not used

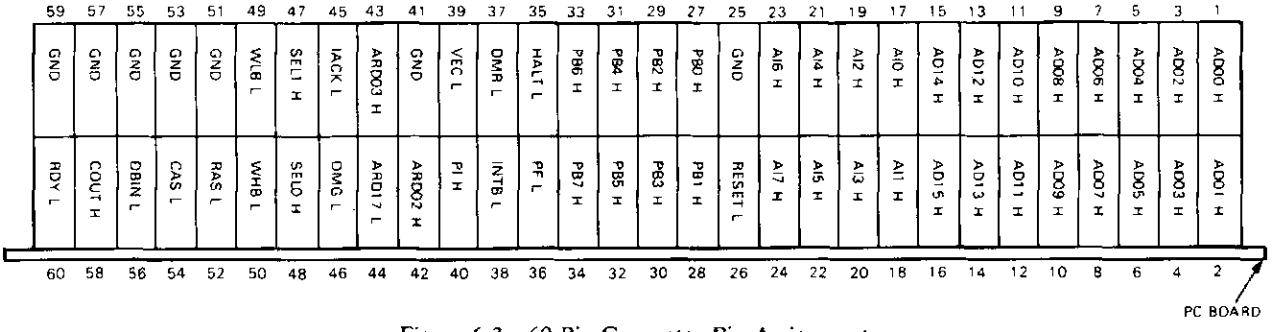


Figure 6-3 60-Pin Connector Pin Assignments

6.17 HARDWARE EXPANSION – EXAMPLE

If you plan to develop and run large programs, one of the first expansion hardware circuits you may want to build is a memory module. Figure 6-4 shows a design for a 16 KB module.

The module responds to addresses 040000 through 077777. The address range decoding signals, ARD02 H and ARD03 H, are used to enable the module.

Note that the signal names on connector J1 of the memory module are in the opposite order as those shown on connector J1 of the DCT11-EM. This scheme eliminates the need to twist the interconnecting cable.

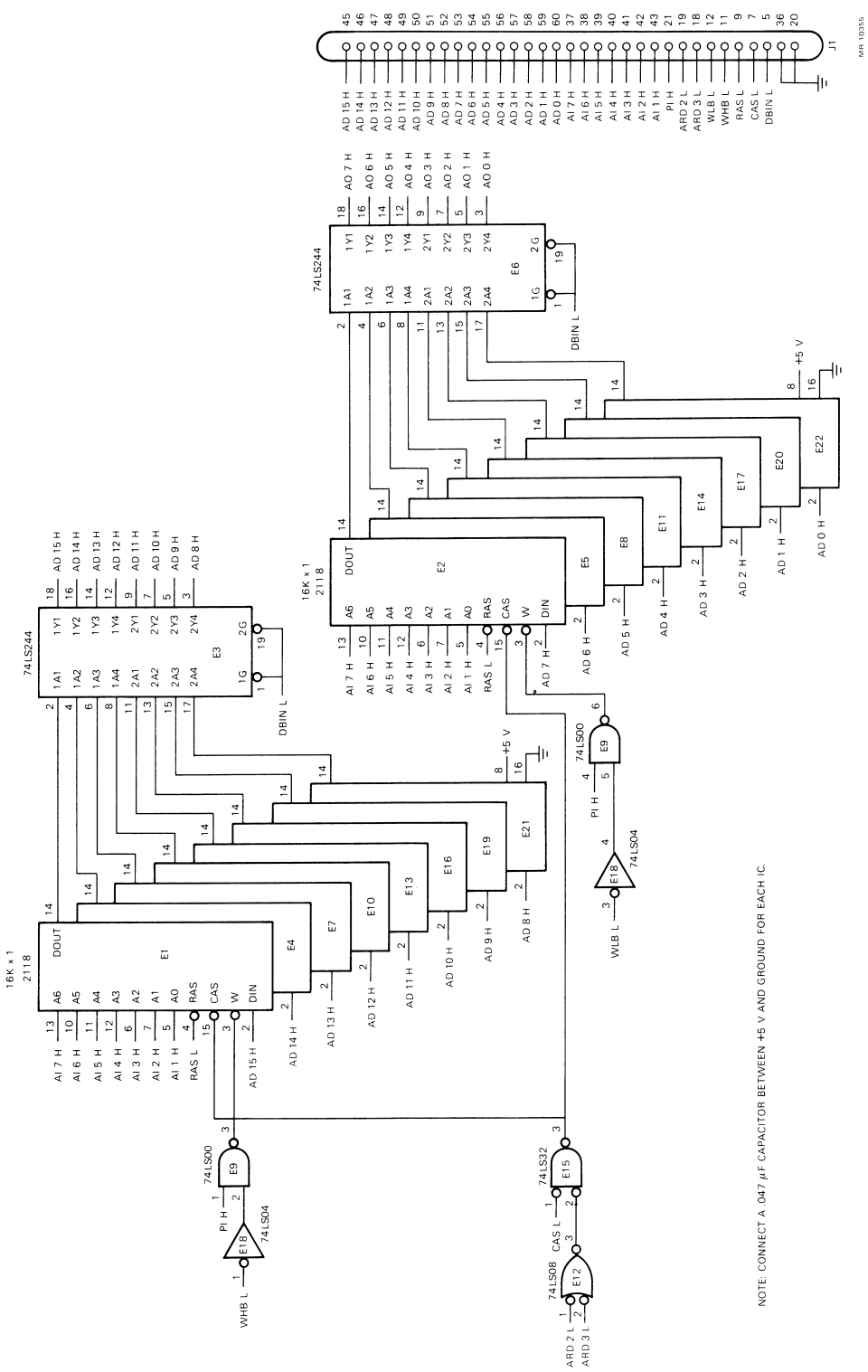


Figure 6-4 16 KB Memory Module

APPENDIX A
MONITOR LISTING

```
T-11 Evaluation Module Monitor  MACRO V05.00  Sunday 13-Mar-83 04:10
Table of contents

 2-  4      Definitions
 3-  2      Scratchpad locations in high RAM
 5-  3      Console Serial Line Support Routines
11-  2      General I/O Support Routines
15-  2      Host Line Support Routines
17-  2      I/O Initialization and LED Driver
20-  2      LED Display Support Routines
27-  2      Error Condition and Startup Entry Code
32-  2      Entry Points
34-  2      Keypad Monitor
35-  2      Key Command Routines
36-  2      Special Keypad Monitor Functions
37-  2      Console Monitor
39-  2      Parsing Routines
44-  2      Directive and Verb Handling Routines
45-  2      Symbol and Label Handling Routines
48-  2      Arithmetic Routines
49-  2      Instruction Encode/Decode Routines
51-  2      Conversion and Typeout Routines
57-  2      Power-up Diagnostics
58-  2      Special Data Structures
59-  2      Spare Locations, Checksum, and ROM I.D.
```

```
                        .ENABL  LC
                ;
                ;               T-11  EVALUATION  MODULE  MONITOR
                ;
                ;               Version 1.0      S.E.C. Hudson, Ma.
                ;
                ;
                ;                       COPYRIGHT (C) 1982 BY
                ;             DIGITAL EQUIPMENT CORPORATION, MAYNARD, MASS.
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                ;
```

```
                                .TITLE T-11 Evaluation Module Monitor
                                .IDENT  /00.001/
                                .SBTTL Definitions

000000                          R0      =%0             ;Registers
000001                          R1      =%1
000002                          R2      =%2
000003                          R3      =%3
000004                          R4      =%4
000005                          R5      =%5
000006                          SP      =%6
000007                          PC      =%7

000024                          PFVEC   ==024           ;power fail vector, called by INT button
000060                          CONIN   ==060           ;DLART receiver interrupt vector
000064                          CONOUT  ==064           ;DLART transmitter interrupt vector
000120                          AUXIN   ==120           ;8251 receiver interrupt vector
000124                          AUXOUT  ==124           ;8251 transmitter interrupt vector
000100                          USERIV  ==100           ;uncommitted interrupt vector
000104                          LEDIV   ==104           ;LED display interrupt vector
000140                          CONBRK  ==140           ;DLART break interrupt vector

177440                          P$PORA  ==177440        ;8255 port A (write only)
177542                          P$PORI  ==177542        ;port B (read only) available to user
177442                          P$PORO  ==177442        ;port B (write only) available to user
177444                          P$PORC  ==177444        ;port C (write only) controls bits 3-0
177544                          P$PORD  ==177544        ;port C (read only) reads bits 7-4
177446                          P$CREG  ==177446        ;8255 command register (write only)

177550                          A$RBUF  ==177550        ;8251 receiver data buffer (read only)
177450                          A$XBUF  ==177450        ;8251 transmitter data buffer (write only)
177552                          A$SREG  ==177552        ;8251 status register (read only)
177452                          A$CREG  ==177452        ;8251 command register (write only)

177560                          C$RCSR  ==177560        ;DLART receiver command/status register
177562                          C$RBUF  ==177562        ;DLART receiver data buffer
177564                          C$XCSR  ==177564        ;DLART transmitter command/status register
177566                          C$XBUF  ==177566        ;DLART transmitter data buffer
```

```
                                .SBTTL  Scratchpad locations in high RAM

000000                          .ASECT

006500          SCRPD1  ==      6500            ;7000           ;bottom of default console monitor scratch
                                                ;default symbol table--66. symbol capacity
007320          TBLTOP  ==      SCRPD1+620      ;top of symbol table, 2 words of name scratch

006500          $UR     ==      6500            ;TBLTOP-<66.*6>


                ;console monitor flag byte pairs--must start at even address

007324          LINFLG  ==      TBLTOP+4        ;flags related to parsing of whole lines
007325          LASLIN  ==      LINFLG+1        ;saved flags from previous line
000001                  F.SST1  =001            ;line contained STEP command
000004                  F.NULL  =004            ;line is (functionally) empty
000010                  F.SAVX  =010            ;we have saved expr for double param commands
000020                  F.COMM  =020            ;we are in a comment, ignore characters

007326          CURCOM  ==      LASLIN+1        ;current command flags
007327          LASCOM  ==      CURCOM+1        ;saved flags from previous command
000001                  F.MNEM  =001            ;was an instruction mnemonic
000002                  F.VALU  =002            ;an undefined symbol or directive
000004                  F.UNDF  =004            ;expression doesn't contain undefined symbols
000010                  F.USRD  =010            ;was a user defined symbol or label

007330          TMPMOD  ==      LASCOM+1        ;current output mode flags
007331          PERMOD  ==      TMPMOD+1        ;permanent output mode flags
000002                  F.ABS   =002            ;absolute values, not symbolic output
004000                  F.VT    =<400*010>              ;vt mode on or off
000100                  F.INST  =100            ;instruction output
                                                ;if neither ASCII nor instruction, then numeric
000200                  F.BYTM  =200            ;byte mode

007332          EXPFLG  ==      PERMOD+1        ;current expression flags

007333          LEVEL   ==      EXPFLG+1        ;parenthesis level in expression
```

```
                        ;other variables:
007334          ADVADR  ==      LEVEL+1         ;due to the varied uses of this location, a
                        ;complete list is in order:
                        ;DOCR:  When dumping locations in response to a <CR>, the next address
                        ;       after that which has been dumped is saved in case the next
                        ;       command line requests another dump.  The value of ADVADR need
                        ;       only be kept intact between two successive empty command lines.
                        ;$.BYTE, $.WORD, GETINS, subroutines of GETINS:
                        ;       These routines use ADVADR as a running copy of the current
                        ;       address.  The current address, as stored in @#$ADDR, must not
                        ;       be changed as successive values are deposited into RAM by a
                        ;       single instruction or directive, because this would alter the
                        ;       value of the dot (.) symbol (current location reference).
                        ;DOSYMB:uses ADVADR to save R2, which points to the name to be defined,
                        ;       while the value to be equated is parsed.  The value saved in
                        ;       R2 is an index to the name on the left of the equals sign, if
                        ;       the name is one of the predefined symbols or a user symbol that
                        ;       has already been defined.
                        ;TYPREG:uses ADVADR as a pointer to the list of registers to be typed.
                        ;EFND:  uses ADVADR to save the upper search range limit before parsing
                        ;       the value and mask parameters.

007336          SAVEXP  ==      ADVADR+2        ;saved expr value for double parameter commands

007340          COUNT1  ==      SAVEXP+2        ;counter for upper level routines
007341          COUNT2  ==      COUNT1+1        ;counter for lower level routines

007342          MODE    ==      COUNT2+1        ;addressing mode scratch--must be even address
007343          OPERAT  ==      MODE+1          ;save operator here in expressions

007344          CNTLC   ==      OPERAT+1        ;CNTLC<0> set to 1 when console types ^C and
                                                ;F.APPL is set, meaning that the
                                                ;currently running program has a ^C handler

007345          DELIM   ==      CNTLC+1         ;the .ASCII directive stores the delimiter here

                                                ;now at 7346, bottom of console monitor stack
007346          BOTTOM  ==      DELIM+1         ;console monitor has 38 word stack
                                                ;NOTE: interrupts need up to 11 stack locations

007400          SCRPAD  ==      BOTTOM+32       ;now at 7400, bottom of keypad monitor scratch
007462          STACK   ==      SCRPAD+62       ;25 word stack for keypad monitor

007462          TBLBOT  ==      STACK           ;pointer to bottom of symbol table space in use
007464          MF8251  ==      STACK + 2       ;8251 mode flags
007466          REPEAT  ==      STACK + 4       ;console monitor command line repeat counter
007470          BUFFER  ==      REPEAT+2        ;96 character console line input buffer
007630          BP      ==      BUFFER+140      ;buffer back pointer, must be even address
007631          FP      ==      BP+1            ;buffer forward pointer, must follow BP
007632          HOSTBF  ==      FP+1            ;32 character host input buffer
007672          HFP     ==      HOSTBF+40       ;buffer forward pointer
007673          HSTFLG  ==      HFP+1           ;host flags
000200                  F.LOAD  =200            ;1 = taking input from host
000100                  F.LDST  =100            ;1 = looking for .START to begin loading
```

Scratchpad locations in high RAM

```
    58        000001                    F.BYTB  =001          ;1 = ignoring message from host (byte bucket)
    59
    60        007674          PWRFVS    ==      HSTFLG+1      ;save user's power fail vector here
    61        007676          KEYPIV    ==      PWRFVS+2      ;keypress service vector
    62        007700          KEYPVS    ==      KEYPIV+2      ;save user's keypress vector here
    63        007702          USERVS    ==      KEYPVS+2      ;save user's interrupt vector here
    64        007704          DEBNCE    ==      USERVS+2      ;keypad debounce register
    65        007706          FLAGS1    ==      DEBNCE+2      ;flag bits, defined as follows
    66        000001                    F.DATA  =000001       ;1 = data entry mode
    67        000002                    F.CHAN  =000002       ;1 = numeric key pressed after opening location
    68        000004                    F.ADDR  =000004       ;1 = address entry mode
    69        000010                    F.REG   =000010       ;1 = register selection mode
    70        000020                    F.BRKS  =000020       ;1 = breakpoint selection mode
    71        000040                    F.FUNC  =000040       ;1 = special function selection mode
    72        000100                    F.USER  =000100       ;1 = executing user code
    73        000200                    F.SST   =000200       ;1 = single stepping
    74        000400                    F.BRKA  =000400       ;1 = breakpoints active (installed)
    75        001000                    F.BRKG  =001000       ;1 = currently stepping over a breakpoint
    76        002000                    F.KEYP  =002000       ;1 = running console monitor
    77        004000                    F.HOST  =004000       ;1 = accepting console commands from both ports
    78        010000                    F.APPL  =010000       ;1 = running program with ^C handler
    79        020000                    F.TBAS  =020000       ;1 = print address break point is at
    80        040000                    F.PROT  =040000       ;1 = monitor scratch protection disabled
    81        100000                    F.PAS1  =100000       ;1 = console monitor PASS1 mode active
    82
    83        007710          CONFLG    ==      FLAGS1+2      ;console line flags, must be even address
    84        000002                    F.STOP  =002          ;control S pressed, execution suspended
    85        000010                    F.CPB0  =010          ;programmable baud rate stored here
    86        000020                    F.CPB1  =020
    87        000040                    F.CPB2  =040
    88        000200                    F.A64X  =200          ;aux port mode word bit<0>, selects 16X or 64X
    89
    90        007711          AUXFLG    ==      CONFLG+1      ;copy of what has been written to A$CREG
    91
    92        007712          SEGBUF    ==      AUXFLG+1      ;6 word segment data buffer for LED displays
    93                                                        ;high byte for upper display, low for lower
    94        007726          SPCLBF    ==      SEGBUF+14     ;1 word buffer for special 2 character display
    95        007730          TIME      ==      SPCLBF+2      ;upper 6 bits count 60 seconds, lower 10 count
    96                                                        ;eighthundredths of seconds
    97        007732          $R0       ==      TIME+2        ;save user context here
    98        007734          $R1       ==      $R0+2
    99        007736          $R2       ==      $R1+2
   100        007740          $R3       ==      $R2+2
   101        007742          $R4       ==      $R3+2
   102        007744          $R5       ==      $R4+2
   103        007746          $SP       ==      $R5+2
   104        007750          $PC       ==      $SP+2
   105        007752          $PS       ==      $PC+2
   106        007754          $WATCH    ==      $PS+2         ;watchpoint address
   107        007756          $ADDR     ==      $WATCH+2      ;current address
   108        007760          BRKFIL    ==      $ADDR+2       ;file of four breakpoint address,contents pairs
```

```
                                        .SBTTL  Console Serial Line Support Routines

        133000                  .       =       133000


                                ;++
                                ;   LINEIN answers console input interrupts and buffers the incoming characters.
                                ;   The characters ^@, ^C, ^O, ^Q, ^S, and ^Y and trapped in this routine.
                                ;--

133000  010046                  LINEIN::MOV     R0,-(SP)        ;preserve some registers for scratch
133002  010146                          MOV     R1,-(SP)
133004  113700  177560          1$:     MOVB    @#C$RCSR,R0     ;read console receiver status register
133010  100375                          BPL     1$              ;in polled mode, wait for a character
133012  013700  177562                  MOV     @#C$RBUF,R0     ;read console receiver
133016  100005                          BPL     2$              ;no error bits set
133020  012700  000007          5$:     MOV     #007,R0         ;on error, output <BELL>
133024  004767  000510                  JSR     PC,CHR01
133030  000457                          BR      9$              ;ignore character, continue

133032  042700  177600          2$:     BIC     #177600,R0      ;clear all but 7 bits
133036  001454                          BEQ     9$              ;ignore ASCII nulls
133040  120027  000003                  CMPB    R0,#003         ;is it ^C?
133044  001454                          BEQ     6$              ;yes
133046  120027  000031                  CMPB    R0,#031         ;is it ^Y?
133052  001461                          BEQ     7$              ;yes
133054  132737  000002  007710          BITB    #F.STOP,@#CONFLG;are we waiting for ^Q?
133062  001407                          BEQ     3$              ;no
133064  120027  000021                  CMPB    R0,#021         ;is it ^Q?
133070  001345                          BNE     1$              ;no, wait for one
133072  142737  000002  007710          BICB    #F.STOP,@#CONFLG;clear ^S flag
133100  000433                          BR      9$              ;ignore character, continue

133102  120027  000023          3$:     CMPB    R0,#023         ;is it ^S?
133106  001006                          BNE     4$              ;no
133110  152737  000002  007710          BISB    #F.STOP,@#CONFLG;set ^S flag to suspend execution
133116  106427  000200                  MTPS    #200            ;accept other interrupts while suspended
133122  000730                          BR      1$              ;wait for ^Q

133124  120027  000017          4$:     CMPB    R0,#017         ;is it ^O?
133130  001004                          BNE     8$              ;no
133132  152737  000001  007673          BISB    #F.BYTB,@#HSTFLG;turn on host line byte bucket
133140  000413                          BR      9$

133142  113701  007631          8$:     MOVB    @#FP,R1         ;get buffer input pointer
133146  042701  177400                  BIC     #177400,R1      ;prevent sign extend
133152  120127  000140                  CMPB    R1,#140         ;is buffer full?  (96 characters)
133156  103320                          BHIS    5$              ;yes, send <BELL>
133160  110061  007470                  MOVB    R0,BUFFER(R1)   ;no, store character
133164  105237  007631                  INCB    @#FP            ;advance pointer

133170  012601                  9$:     MOV     (SP)+,R1        ;restore registers
133172  012600                          MOV     (SP)+,R0
133174  000002                          RTI                     ;and continue
```

```
    58 133176  032737  030000  007706  6$:     BIT     #F.APPL!F.TBAS,@#FLAGS1 ;stop on ^C?
    59 133204  001404                          BEQ     7$              ;yes, not running program with ^C handler
    60 133206  152737  000001  007344          BISB    #1,@#CNTLC      ;no, just set flag for application program
    61 133214  000765                          BR      9$              ;and return
    62
    63 133216  012700  054536          7$:     MOV     #400*131!136,R0 ;^C and ^Y terminate execution
    64 133222  004767  000302                  JSR     PC,CHROUT       ;type "^Y"
    65 133226  042737  000300  007706          BIC     #F.USER!F.SST,@#FLAGS1  ;clear user program flags
    66 133234  000167  004330                  JMP     $MONIT          ;remove breakpoints, enter monitor
```



```
     1
     2
     3                                  ;++
     4                                  ;   GETLIN prompts for a line from the console, and returns with the line in
     5                                  ;   BUFFER and R3 cleared.  Upon entry, BP should index the buffer position
     6                                  ;   just beyond the last character previously taken from the buffer (if typeahead
     7                                  ;   characters are desired).  To throw away the typeahead characters, set BP and
     8                                  ;   FP to zero.
     9                                  ;   The characters typed on the console (and any earlier typeahead characters)
    10                                  ;   are echoed to the console following the prompt, "> ".  Note that the ECHO
    11                                  ;   routine, which was specialized for use with monitor command input, echoes
    12                                  ;   control characters as "^"<character> until a semicolon is found on the line.
    13                                  ;   Control characters to the right of a semicolon (i.e. within a "comment") are
    14                                  ;   echoed invisibly so that the user can echo control sequences to the console
    15                                  ;   terminal.
    16                                  ;
    17                                  ;   Uses:       BP  Index to BUFFER location just beyond last fetched character
    18                                  ;                   (which is the location that contains the first character in
    19                                  ;                   the new line)
    20                                  ;
    21                                  ;   Returns:
    22                                  ;               BP      Cleared
    23                                  ;               R3      Cleared
    24                                  ;               BUFFER  Locations indexed by entry value of BP through the end of the
    25                                  ;                       buffer replace contents of locations at the beginning of the
    26                                  ;                       buffer
    27                                  ;               FP      Adjusted to index the new next available location in the buffer
    28                                  ;--
    29
    30 133240  105037  007324          GETLIN::CLRB    @#LINFLG        ;reset line parsing flags for new line
    31 133244  004767  000200                  JSR     PC,PURGE        ;purge bottom of buffer, clear running pointer
    32
    33 133250  004767  000250          1$:     JSR     PC,CRLF         ;start a new line
    34 133254  012700  020076                  MOV     #400*040!076,R0 ;type > <SPACE>
    35 133260  004767  000244                  JSR     PC,CHROUT
    36 133264  123703  007631          2$:     CMPB    @#FP,R3         ;see if a character has been typed
    37 133270  001775                          BEQ     2$              ;no, wait for one
    38 133272  004767  000644                  JSR     PC,ECHO         ;echo character to console
    39 133276  126327  007467  000015        CMPB    BUFFER-1(R3),#015       ;is last character a <CR>?
    40 133304  001367                          BNE     2$              ;no, wait for one
    41 133306  105037  007324                  CLRB    @#LINFLG        ;reset line flags from ECHO
    42 133312  005003                          CLR     R3              ;set running pointer to beginning of line
    43 133314  000207                          RTS     PC              ;return to caller
```

```
                                ;++
                                ;   GETCH retrieves characters from the input buffer using R3 as an index.
                                ;   The character is placed in the lower 7 bits of R0.  Lower case characters
                                ;   are folded to upper case.  The N flag is set if the character is a separator
                                ;   (space, horizontal tab, vertical tab, line feed, or form feed) and the C flag
                                ;   is set if the character has been folded.  Upon entry, R3 must index a byte
                                ;   within the console input buffer (R3 < 140 octal or 96. decimal).
                                ;
                                ;   Uses:  R3           Index to next character in console input buffer (BUFFER)
                                ;
                                ;   Returns:
                                ;          R0           Contains character fetched from BUFFER in lower 7 bits,
                                ;                       upper bits cleared
                                ;          R3           Set to previous value + 1
                                ;          N,C          See comments above
                                ;--

133316  116300  007470  GETCH:: MOVB    BUFFER(R3),R0   ;yes, get a character--bit 7 should be clear
133322  005203                 INC     R3
133324  120027  000011          CMPB    R0,#011         ;is it less than <TAB>?
133330  103423                 BLO     3$              ;yes, not a separator
133332  120027  000040          CMPB    R0,#040         ;is it a space?
133336  001403                 BEQ     2$              ;yes, a separator
133340  120027  000014          CMPB    R0,#014         ;is it <FF> or lower?
133344  101003                 BHI     4$              ;no, check for lower case
133346  000270          2$:    SEN                     ;flag a separator
133350  000241                 CLC
133352  000207                 RTS     PC

133354  120027  000141  4$:    CMPB    R0,#141         ;is it lower case 'a'?
133360  103407                 BLO     3$              ;no, don't fold
133362  120027  000172          CMPB    R0,#172         ;is it lower case 'z'?
133366  101004                 BHI     3$              ;no, don't fold
133370  162700  000040          SUB     #040,R0         ;fold to upper case
133374  000261                 SEC                     ;flag folded character
133376  000401                 BR      5$

133400  000241          3$:    CLC                     ;flag a normal character
133402  000250          5$:    CLN
133404  000207                 RTS     PC
```

```
                                        .ENABL  LSB
                                ;++
                                ;   GETLCH recovers the most recently gotten character.
                                ;
                                ;   Uses:       R3      Index to location in BUFFER just beyond character to be
                                ;                       returned
                                ;
                                ;   Returns:
                                ;               R3      Equal to previous value
                                ;               R0      Contains fetched character in lower 7 bits, upper bits cleared
                                ;               N,C     (See header of GETCH routine)
                                ;--

133406  005303                GETLCH::DEC     R3
133410  000742                        BR      GETCH

                                ;GETCHC is like GETCH except it doesn't fold lower case.
133412  004767  177700        GETCHC::JSR     PC,GETCH
133416  103002                2$:     BCC     1$
133420  062700  000040                ADD     #040,R0
133424  000207                1$:     RTS     PC


                                ;++
                                ;   GETNXT is like GETCH except it doesn't return separators.
                                ;
                                ;   (See usage information of GETCH)
                                ;--

133426  004767  177664        GETNXT::JSR     PC,GETCH
133432  100775                        BMI     GETNXT
133434  000207                        RTS     PC
                                        .DSABL LSB


                                ;++
                                ;   GETBP places the back pointer in R3 and prevents sign extension.  This is
                                ;   useful to refetch characters from a line (providing BP still indexes the
                                ;   beginning of the line).
                                ;
                                ;   Uses:       BP      Index to be transferred to R3
                                ;
                                ;   Returns:
                                ;               R3      Contains value in BP
                                ;--

133436  113703  007630        GETBP:: MOVB    @#BP,R3
133442  042703  177400                BIC     #177400,R3
133446  000207                        RTS     PC
```

```
                                ;++
                                ;   PURGE shifts the input buffer to eliminate space below BP, the back pointer.
                                ;   Console input interrupts are blocked while the shift is occurring.  R3, the
                                ;   running pointer, is cleared.
                                ;
                                ;   Uses:       BP      Index of first location to be kept in console input buffer
                                ;                       (Locations below BUFFER+[BP] are overwritten)
                                ;               FP      Index of first unused location in BUFFER
                                ;
                                ;   Returns:
                                ;               BP      Cleared
                                ;               R3      Cleared
                                ;               FP      Indexes new first unused location in BUFFER
                                ;--

133450  106746          PURGE:: MFPS    -(SP)           ;save priority
133452  106427  000340          MTPS    #340            ;disable interrupts temporarily
133456  004767  177754          JSR     PC,GETBP        ;get back pointer
133462  005000                  CLR     R0              ;make a pointer to the bottom of the buffer
133464  120337  007631  2$:     CMPB    R3,@#FP         ;has entire buffer been transferred?
133470  103006                  BHIS    1$              ;yes
133472  116360  007470  007470  MOVB    BUFFER(R3),BUFFER(R0)   ;transfer a character
133500  005200                  INC     R0
133502  005203                  INC     R3
133504  000767                  BR      2$

133506  110037  007631  1$:     MOVB    R0,@#FP         ;fix forward pointer,
133512  105037  007630          CLRB    @#BP            ;back pointer,
133516  005003                  CLR     R3              ;and running pointer
133520  106426                  MTPS    (SP)+           ;restore priority
133522  000207                  RTS     PC


                                ;++
                                ;   CRLF sends a carriage return and line feed to the console (and printer).
                                ;
                                ;   Returns:
                                ;               R0      Contains garbage (400 * 15 + 12)
                                ;--

133524  012700  005015  CRLF:: MOV     #400*012+015,R0 ;<CR>, <LF>
```

```
 1
 2                                ;++
 3                                ;   CHROUT outputs the lower byte of R0 to the console, and to the aux port
 4                                ;   if the printer port bit is set.  If the upper byte of R0 is non-zero,
 5                                ;   it is also sent to the port(s).  CHRO1 outputs only the lower byte of R0,
 6                                ;   and CHRO2 can be used to output a character to the aux. port only.
 7                                ;
 8                                ;   Uses:       R0      Lower byte contains first ASCII character to be output
 9                                ;                       Upper byte contains zero or second character to be output
10                                ;--
11
12                                        .ENABL  LSB
13 133530  004767  000004          CHROUT::JSR     PC,CHRO1        ;output lower half of R0
14 133534  105700                          TSTB    R0              ;is there a second character?
15 133536  001431                          BEQ     1$              ;no
16
17 133540  105737  177564          CHRO1:: TSTB    @#C$XCSR        ;check console transmitter status register
18 133544  100375                          BPL     CHRO1           ;wait until transmitter ready bit is set
19 133546  110037  177566                  MOVB    R0,@#C$XBUF     ;then output a character
20 133552  000423                          BR      1$              ;no, done
21 133554  132737  000004  177552  CHRO2:: BITB    #004,@#A$SREG   ;is aux port transmitter empty?
22 133562  001774                          BEQ     CHRO2           ;no, wait until it is
23 133564  105737  177552                  TSTB    @#A$SREG        ;is DSR active?
24 133570  000240                          NOP                     ;placeholder for above line
25 133572  106746                          MFPS    -(SP)           ;save priority
26 133574  106427  000340                  MTPS    #340            ;block interrupts while we
27 133600  112737  000047  177452          MOVB    #047,@#A$CREG   ;enable aux port transmitter
28 133606  110037  177450                  MOVB    R0,@#A$XBUF     ;output a character
29 133612  113737  007711  177452          MOVB    @#AUXFLG,@#A$CREG ;restore previous aux port command word
30 133620  106426                          MTPS    (SP)+           ;restore priority
31 133622  000300                  1$:     SWAB    R0
32 133624  000207                          RTS     PC
33                                        .DSABL  LSB
```

```
                                        .SBTTL  General I/O Support Routines

                                ;++
                                ;   ASCOUT outputs the character in R0 to the port(s) if it is not a control
                                ;   character.  If so, the special sequences '^A' through '^_' are sent with
                                ;   exceptions <SP>, <ESC>, and <DEL>.
                                ;
                                ;   Uses:       R0      Lower 7 bits contain character to be printed
                                ;
                                ;   Returns:
                                ;               R0      Contains garbage
                                ;--

133626  042700  177600          ASCOUT::BIC     #177600,R0      ;make R0 a 7-bit character
133632  120027  000177                  CMPB    R0,#177         ;is it delete?
133636  001413                          BEQ     1$              ;yes, type <DEL>
133640  120027  000040                  CMPB    R0,#040         ;is it control?
133644  101331                          BHI     CHROUT          ;no, type it normally
133646  001416                          BEQ     5$              ;make spaces visible
133650  120027  000033                  CMPB    R0,#033         ;is it escape?
133654  001422                          BEQ     3$              ;yes, type <ESC>
133656  000300                          SWAB    R0              ;no, type ^(letter)
133660  062700  040136                  ADD     #400!100+136,R0 ;make it second character after '^'
133664  000721                          BR      CHROUT          ;and type it

133666  012700  042074          1$:     MOV     #400!104+074,R0 ;type <D
133672  004767  177632                  JSR     PC,CHROUT
133676  012700  046105                  MOV     #400!114+105,R0 ;type EL
133702  000415                          BR      4$

133704  012700  051474          5$:     MOV     #400!123+074,R0 ;type <S
133710  004767  177614                  JSR     PC,CHROUT
133714  012700  037120                  MOV     #400!076+120,R0 ;type P>
133720  000703                          BR      CHROUT

133722  012700  042474          3$:     MOV     #400!105+074,R0 ;type <E
133726  004767  177576                  JSR     PC,CHROUT
133732  012700  041523                  MOV     #400!103+123,R0 ;type SC
133736  004767  177566          4$:     JSR     PC,CHROUT
133742  012700  000076                  MOV     #076,R0         ;type >
133746  000670                          BR      CHROUT
```

```
 1
 2                                ;++
 3                                ;   PRINTA prints an ASCII string pointed to by R1.  The string must end with a
 4                                ;   blank byte.
 5                                ;
 6                                ;   Uses:      R1      Points to string of bytes to be printed
 7                                ;
 8                                ;   Returns:
 9                                ;               R1      Points to byte just beyond first byte in string containing zero
10                                ;--
11
12                                        .ENABL  LSB
13 133750  004767  177564         1$:     JSR     PC,CHRO1
14 133754  112100                 PRINTA::MOVB    (R1)+,R0        ;get a character from string
15 133756  001374                         BNE     1$              ;print it
16 133760  000207                         RTS     PC
17                                        .DSABL  LSB
18
```

```
                        ;++
                        ;   PRINT outputs a radix-50 string pointed to by R2.  The string must end with
                        ;   a blank word.
                        ;   PRINT1 outputs a single radix-50 triplet in R1.
                        ;   PRINT2 outputs a pair of radix-50 triplets pointed to by R2.  No terminator
                        ;   is needed.
                        ;   PRINT3 outputs the most significant radix-50 character in R1 and multiplies
                        ;   R1 by 40.  (PRINT3 is called 3 times by PRINT1.)
                        ;
                        ;   Uses:       R2      Points to RAD50 string to be printed (PRINT)
                        ;                       Points to RAD50 pair of words to be printed (PRINT2)
                        ;               R1      Contains RAD50 triplet to be printed (PRINT1)
                        ;                       Contains RAD50 character to be printed (PRINT3)
                        ;
                        ;   Returns:
                        ;               R2      Points to next word after blank word in RAD50 string (PRINT)
                        ;                       Points to word after the pair of words printed (PRINT2)
                        ;               R1      Contains zero (PRINT, PRINT1, PRINT2)
                        ;                       Contains <previous value of R1> MOD 1600. * 40. (PRINT3)
                        ;--

                                .ENABL  LSB
000016          1$:     JSR     PC,PRINT1       ;type the triplet
012201          PRINT::MOV      (R2)+,R1        ;get a triplet
001374                  BNE     1$              ;not the end yet
000207                  RTS     PC
                        .DSABL  LSB

012201          PRINT2::MOV     (R2)+,R1        ;get a triplet
004767  000002          JSR     PC,PRINT1       ;type it
012201                  MOV     (R2)+,R1        ;get another

004767  000004  PRINT1::JSR     PC,PRINT3       ;type the first character
004767  000000  PRINT4: JSR     PC,PRINT3       ;and the second

005000          PRINT3::CLR     R0              ;divide by successive subtraction
005200          1$:     INC     R0
162701  003100          SUB     #50*50,R1       ;try to subtract 1600.
103374                  BCC     1$              ;worked, no borrow
005300                  DEC     R0              ;fix R0
062701  003100          ADD     #50*50,R1       ;and R1
004767  000062          JSR     PC,R1X40        ;multiply R1 by 40
005700                  TST     R0
001413                  BEQ     2$              ;0 means space
020027  000033          CMP     R0,#033         ;032 means Z
103413                  BLO     3$              ;A through Z
001415                  BEQ     4$              ;033 means $
020027  000035          CMP     R0,#035         ;035 is undefined, but type *
001415                  BEQ     5$
062700  000022          ADD     #022,R0         ;0 through 9 and '.'
000167  177436  6$:     JMP     CHROUT

012700  000040  2$:     MOV     #040,R0         ;type space
000773                  BR      6$

062700  000100  3$:     ADD     #100,R0         ;A through Z
```

```
    58 134104  000770                      BR      6$
    59
    60 134106  012700  000044        4$:   MOV     #044,R0         ;type $
    61 134112  000765                      BR      6$
    62
    63 134114  012700  000052        5$:   MOV     #052,R0         ;type *
    64 134120  000762                      BR      6$
    65
    66 134122  006301                R1X40:: ASL     R1              ;multiply R1 by 8
    67 134124  006301                      ASL     R1
    68 134126  006301                      ASL     R1
    69 134130  010146                      MOV     R1,-(SP)        ;save 8 X
    70 134132  006301                      ASL     R1
    71 134134  006301                      ASL     R1              ;32 X
    72 134136  062601                      ADD     (SP)+,R1        ;plus 8 X makes 40 X
    73 134140  000207                      RTS     PC
    74
```

```
                                ;++
                                ;   ECHO reads the line buffer as characters are typed in and echoes them
                                ;   to the console (and printer, if selected).  Control characters are echoed
                                ;   as ^(letter) except within comments.  LINFLG is used to record comment status.
                                ;   If ECHO encounters ^R, ^U, ^X, or <DELETE>, it responds or modifies the line
                                ;   buffer accordingly.  ECHO begins echoing characters at the running pointer
                                ;   (R3) and continues until R3 = FP or a <CR> is found.
                                ;
                                ;   Uses:       R3      Index to first character in BUFFER to be echoed
                                ;               FP      Index to end of data in buffer
                                ;
                                ;   Returns:
                                ;               R3      Index to location in BUFFER logically just beyond last echoed
                                ;                       byte  (This means R3 returns zero if ^U or ^X was the last
                                ;                       character in the buffer, etc.)
                                ;--

134142  116300  007470          ECHO::  MOVB    BUFFER(R3),R0   ;get character
134146  120027  000022                  CMPB    R0,#022         ;is it ^R?
134152  001447                         BEQ     1$              ;yes, retype line
134154  120027  000030                  CMPB    R0,#030         ;is it ^X?
134160  001002                         BNE     3$              ;no
134162  012700  000025                  MOV     #025,R0         ;map ^X to ^U
134166  120027  000025          3$:     CMPB    R0,#025         ;is it ^U?
134172  001450                         BEQ     2$              ;yes, cancel line
134174  120027  000015                  CMPB    R0,#015         ;is it <CR>?
134200  001432                         BEQ     17$             ;yes, stop echoing characters
134202  120027  000177                  CMPB    R0,#177         ;is it <DELETE>?
134206  001453                         BEQ     4$              ;yes, delete last character
134210  120027  000073                  CMPB    R0,#073         ;is it a semicolon
134214  001003                         BNE     5$              ;no
134216  152737  000020  007324          BISB    #F.COMM,@#LINFLG;yes, show we are in a comment
134224  132737  000020  007324  5$:     BITB    #F.COMM,@#LINFLG;are we in a comment?
134232  001006                         BNE     7$              ;yes, echo characters literally
134234  004767  177152                  JSR     PC,GETCHC
134240  100404                         BMI     6$
134242  004767  177360          14$:    JSR     PC,ASCOUT       ;type non-printable characters visibly
134246  000403                         BR      8$

134250  005203                  7$:     INC     R3              ;advance running pointer
134252  004767  177252          6$:     JSR     PC,CHROUT       ;type non-printable characters as they are
134256  120337  007631          8$:     CMPB    R3,@#FP         ;have we echoed everything?
134262  103727                         BLO     ECHO            ;no, do some more
134264  000207                         RTS     PC              ;yes, continue

134266  005203                  17$:    INC     R3              ;step past <CR>
134270  000207                         RTS     PC              ;and return

134272  004767  000172          1$:     JSR     PC,10$          ;some common code
134276  004767  000210                  JSR     PC,15$          ;remove ^R from line
134302  004767  177130                  JSR     PC,GETBP        ;go back to the beginning
134306  106427  000000                  MTPS    #000            ;take characters again
134312  000761                         BR      8$              ;and echo line

134314  004767  000150          2$:     JSR     PC,10$          ;some common code
134320  004767  177112                  JSR     PC,GETBP        ;go back to the bottom of the buffer
```

```
    58 134324  110337  007631                MOVB    R3,@#FP         ;indicate buffer empty
    59 134330  106427  000000                MTPS    #000            ;take characters again
    60 134334  000207                        RTS     PC              ;wait for new characters
    61
    62 134336  106427  000200          4$:   MTPS    #200            ;don't take characters while buffer is fixed
    63 134342  004767  000144                JSR     PC,15$          ;remove <DELETE> from line, decrement FP
    64 134346  120337  007630                CMPB    R3,@#BP         ;is there anything to delete?
    65 134352  001443                        BEQ     9$              ;no, continue
    66 134354  005303                        DEC     R3              ;back up to character to be deleted
    67 134356  032767  004000  052744  100$:  BIT     #F.VT,TMPMOD    ;see if video mode
    68 134364  001415                        BEQ     200$            ;branch if not
    69 134366  012700  000010                MOV     #10,R0          ;send backspace
    70 134372  004767  177132                JSR     PC,CHROUT
    71 134376  012700  000040                MOV     #40,R0          ;send space
    72 134402  004767  177122                JSR     PC,CHROUT
    73 134406  012700  000010                MOV     #10,R0          ;send backspace
    74 134412  004767  177112                JSR     PC,CHROUT
    75 134416  000410                        BR      210$            ;skip printer '\'
    76 134420  012700  000134          200$: MOV     #134,R0         ;type '\'
    77 134424  004767  177100                JSR     PC,CHROUT
    78 134430  116300  007470                MOVB    BUFFER(R3),R0   ;get deleted character
    79 134434  004767  177166                JSR     PC,ASCOUT       ;type it
    80 134440  116300  007470          210$: MOVB    BUFFER(R3),R0   ;check if we deleted a ';'
    81 134444  120027  000073                CMPB    R0,#073
    82 134450  001002                        BNE     13$
    83 134452  105037  007324                CLRB    @#LINFLG        ;yes, so we aren't in a comment anymore
    84 134456  004767  000030          13$:  JSR     PC,15$          ;remove deleted character from buffer
    85 134462  106427  000000          9$:   MTPS    #000            ;take characters again
    86 134466  000673                        BR      8$              ;echo rest of line
    87
    88 134470  106427  000200          10$:  MTPS    #200            ;don't take characters for a while
    89 134474  004767  177126                JSR     PC,ASCOUT       ;echo the special character
    90 134500  004767  177020                JSR     PC,CRLF         ;start a new line
    91 134504  105037  007324                CLRB    @#LINFLG        ;initialize flags
    92 134510  000207                        RTS     PC
    93
    94 134512  110300                15$:   MOVB    R3,R0           ;get a scratch copy of running pointer
    95 134514  116060  007471  007470  16$:  MOVB    BUFFER+1(R0),BUFFER(R0) ;remove 1 character from buffer
    96 134522  005200                        INC     R0
    97 134524  120037  007631                CMPB    R0,@#FP         ;is that everything?
    98 134530  103771                        BLO     16$             ;no, do more
    99 134532  105337  007631                DECB    @#FP            ;fix FP
   100 134536  000207                        RTS     PC
```

```
 1
 2                                       .SBTTL  Host Line Support Routines
 3
 4                                ;++
 5                                ;    HOSTIN answers aux. port receiver interrupts and buffers the incoming
 6                                ;    characters in HOSTBF (up to 32 characters).  ^@, ^C, ^S, and ^Y are ignored
 7                                ;    coming from this port.  When the buffer becomes half-full (16 characters),
 8                                ;    a ^S is sent to the host.
 9                                ;--
10
11 134540  010046                HOSTIN::MOV     R0,-(SP)        ;preserve some registers for scratch
12 134542  010146                        MOV     R1,-(SP)
13 134544  113700  177550                MOVB    @#A$RBUF,R0     ;get the character, reset interrupt
14 134550  132737  000060  177552        BITB    #060,@#A$SREG   ;framing or overrun error?
15 134556  001050                        BNE     3$              ;yes, beep console, and ignore character
16 134560  042700  177600                BIC     #177600,R0      ;clear all but 7 bits
17 134564  001464                        BEQ     1$              ;ignore ASCII nulls
18 134566  120027  000003                CMPB    R0,#003         ;ignore ^C
19 134572  001453                        BEQ     2$
20 134574  120027  000031                CMPB    R0,#031         ;and ^Y
21 134600  001450                        BEQ     2$
22 134602  120027  000023                CMPB    R0,#023         ;and ^S so that host line traps the same chars
23 134606  001445                        BEQ     2$              ;as console line, even though ignored
24 134610  113701  007672                MOVB    @#HFP,R1        ;get the host buffer input pointer
25 134614  042701  177400                BIC     #177400,R1      ;prevent sign extend
26 134620  120127  000040                CMPB    R1,#40          ;is buffer full?
27 134624  103036                        BHIS    2$              ;yes, beep the console, ignore error
28 134626  110061  007632                MOVB    R0,HOSTBF(R1)   ;no, store character
29 134632  105237  007672                INCB    @#HFP           ;advance the pointer
30 134636  120127  000020                CMPB    R1,#20          ;is buffer half full?
31 134642  103435                        BLO     1$              ;no, return
32 134644  132737  000002  007673        BITB    #F.STOP,@#HSTFLG;have we already sent ^S to host?
33 134652  001031                        BNE     1$              ;yes, return
34 134654  106466  000006                MTPS    6(SP)           ;restore priority in case another char comes in
35 134660  012700  000023                MOV     #023,R0         ;send ^S to host
36 134664  004767  176664                JSR     PC,CHR02
37 134670  152737  000002  007673        BISB    #F.STOP,@#HSTFLG;show we have done so
38 134676  000417                        BR      1$
39
40 134700  113701  007711        3$:     MOVB    @#AUXFLG,R1     ;get saved copy of A$CREG
41 134704  052701  000020                BIS     #20,R1          ;add the error reset bit
42 134710  110137  177452                MOVB    R1,@#A$CREG     ;reset errors
43 134714  113737  007711  177452        MOVB    @#AUXFLG,@#A$CREG       ;restore to normal
44 134722  012700  000007        2$:     MOV     #007,R0         ;beep the console on error
45 134726  106466  000006                MTPS    6(SP)           ;restore priority in case another char comes in
46 134732  004767  176602                JSR     PC,CHR01
47 134736  012601                1$:     MOV     (SP)+,R1        ;restore registers
48 134740  012600                        MOV     (SP)+,R0
49 134742  000002                        RTI
50
```

```
                                ;++
                                ;   HGETCH gets a character from the host input buffer and shifts the buffer down
                                ;   one character.  If the buffer is reduced from 16 or more characters to just
                                ;   four, a ^Q is sent to the host.  Do not call this routine if no characters
                                ;   are available in HOSTBF (i.e, HFP = 0).
                                ;
                                ;   Uses:       HFP     Index to next available location in HOSTBF
                                ;               F.STOP  Status flag =1 if a ^S has been sent to the host
                                ;
                                ;   Returns:
                                ;               R1      Lower byte contains the first character in HOSTBF, upper byte
                                ;                       contains sign extension of bit 7
                                ;               HFP     Decremented to index new next available location in HOSTBF
                                ;               F.STOP  Cleared if ^Q was sent
                                ;               R0      Contains garbage
                                ;--

134744  005001                HGETCH::CLR     R1
134746  113746  007632                MOVB    @#HOSTBF,-(SP)  ;save the first character in buffer
134752  005201                1$:     INC     R1
134754  120137  007672                CMPB    R1,@#HFP        ;are we too close for comfort?
134760  103004                        BHIS    3$              ;yes, disable interrupts before doing this one
134762  116161  007632  007631        MOVB    HOSTBF(R1),HOSTBF-1(R1) ;shift down one character
134770  000770                        BR      1$              ;do entire buffer up to one less than HFP

134772  106746                3$:     MFPS    -(SP)           ;save priority
134774  106427  000340              MTPS    #340            ;disable interrupts to prevent screwups
135000  120137  007672        4$:     CMPB    R1,@#HFP        ;are we really done?
135004  103005                        BHIS    5$              ;yes, all characters transferred
135006  116161  007632  007631        MOVB    HOSTBF(R1),HOSTBF-1(R1) ;shift down one character
135014  005201                        INC     R1
135016  000770                        BR      4$

135020  105337  007672        5$:     DECB    @#HFP           ;adjust buffer input pointer
135024  005000                        CLR     R0
135026  123727  007672  000004        CMPB    @#HFP,#4        ;have we reduced to just four characters?
135034  101006                        BHI     2$              ;no
135036  132737  000002  007673        BITB    #F.STOP,@#HSTFLG;and was ^S sent?
135044  001402                        BEQ     2$              ;no
135046  012700  000021                MOV     #021,R0         ;put ^Q in R0
135052  106426                2$:     MTPS    (SP)+           ;restore priority
135054  112601                        MOVB    (SP)+,R1        ;recover character
135056  005700                        TST     R0              ;did we decide to send ^Q?
135060  001405                        BEQ     6$              ;no
135062  004767  176466              JSR     PC,CHR02        ;yes, send ^Q to host
135066  142737  000002  007673        BICB    #F.STOP,@#HSTFLG;show we have done so

135074  000207                6$:     RTS     PC
```

```
 1
 2                                       .SBTTL  I/O Initialization and LED Driver
 3
 4                                ;++
 5                                ;   IOINIT asserts the RESET L line on the board, thereby clearing the
 6                                ;   configuration of the peripheral chips.  It then initializes the peripheral
 7                                ;   chips to an idle state.  SETAX2 configures the aux. port to operate with
 8                                ;   a 16X clock, so that its baud rate will be equal to that of the console port.
 9                                ;   The RS-232 control output signals are left deasserted, and the aux. port
10                                ;   receiver and transmitter are left disabled.  SETAX1 is like SETAX2, except
11                                ;   that the clock divisor of the aux. port is set to 16 if R0 = 0 upon entry,
12                                ;   or 64 if R0 = 1.  A 64X clock means that the aux. port baud rate will be
13                                ;   one fourth of the console port baud rate.
14                                ;--
15
16 135076  000005                IOINIT::RESET                   ;disable interrtups
17 135100  112737  000212  177446        MOVB    #212,@#P$CREG   ;configure 8255 with port B as input
18 135106  112737  000010  177444        MOVB    #010,@#P$PORC   ;disable LED display
19 135114  105037  177560              CLRB    @#C$RCSR        ;disable DLART receiver
20 135120  105037  177564              CLRB    @#C$XCSR        ;disable DLART transmitter
21 135124  005000                SETAX2: CLR     R0              ;indicate 16X clock for aux port
22 135126  112737  000200  177452 SETAX1: MOVB    #200,@#A$CREG   ;send a harmless mode word to make sure next
23                                                                ;word is interpreted as a control word so that
24 135134  112737  000100  177452        MOVB    #100,@#A$CREG   ;this control word puts us back to mode load
25 135142  152737  000002  007464        BISB    #2,@#MF8251     ;make sure baude rates will match
26 135150  063700  007464              ADD     @#MFB251,R0     ;add in mode byte incase user has changed anything
27 135154  110037  177452              MOVB    R0,@#A$CREG     ;now initialize modes
28 135160  112737  000020  177452        MOVB    #020,@#A$CREG   ;reset error flags, disable 8251
29 135166  000207                      RTS     PC
30
31
32                                ;++
33                                ;   SETAUX reconfigures the aux. port to operate with a 16X clock if bit 7 of
34                                ;   CONFLG = 0, or with a 64X clock if bit 7 of CONFLG = 1.  The aux. port
35                                ;   receiver and transmitter are left disabled, but the RS-232 control signals
36                                ;   request-to-send and data-terminal-ready are asserted.  A copy of the command
37                                ;   byte sent to the aux. port is saved in AUXFLG for future reference, since
38                                ;   A$CREG is a write-only location.
39                                ;--
40
41 135170  005000                SETAUX::CLR     R0
42 135172  105737  007710              TSTB    @#CONFLG        ;is 64X clock currently selected?
43 135176  100001                      BPL     1$              ;no, 16X clock
44 135200  005200                      INC     R0
45 135202  004767  177720        1$:   JSR     PC,SETAX1       ;set aux port baud rate, disable
46 135206  112737  000042  177452        MOVB    #042,@#A$CREG   ;command 8251 to assert RTS, DTR, and disable
47 135214  112737  000042  007711        MOVB    #042,@#AUXFLG   ;save a copy since A$CREG is write only
48 135222  000207                      RTS     PC
49
```

```
                                ;++
                                ;   IOVECT initializes the interrupt vectors at locations 60, 64, 70, 74, ...,
                                ;   130, and 134 to point to an RTI instruction with priority 7.  It then attaches
                                ;   interrupt service routines for console break, invalid instruction, breakpoint,
                                ;   and LED display refresh.  The power fail vector is also attached to an RTI
                                ;   instruction, with priority 6.  The LED display hardware and both serial ports
                                ;   are disabled.
                                ;--

135224                          IOVECT::
135224  012700  000060                MOV     #060,R0         ;initialize I/O vectors and disable interrupts
135230  012701  000014                MOV     #12.,R1         ;15 coded priority vectors (2 not used)
135234  012720  135676          1$:   MOV     #$NULLI,(R0)+   ;set address element to null service routine
135240  012720  000340                MOV     #340,(R0)+      ;set priority level to 7
135244  077105                      SOB     R1,1$
135246  012720  137114                MOV     #BREAK,(R0)+    ;connect console break routine
135252  012720  000340                MOV     #340,(R0)+      ;priority 7 for console break
135256  012700  000010                MOV     #010,R0
135262  012720  137334                MOV     #ITRAP,(R0)+    ;connect invalid instruction trap
135266  012720  000340                MOV     #340,(R0)+
135272  012720  137174                MOV     #BRKPT,(R0)+    ;connect breakpoint trap
135276  012720  000340                MOV     #340,(R0)+
135302  012737  135344  000104        MOV     #DISPLA,@#LEDIV ;connect LED display routine
135310  005037  007676                CLR     @#KEYFIV        ;disconnect keypress service vector
                                ;now disable interrupt hardware for ports
135314  112737  000010  177444        MOVB    #010,@#P$PORC   ;disable LED display
135322  142737  000100  177560        BICB    #100,@#C$RCSR   ;disable console receiver
135330  142737  000100  177564        BICB    #100,@#C$XCSR   ;disable console transmitter
135336  105037  177452                CLRB    @#A$CREG        ;disable auxiliary receiver and transmitter
135342  000207                        RTS     PC
```

```
                                .ENABL  LSB
                        ;++
                        ;   DISPLA is the LED refresh interrupt service routine.  It multiplexes the
                        ;   contents of SEGBUF to the LEDs through parallel port A, and checks if a
                        ;   keypad key has been pressed.  If a key has been pressed and the value in
                        ;   location KEYPIV is not zero, then control will be transferred to the routine
                        ;   at [KEYPIV] for interrupt driven keypad input.  The keypress routine at
                        ;   [KEYPIV] must restore R2, R1, and R0 from the stack (in that order) before
                        ;   executing an RTI.  Note that if the contents of SPCLBF are nonzero, a flashing
                        ;   display of '  xx    will appear in the LEDs instead of the contents of SEGBUF.
                        ;              Error'
                        ;   DISPLA also counts the number of times it has been called (which is determined
                        ;   by the hardware to be 800 times per second, when display refresh is enabled)
                        ;   in the location TIME.  The lower 10 bits of TIME count 0 through 799., and the
                        ;   upper six bits count 0 through 59. seconds.
                        ;--

135344  005237  007730        DISPLA::INC     @#TIME          ;keep a count of 800ths of seconds in TIME
135350  010046                MOV     R0,-(SP)        ;preserve registers
135352  010146                MOV     R1,-(SP)
135354  010246                MOV     R2,-(SP)
135356  013700  007730        MOV     @#TIME,R0       ;prepare to check for overflow of 800ths
135362  005100                COM     R0
135364  032700  001440        BIT     #001440,R0
135370  001016                BNE     1$              ;no overflow
135372  042737  001777  007730        BIC     #001777,@#TIME  ;overflow, so clear 800ths
135400  062737  002000  007730        ADD     #002000,@#TIME  ;and add 1 second
135406  013700  007730        MOV     @#TIME,R0       ;check if overflow past 60 seconds
135412  005100                COM     R0
135414  032700  170000        BIT     #170000,R0
135420  001002                BNE     1$              ;no overflow of seconds
135422  005037  007730        CLR     @#TIME          ;yes, so clear the whole thing

135426  013700  007730        1$:     MOV     @#TIME,R0
135432  042700  177770        BIC     #177770,R0      ;strip R0 to make it a multiplex address
135436  006300                ASL     R0              ;make it a word index
135440  016001  007712        MOV     SEGBUF(R0),R1   ;set segment data for this digit pair
135444  005737  007726        TST     @#SPCLBF        ;is there a special error display?
135450  001422                BEQ     3$              ;no
135452  005001                CLR     R1
135454  032737  001000  007730        BIT     #001000,@#TIME  ;true for approx. 1/3 of each second
135462  001015                BNE     3$              ;flashing error message, no less
135464  016001  135756        MOV     ERRSEG(R0),R1   ;set segment data for ' Error'
135470  132700  000004        BITB    #004,R0         ;is this digit 2 or 3?
135474  001410                BEQ     3$              ;no, so no overlay on upper display
135476  013702  007726        MOV     @#SPCLBF,R2     ;set overlay characters
135502  132700  000002        BITB    #002,R0         ;is this digit 3?
135506  001001                BNE     4$              ;digit 3 character is in upper byte
135510  000302                SWAB    R2              ;swap for digit 2
135512  105002                4$:     CLRB    R2              ;save only upper display character
135514  060201                ADD     R2,R1           ;combine upper and lower display characters
135516  112737  000010  177444  3$:     MOVB    #010,@#P$PORC   ;turn off display, enable upper display latch
135524  000301                SWAB    R1              ;set upper display data in lower byte
135526  110137  177440        MOVB    R1,@#P$PORA     ;output upper display data
135532  000301                SWAB    R1              ;back to lower display data
135534  112737  000007  177444        MOVB    #007,@#P$PORC   ;display still off, but upper latch closed
```

```
 58 135542  110137  177440                MOVB    R1,@#P$PORA     ;output lower display data
 59 135546  010001                       MOV     R0,R1
 60 135550  006201                       ASR     R1              ;multiplex digit address (byte index)
 61 135552  110137  177444               MOVB    R1,@#P$PORC     ;turn on display
 62 135556  000240                       NOP                     ;now do keypad input...
 63 135560  113702  177544               MOVB    @#P$PORD,R2     ;keypad return lines in bits 4 to 7
 64 135564  042702  177417               BIC     #177417,R2      ;clean up keypad data
 65 135570  060002                       ADD     R0,R2           ;combine index and return data
 66 135572  013701  007704               MOV     @#DEBNCE,R1     ;get a scratch copy of debounce state register
 67 135576  001413                       BEQ     5$              ;not debouncing a key, take a new one
 68 135600  074201                       XOR     R2,R1
 69 135602  001420                       BEQ     6$              ;total match, take it as a keypress
 70 135604  032701  000016               BIT     #000016,R1      ;compare multiplex address field
 71 135610  001027                       BNE     2$              ;not the same, so ignore it
 72 135612  032701  000360               BIT     #000360,R1      ;compare return line field
 73 135616  001424                       BEQ     2$              ;same key held, so ignore it
 74 135620  005037  007704               CLR     @#DEBNCE        ;no longer same key pressed, so reset state
 75 135624  000421                       BR      2$
 76
 77 135626  004767  000046         5$:   JSR     PC,7$           ;convert positional bit to number
 78 135632  005701                       TST     R1              ;is this a valid key depression?
 79 135634  100415                       BMI     2$              ;no, so ignore it
 80 135636  010237  007704               MOV     R2,@#DEBNCE     ;yes, take it and wait for confirmation
 81 135642  000412                       BR      2$
 82
 83 135644  052737  100000  007704  6$:  BIS     #100000,@#DEBNCE;make sure we get only one keypress per key
 84 135652  005737  007676               TST     @#KEYPIV        ;do we have an active vector?
 85 135656  001404                       BEQ     2$              ;no, discard keypress
 86 135660  004767  000014               JSR     PC,7$           ;get a useful key number in R1
 87 135664  000177  052006               JMP     @KEYPIV         ;pass it to attached service routine
 88
 89 135670  012602                2$:    MOV     (SP)+,R2        ;service routine at @KEYPIV should also restore
 90 135672  012601                        MOV     (SP)+,R1        ;the registers in this manner
 91 135674  012600                        MOV     (SP)+,R0
 92 135676  000002                $NULLI::RTI
 93
 94 135700  010200                7$:    MOV     R2,R0           ;make a scratch copy
 95 135702  000300                        SWAB    R0              ;move key data to upper byte
 96 135704  042700  007777               BIC     #007777,R0      ;keep only return line data
 97 135710  012701  000004               MOV     #4,R1           ;shift out 4 bits max
 98 135714  006300                8$:    ASL     R0              ;shift out a bit, look for a one
 99 135716  103013                        BCC     9$              ;didn't find it
100 135720  001013                        BNE     10$             ;more than one true bit--invalid data
101 135722  005301                        DEC     R1              ;R1 is now 3, 2, 1, or 0
102 135724  006302                        ASL     R2              ;least two bits are 0
103 135726  060201                        ADD     R2,R1           ;combine multiplex address and positional count
104 135730  042701  177740               BIC     #177740,R1      ;clean up key code
105 135734  006202                        ASR     R2              ;restore R2
106 135736  010200                11$:   MOV     R2,R0
107 135740  042700  177761               BIC     #177761,R0      ;restore R0
108 135744  000207                       RTS     PC
109
110 135746  077116                9$:    SOB     R1,8$           ;keep searching
111 135750  012701  177777         10$:   MOV     #177777,R1      ;indicate invalid data
112 135754  000770                       BR      11$             ;restore and exit
113                                      .DSABL  LSB
114
```

```
   115 135756  000120  000134  000120  ERRSEG: .WORD   120,134,120     ;r, o, r
   116 135764  000120  000171  000000          .WORD   120,171,000     ;r, E, space
```



```
     1
     2                                      .SBTTL  LED Display Support Routines
     3
     4                              ;++
     5                              ;    DSPDIG takes a hex number in the lower 4 bits of R0 and displays the
     6                              ;    corresponding segment pattern on the LED digit indexed by R1.  R1 = 0
     7                              ;    to index the rightmost lower LED digit, = 1 to index the rightmost upper
     8                              ;    LED digit, ..., = 13 to index the leftmost upper LED digit.  Returns R1
     9                              ;    incremented by 2 to index the next digit to the left on the same display
    10                              ;    row.
    11                              ;
    12                              ;    Uses:      R0      Hex value to be displayed
    13                              ;               R1      Index to LED digit on which to display it
    14                              ;
    15                              ;    Returns:
    16                              ;               R0      Previous value with bits 15. through 4 cleared
    17                              ;               R1      Previous value + 2
    18                              ;--
    19
    20 135772  042700  177760          DSPDIG::BIC     #177760,R0      ;range-limit R0
    21 135776  020127  000013                  CMP     R1,#000013      ;maximum value for digit index
    22 136002  101004                          BHI     1$              ;out-of-range, so ignore call
    23 136004  116061  136016  007712         MOVB    HEXSEG(R0),SEGBUF(R1)   ;display digit
    24 136012  005721                          TST     (R1)+           ;index next digit of same display level
    25 136014  000207                  1$:     RTS     PC
    26
    27 136016     077     006     133  HEXSEG::.BYTE   077,006,133,117 ;0, 1, 2, 3
       136021     117
    28 136022     146     155     175          .BYTE   146,155,175,007 ;4, 5, 6, 7
       136025     007
    29 136026     177     157     167          .BYTE   177,157,167,174 ;8, 9, A, b
       136031     174
    30 136032     071     136     171          .BYTE   071,136,171,161 ;C, d, E, F
       136035     161
    31                                          .EVEN
    32
```

```
 1
 2                              ;++
 3                              ;   DSPUNM and DSPLNM take full words in R2 and write octal numbers to the upper
 4                              ;   and lower LED displays, respectively.
 5                              ;
 6                              ;   Uses:      R2      Octal value to be displayed
 7                              ;
 8                              ;   Returns:
 9                              ;               R0      Contains garbage
10                              ;               R1      Contains garbage
11                              ;--
12
13 136036  012701  000001       DSPUNM::MOV     #1,R1           ;index upper display
14 136042  000402                       BR      DSPNUM
15
16 136044  012701  000000       DSPLNM::MOV     #0,R1           ;index lower display
17
18 136050  010246               DSPNUM: MOV     R2,-(SP)        ;preserve R2
19 136052  010346                       MOV     R3,-(SP)        ;get a scratch register
20 136054  012703  000006               MOV     #6,R3           ;count 6 digits
21 136060  010200               1$:     MOV     R2,R0           ;move octal digit to R0
22 136062  042700  177770               BIC     #177770,R0      ;make sure it's octal
23 136066  004767  177700               JSR     PC,DSPDIG       ;display digit
24 136072  000241                       CLC
25 136074  006002                       ROR     R2              ;move to next octal digit
26 136076  006202                       ASR     R2
27 136100  006202                       ASR     R2
28 136102  077312                       SOB     R3,1$           ;do five digits
29 136104  012603                       MOV     (SP)+,R3
30 136106  012602                       MOV     (SP)+,R2
31 136110  000207                       RTS     PC
32
33
34
```

```
 1                                      ;++
 2                                      ;   DSPNAM is a routine to display names of registers, etc. on upper display.
 3                                      ;   R2 points to the message to be displayed.  The message should be a string
 4                                      ;   of 6 bytes corresponding to the segment patterns for each LED digit, starting
 5                                      ;   with the rightmost digit.
 6                                      ;
 7                                      ;   Uses:      R2      Pointer to string of segment patterns
 8                                      ;
 9                                      ;   Returns:
10                                      ;               R1      Contains garbage
11                                      ;               R0      Contains garbage
12                                      ;--
13
14 136112  012701  000001          DSPNAM::MOV     #1,R1           ;index upper display
15 136116  010246                          MOV     R2,-(SP)        ;preserve message index
16 136120  006302                          ASL     R2              ;multiply it by 6
17 136122  010200                          MOV     R2,R0
18 136124  006302                          ASL     R2
19 136126  060002                          ADD     R0,R2
20 136130  012700  000006                  MOV     #6,R0           ;character count
21 136134  116261  136154  007712  1$:     MOVB    NAMTBL(R2),SEGBUF(R1)   ;move segment data to LED buffer
22 136142  005721                          TST     (R1)+           ;index next LED digit
23 136144  005202                          INC     R2              ;index next character
24 136146  077006                          SOB     R0,1$           ;do six characters
25 136150  012602                          MOV     (SP)+,R2        ;restore R2
26 136152  000207                          RTS     PC
27
28 136154     000     000     077  NAMTBL::.BYTE   0,0,077,120,0,0 ;'  r0  '
   136157     120     000     000
29 136162     000     000     006          .BYTE   0,0,006,120,0,0 ;'  r1  '
   136165     120     000     000
30 136170     000     000     133          .BYTE   0,0,133,120,0,0 ;'  r2  '
   136173     120     000     000
31 136176     000     000     117          .BYTE   0,0,117,120,0,0 ;'  r3  '
   136201     120     000     000
32 136204     000     000     146          .BYTE   0,0,146,120,0,0 ;'  r4  '
   136207     120     000     000
33 136212     000     000     155          .BYTE   0,0,155,120,0,0 ;'  r5  '
   136215     120     000     000
34 136220     000     000     163          .BYTE   0,0,163,155,0,0 ;'  SP  '
   136223     155     000     000
35 136226     000     000     071          .BYTE   0,0,071,163,0,0 ;'  PC  '
   136231     163     000     000
36 136234     000     000     155          .BYTE   0,0,155,163,0,0 ;'  PS  '
   136237     163     000     000
37 136242     120     136     167          .BYTE   120,136,167
38 136245     170     124     163          .BYTE   170,124,163     ;'PntAdr'
39 136250     000     120     136          .BYTE   000,120,136
40 136253     136     167     000          .BYTE   136,167,000     ;' Addr '
41 136256     000     075     171          .BYTE   000,075,171
42 136261     120     000     000          .BYTE   120,000,000     ;'  rEG '
43 136264     006     170     124          .BYTE   006,170,124
44 136267     163     120     174          .BYTE   163,120,174     ;'brPnt1'
45 136272     133     170     124          .BYTE   133,170,124
46 136275     163     120     174          .BYTE   163,120,174     ;'brPnt2'
47 136300     117     170     124          .BYTE   117,170,124
48 136303     163     120     174          .BYTE   163,120,174     ;'brPnt3'
```

```
    49 136306  146  170  124        .BYTE  146,170,124
    50 136311  163  120  174        .BYTE  163,120,174     ;'brPnt4'
    51 136314  000  130  124        .BYTE  000,130,124
    52 136317  034  161  000        .BYTE  034,161,000     ;' Func '
    53 136322  060  134  155        .BYTE  060,134,155
    54 136325  124  134  071        .BYTE  124,134,071     ;'ConSol'
    55 136330  170  120  134        .BYTE  170,120,134
    56 136333  163  200  167        .BYTE  163,200,167     ;'A,Port'
    57                              .EVEN
```

```
 1                              ;++
 2                              ;   BLNKLO and BLNKHI are routines to erase the segment data in the lower and
 3                              ;   upper LED buffers, respectively.  Returns garbage in R0 and R1.
 4                              ;--
 5
 6 136336  012701  000000      BLNKLO::MOV     #0,R1           ;index lower display
 7 136342  000402                      BR      BLNKDS
 8
 9 136344  012701  000001      BLNKHI::MOV     #1,R1           ;index upper display
10
11 136350  012700  000006      BLNKDS: MOV     #6,R0           ;count 6 digits
12 136354  105061  007712      1$:     CLRB    SEGBUF(R1)      ;blank a digit
13 136360  005721                      TST     (R1)+           ;index next digit of same display level
14 136362  077004                      SOB     R0,1$           ;do six digits
15 136364  000207                      RTS     PC
16
17
18                              ;++
19                              ;   DSPDEC takes a number in R1 and an index to either second-from-the-left LED
20                              ;   digit in R2 and displays the number as a decimal value on the corresponding
21                              ;   LED digits.  R2 = 10 to index the lower row of LEDs, = 11 for the upper row.
22                              ;   The leftmost LED digits are not affected.  To display a two's complement
23                              ;   decimal value, call this routine from another routine, which places a minus
24                              ;   sign in the leftmost LED digit and passes the absolute value of the number
25                              ;   to be displayed to this routine.
26                              ;
27                              ;   Uses:       R1      Decimal value to be displayed
28                              ;               R2      Index to LED row on which to display it
29                              ;
30                              ;   Returns:
31                              ;               R0, R1, Contain garbage
32                              ;               R2, R3
33                              ;--
34
35 136366  004767  015662      DSPDEC::JSR     PC,BINAS1       ;get 10000's digit
36 136372  010146                      MOV     R1,-(SP)        ;save remainder
37 136374  010201                      MOV     R2,R1           ;index left LED digit
38 136376  004767  177370              JSR     PC,DSPDIG       ;display decimal digit
39 136402  005742                      TST     -(R2)           ;index next digit
40 136404  012601                      MOV     (SP)+,R1
41 136406  012703  000004              MOV     #4,R3           ;make a counter
42 136412  004767  015576      1$:     JSR     PC,BINASC       ;strip a digit from R1
43 136416  010146                      MOV     R1,-(SP)        ;switch registers
44 136420  010201                      MOV     R2,R1
45 136422  004767  177344              JSR     PC,DSPDIG       ;display decimal digit
46 136426  005742                      TST     -(R2)           ;index next digit to the right
47 136430  012601                      MOV     (SP)+,R1        ;get back decimal number
48 136432  077311                      SOB     R3,1$           ;do six digits
49 136434  000207                      RTS     PC
50
```

```
                                ;++
                                ;   KEYGET turns on the LEDs and waits for a keypress.  The key number of the
                                ;   key that was pressed is returned in R1.  The keys are numbered as follows:
                                ;       00 -- [CLR]         12 -- [ 6 ]
                                ;       01 -- [ 1 ]         13 -- [ 9 ]
                                ;       02 -- [ 4 ]         14 -- [ADV]
                                ;       03 -- [ 7 ]         15 -- [BAC]
                                ;       04 -- [ 0 ]         16 -- [REG]
                                ;       05 -- [ 2 ]         17 -- [ADR]
                                ;       06 -- [ 5 ]         20 -- [SST]
                                ;       07 -- [ 8 ]         21 -- [GO ]
                                ;       10 -- [EXA]         22 -- [BPT]
                                ;       11 -- [ 3 ]         23 -- [FNC]
                                ;
                                ;   Uses:
                                ;
                                ;   Returns:
                                ;               R1      Contains number of key that was pressed
                                ;               KEYPIV  Cleared
                                ;               SPCLBF  Cleared
                                ;               PS      Priority reduced to 5
                                ;--

136436  012737  136470  007676  KEYGET::MOV     #KEYGE1,@#KEYPIV;link input routine to keypress vector
136444  112737  000007  177444          MOVB    #007,@#P$PORC   ;turn on LED displays
136452  106701                  MFPS    R1
136454  120127  000277          CMPB    R1,#277         ;priority 5 is maximum for LEDs to operate
136460  101402                  BLOS    1$
136462  106427  000240          MTPS    #240            ;set priority 5
136466  000777          1$:     BR      1$              ;wait for keypress

136470  005037  007676  KEYGE1: CLR     @#KEYPIV        ;disconnect keypress vector
136474  005037  007726          CLR     @#SPCLBF        ;turn off flashing error, if any
136500  012602                  MOV     (SP)+,R2        ;restore R2
136502  005726                  TST     (SP)+           ;discard old R1
136504  012600                  MOV     (SP)+,R0        ;restore R0
136506  005726                  TST     (SP)+           ;discard return address
136510  106426                  MTPS    (SP)+           ;but replace PS byte
136512  000207                  RTS     PC              ;return to caller of KEYGET
```

```
                                ;++
                                ;   KEYBCD translates the key number in R1 into a BCD value for the keys 0 to 9,
                                ;   12 for the CLR key, 013 for the EXA key, and -1 for all other keys.
                                ;
                                ;   Uses:       R1      Key number to be translated
                                ;
                                ;   Returns:
                                ;               R1      Translated value
                                ;--

136514  116101  136522          KEYBCD::MOVB    BCDTBL(R1),R1   ;translate R1 into BCD code
136520  000207                          RTS     PC

136522     012                  BCDTBL: .BYTE   012             ;[CLR]
136523     001                          .BYTE   001             ;[ 1 ]
136524     004                          .BYTE   004             ;[ 4 ]
136525     007                          .BYTE   007             ;[ 7 ]
136526     000                          .BYTE   000             ;[ 0 ]
136527     002                          .BYTE   002             ;[ 2 ]
136530     005                          .BYTE   005             ;[ 5 ]
136531     010                          .BYTE   010             ;[ 8 ]
136532     013                          .BYTE   013             ;[EXA]
136533     003                          .BYTE   003             ;[ 3 ]
136534     006                          .BYTE   006             ;[ 6 ]
136535     011                          .BYTE   011             ;[ 9 ]
136536     377                          .BYTE   377             ;[ADV]
136537     377                          .BYTE   377             ;[BAC]
136540     377                          .BYTE   377             ;[REG]
136541     377                          .BYTE   377             ;[ADD]
136542     377                          .BYTE   377             ;[SST]
136543     377                          .BYTE   377             ;[GO ]
136544     377                          .BYTE   377             ;[BPT]
136545     377                          .BYTE   377             ;[FNC]
                                        .EVEN
```

```
 1
 2                                ;++
 3                                ;   NUMGET displays the current value of R2 in the lower row of LEDs, leaving the
 4                                ;   upper row intact.  The keypad is enabled to allow the user to modify the value
 5                                ;   in R2 with the 0 - 7 and CLR keys.  The value in R2 is returned, whether
 6                                ;   altered or not, when the user presses EXA.
 7                                ;
 8                                ;   Uses:       R2      Initial value
 9                                ;
10                                ;   Returns:
11                                ;               R2      New value (if changed)
12                                ;               F.CHAN  Flag in FLAGS1 is set if R2 was changed, cleared otherwise
13                                ;               R1      Contains garbage
14                                ;               R0      Contains garbage
15                                ;--
16
17 136546  042737  000002  007706 NUMGET::BIC     #F.CHAN,@#FLAGS1;show R2 hasn't changed yet
18 136554  004767  177264         1$:     JSR     PC,DSPLNM       ;display value in R2 on lower LEDs
19 136560  004767  177652                 JSR     PC,KEYGET       ;wait for a keypress
20 136564  004767  177724                 JSR     PC,KEY$BCD      ;convert key number into BCD
21 136570  005701                         TST     R1              ;was it a legal key?
22 136572  100770                         BMI     1$              ;no, get another
23 136574  020127  000012                 CMP     R1,$012         ;was it numeric?
24 136600  101026                         BHI     2$              ;no, it was EXA/ENT, so return value in R2
25 136602  001420                         BEQ     3$              ;no, it was clear
26 136604  020127  000010                 CMP     R1,$010         ;was it 8 or 9 (not valid octal digits)?
27 136610  103361                         BHIS    1$              ;yes, so ignore it
28 136612  032737  000002  007706         BIT     #F.CHAN,@#FLAGS1;has R2 been changed yet?
29 136620  001004                         BNE     4$              ;yes, just scroll in key
30 136622  005002                         CLR     R2              ;else clear old value first
31 136624  052737  000002  007706         BIS     #F.CHAN,@#FLAGS1;indicate it has been changed
32 136632  006302                 4$:     ASL     R2              ;make space for new digit
33 136634  006302                         ASL     R2
34 136636  006302                         ASL     R2
35 136640  060102                         ADD     R1,R2           ;scroll in new digit
36 136642  000744                         BR      1$              ;accept additional digits
37
38 136644  005002                 3$:     CLR     R2              ;clear number for CLR key
39 136646  052737  000002  007706         BIS     #F.CHAN,@#FLAGS1;show R2 changed
40 136654  000737                         BR      1$
41
42 136656  000207                 2$:     RTS     PC              ;return value
```

```
 1
 2                                       .SBTTL Error Condition and Startup Entry Code
 3
 4                                ;++
 5                                ;   $START is the powerup initialzation routine, which is executed after the
 6                                ;   diagnostics are completed.
 7                                ;--
 8
 9 136660  005000                $START::CLR     R0              ;clear RAM from 0 to 27777
10 136662  012701  014000                MOV     #14000,R1
11 136666  005020                1$:     CLR     (R0)+
12 136670  077102                        SOB     R1,1$
13 136672  010537  007726                MOV     R5,@#SPCLBF     ;put power-up error code on LEDs
14 136676  012737  007400  007746        MOV     #SCRPAD,@#SP    ;set up user stack pointer
15 136704  112737  000050  007710        MOVB    #050,@#CONFLG   ;set default baud rates
16 136712  112767  000116  050544        MOVB    #116,MF8251     ;set default value for 8251 mode byte
17 136720  012737  135676  007702        MOV     #$NULLI,@#USERVS;initialize user's interrupt vector
18 136726  012737  135676  000024        MOV     #$NULLI,@#24    ;pf points at null
19 136734  012737  000340  000026        MOV     #340,@#26       ;
20 136742  012737  007320  007462        MOV     #TBLTOP,@#TBLBOT;initialize empty symbol table
21 136750  000402                        BR      $HALT+4         ;don't clear error display
22
23                                ;++
24                                ;   $HALT is the routine invoked by the HALT button, the HALT L line on the
25                                ;   board, and the HALT instruction.  It saves the processor registers and the
26                                ;   contents of USERIV and KEYPIV if a user program was running.  It also
27                                ;   performs a bus reset and reinitialization of peripheral chips before
28                                ;   invoking the keypad monitor.
29                                ;--
30
31 136752  005037  007726        $HALT:: CLR     @#SPCLBF        ;clear error code on LEDs, if any
32 136756  004767  000022                JSR     PC,UCSAVE       ;save context and fix user SP
33 136762  004767  176110                JSR     PC,IOINIT       ;assert RESET line and reinitialize ports
34 136766  042737  177377  007706        BIC     #177377,@#FLAGS1;reset mode, set keypad command entry
35                                                                ;leave F.BRKA so breakpoints will be removed
36 136774  004767  176224                JSR     PC,IOVECT       ;make sure interrupt vectors aren't damaged
37 137000  000167  000564                JMP     $MONIT          ;enter monitor
38
```

```
                                ;++
                                ;   UCSAVE saves the processor registers and the contents of USERIV and KEYPIV
                                ;   if a user program was running.  It also initializes the monitor stack.
                                ;--

137004  012637  007460          UCSAVE::MOV     (SP)+,@#$STACK-2 ;move return address to monitor stack
137010  032737  000100  007706          BIT     #F.USER,@#FLAGS1;running user code?
137016  001433                        BEQ     1$              ;no
137020  012637  007750                MOV     (SP)+,@#$PC     ;yes, save user context, starting with PC
137024  112637  007752                MOVB    (SP)+,@#$PS     ;PS next
137030  042737  177400  007752        BIC     #177400,@#$PS   ;prevent sign extension
137036  010637  007746                MOV     SP,@#$SP        ;fix and save stack pointer
137042  010037  007732                MOV     R0,@#$R0        ;save R0,
137046  010137  007734                MOV     R1,@#$R1        ;R1,
137052  010237  007736                MOV     R2,@#$R2        ;R2,
137056  010337  007740                MOV     R3,@#$R3        ;R3,
137062  010437  007742                MOV     R4,@#$R4        ;R4, and
137066  010537  007744                MOV     R5,@#$R5        ;R5
137072  013737  007676  007700        MOV     @#KEYPIV,@#KEYPVS       ;save user keypress vector
137100  042737  000100  007706        BIC     #F.USER,@#FLAGS1;show that user context has been saved
137106  012706  007460          1$:   MOV     #STACK-2,SP     ;go to monitor stack
137112  000207                        RTS     PC              ;and return to calling routine in monitor


                                ;++
                                ;   BREAK is the console break interrupt service routine.  It is similar to HALT
                                ;   except that it does not invoke the keypad monitor if the console monitor was
                                ;   running previously.  The host mode is terminated by BREAK.
                                ;--

137114  005737  177562          BREAK:: TST     @#C$RBUF        ;acknowledge interrupt
137120  004767  177660                  JSR     PC,UCSAVE       ;save user context
137124  004767  175746                  JSR     PC,IOINIT       ;assert RESET line and reinitialize ports
137130  042737  035377  007706        BIC     #035377,@#FLAGS1;initialize monitor modes
137136  012737  133000  000060        MOV     #LINEIN,@#CONIN ;hook up console input service routine
137144  142737  000007  007710        BICB    #007,@#CONFLG   ;clear console line flags (but not speed)
137152  113700  007710                MOVB    @#CONFLG,R0     ;get current baud rate
137156  052700  000002                BIS     #000002,R0      ;enable pros. baud rate, disable xmit interrupt
137162  010037  177564                MOV     R0,@#C$XCSR     ;transfer control word to console port
137166  012700  000001                MOV     #1,R0           ;indicate console break service
137172  000466                        BR      FERROR          ;go to fatal error handler to reenter monitor
```

```
 1
 2                              ;++
 3                              ;   BRKPT is the breakpoint service routine.  If invoked from a user program, the
 4                              ;   processor context is saved.  If invoked in response to a monitor breakpoint
 5                              ;   rather than a single step or user breakpoint, the PC value saved from the
 6                              ;   previous context is adjusted to point to the location which contained the
 7                              ;   monitor breakpoint.
 8                              ;--
 9
10 137174  106427  000340          BRKPT:: MTPS    #340            ;disable interrupts in case vector is damaged
11 137200  004767  177600                  JSR     PC,UCSAVE       ;save user context
12 137204  032737  001000  007706          BIT     #F.BRKG,@#FLAGS1;are we single stepping through a break
13                                                                 ;point
14 137212  001405                          BEQ     2$              ;no, so check if single step or new breakpoint
15 137214  042737  001000  007706          BIC     #F.BRKG,@#FLAGS1;reset condition
16 137222  000167  002466                  JMP     $GO             ;install breakpoints and resume execution
17
18 137226  032737  000200  007706  2$:     BIT     #F.SST,@#FLAGS1 ;are we single stepping?
19 137234  001155                          BNE     $MONIT          ;yes, so not a breakpoint--enter monitor
20 137236  032737  000400  007706          BIT     #F.BRKA,@#FLAGS1;are breakpoints installed?
21 137244  001430                          BEQ     5$              ;no--user program contains BRK, so signal error
22 137246  013701  007750                  MOV     @#$PC,R1        ;get user PC
23 137252  005741                          TST     -(R1)           ;back up to BRK instruction
24 137254  012700  007760                  MOV     #BRKFIL,R0      ;index breakpoint file
25 137260  012702  000004                  MOV     #4,R2           ;four entries in file
26 137264  022001                  4$:     CMP     (R0)+,R1        ;did we in fact encounter a breakpoint?
27 137266  001403                          BEQ     3$              ;yes, so adjust PC, no error message
28 137270  005720                          TST     (R0)+           ;advance to next entry
29 137272  077204                          SOB     R2,4$
30 137274  000414                          BR      5$              ;no match--program contains BRK...signal error
31
32 137276  052737  020000  007706  3$:     BIS     #F.TBAS,@#FLAGS1;show we need to print break point message
33 137304  010137  007750                  MOV     R1,@#$PC        ;fix PC
34 137310  052737  001000  007706          BIS     #F.BRKG,@#FLAGS1;show we need to single step
35 137316  032737  002000  007706          BIT     #F.KEYP,@#FLAGS1;no message if in keypad mode
36 137324  001521                          BEQ     $MONIT          ;so just enter monitor
37 137326  012700  000002          5$:     MOV     #2,R0           ;indicate breakpoint service
38 137332  000406                          BR      FERROR          ;go to fatal error handler to reenter monitor
39
40
41                              ;++
42                              ;   ITRAP is the illegal instruction trap routine.  If a user program was running,
43                              ;   the processor context is saved before invoking the monitor.
44                              ;--
45
46 137334  106427  000340          ITRAP:: MTPS    #340            ;disable interrupts in case vector is damaged
47 137340  004767  177440                  JSR     PC,UCSAVE       ;save user context
48 137344  012700  000003                  MOV     #3,R0           ;indicate invalid instruction trap
49
```

```
 1
 2                                ;++
 3                                ;   FERROR signals errors for the above routines and others in the keypad monitor.
 4                                ;   If the keypad monitor is running, the errors are displayed on the LEDs.  For
 5                                ;   the console monitor, the error messages are displayed on the console.
 6                                ;--
 7
 8 137350  010046                FERROR::MOV     R0,-(SP)        ;save error number
 9 137352  004767  175646                JSR     PC,IOVECT       ;make sure interrupt vectors aren't damaged
10 137356  012600                        MOV     (SP)+,R0                ;get error number
11 137360  006300                        ASL     R0              ;turn it into an index
12 137362  032737  002000  007706        BIT     #F.KEYP,@#FLAGS1;are we in keypad mode?
13 137370  001411                        BEQ     1$              ;yes, so no console message
14 137372  016002  137422                MOV     FMESAG-2(R0),R2 ;start address of selected message
15 137376  004767  174122                JSR     PC,CRLF         ;send <CR> <LF>
16 137402  004767  174360                JSR     PC,PRINT        ;print radix-50 message
17 137406  005037  007630                CLR     @#BP            ;make sure nothing left in buffer
18 137412  000466                2$:     BR      $MONIT
19
20 137414  016037  137542  007726  1$:     MOV     FERCHR(R0),@#SPCLBF     ;put two character error code on LEDs
21 137422  000462                        BR      $MONIT
22
23 137424  137434                FMESAG::.WORD   FMESG1          ;pointers to error messages
24 137426  137450                        .WORD   FMESG2
25 137430  137472                        .WORD   FMESG3
26 137432  137522                        .WORD   FMESG4
27
28 137434  012446  074444  017502  FMESG1: .RAD50  /CONSOLE BREAK/
   137442  070511  042300
29 137446  000000                        .WORD   0
30 137450  007525  003770  063141  FMESG2: .RAD50  /BREAK POINT ENCOUNTERED/
   137456  055240  020563  060426
   137464  076732  017740
31 137470  000000                        .WORD   0
32 137472  035206  004051  014411  FMESG3: .RAD50  /INVALID INSTRUCTION ENCOUNTERED/
   137500  055214  071713  077167
   137506  053605  054007  102604
   137514  021025  014400
33 137520  000000                        .WORD   0
34 137522  035206  004051  014423  FMESG4: .RAD50  /INVALID STACK POINTER/
   137530  076453  042320  057466
   137536  076732
35 137540  000000                        .WORD   0
36
37 137542     120     076        FERCHR::.BYTE   120,076         ;rU (Ur Error)
38 137544     174     071                .BYTE   174,071         ;bC (Cb Error)
39 137546     163     174                .BYTE   163,174         ;Pb (bP Error)
40 137550     124     006                .BYTE   124,006         ;nI (In Error)
41 137552     163     155                .BYTE   163,155         ;PS (SP Error)
42 137554     006     174                .BYTE   006,174         ;Ib (bI Error)
43                                       .EVEN
44
```

```
                                ;++
                                ;   MONIT1 is the monitor entry point to be used for normal exit from user
                                ;   programs.  The processor context is saved, except for the PC, which retains
                                ;   its previous value so that the program can be run again.  $MONIT is the
                                ;   entry point used by monitor routines after the processor context has been
                                ;   saved.
                                ;--

137556  106746                  MONIT1::MFPS    -(SP)           ;push PS, PC like from a trap
137560  013746  007750                  MOV     @#$PC,-(SP)     ;but keep previous user PC value
137564  004767  177214                  JSR     PC,UCSAVE       ;save user context
137570  032737  000400  007706  $MONIT::BIT     #F.BRKA,@#FLAGS1;breakpoints currently installed?
137576  001426                        BEQ     2$              ;no
137600  012700  000014                  MOV     #014,R0         ;index last breakpoint address
137604  016001  007760          3$:     MOV     BRKFIL(R0),R1   ;get breakpoint address
137610  001404                        BEQ     4$              ;this breakpoint is not defined
137612  005720                        TST     (R0)+           ;point to previous contents
137614  016011  007760                  MOV     BRKFIL(R0),(R1) ;restore contents of breakpoint
137620  005740                        TST     -(R0)           ;go back to address
137622  024040                  4$:     CMP     -(R0),-(R0)     ;backup to next address
137624  005700                        TST     R0
137626  100366                        BPL     3$              ;do four entries
137630  013704  007750                  MOV     @#$PC,R4        ;point to next location
137634  032737  020000  007706          BIT     #F.TBAS,@#FLAGS1;see if we should print message
137642  001404                        BEQ     2$              ;branch if not
137644  004767  015400                  JSR     PC,TYPADR       ;type address
137650  004767  015314                  JSR     PC,TYPLOI       ;disassemble next instruction
137654  042737  030400  007706  2$:     BIC     #F.BRKA!F.APPL!F.TBAS,@#FLAGS1  ;indicate breakpoints removed
                                                                ;and enable break on ^C
137662  032737  002000  007706          BIT     #F.KEYP,@#FLAGS1;keypad mode?
137670  001402                        BEQ     1$              ;yes, go to keypad monitor
137672  000167  003026                  JMP     CMONIT          ;and go to console monitor

137676  000167  000276          1$:     JMP     KMONIT

        000076                          .REPT   <140000-.>
                                        .BYTE   0
                                        .ENDR
```

```
                                        .SBTTL  Entry Points

                                ;++
                                ;   MONITOR  ENTRY  POINTS:
                                ;--

140000  000167  015330          START:: JMP     DIAGNO          ;do diagnostics, then initialize monitor

140004  000167  176742          RSTART::JMP     $HALT           ;HALT instructions and halt line vector
                                                                ;save context and restart monitor

140010  000167  177542          MONITR::JMP     MONIT1          ;standard monitor entry (no error condition)
                                                                ;from user program, save context and remove
                                                                ;breakpoints

                                ;++
                                ;   KEYPAD/LED  UTILITY  ENTRY POINTS:
                                ;--

140014  000167  175752          DGDISP::JMP     DSPDIG          ;Display number in R0 bits 3 to 0 as a hex
                                                                ;digit at LED position indexed by R1.
                                                                ;R1=12,10,06,04,02,00 -- lower display digits
                                                                ;R1=13,11,07,05,03,01 -- upper display digits
                                                                ;R0 bits 15 to 4 are cleared, 2 is added to R1

140020  000167  176012          UPDISP::JMP     DSPUNM          ;Display number in R2 as a 6 digit octal value
                                                                ;in the upper row of LEDs.  Returns 15 in R1
                                                                ;and garbage in R0.

140024  000167  176014          LODISP::JMP     DSPLNM          ;Display number in R2 as a 6 digit octal value
                                                                ;in the lower row of LEDs.  Returns 14 in R1
                                                                ;and garbage in R0.

140030  000167  176332          DECDSP::JMP     DSPDEC          ;Display number in R1 as a 5 digit decimal
                                                                ;value on the row of LEDs indexed by R2.
                                                                ;R2 = 010 for the lower row, 011 for the upper
                                                                ;Returns zero in R1 and R3, and garbage in R0
                                                                ;and R2.

140034  000167  176304          UPBLNK::JMP     BLNKHI          ;Blank the upper row of LEDs.  Returns zero in
                                                                ;R0 and garbage in R1.

140040  000167  176272          LOBLNK::JMP     BLNKLO          ;Blank the lower row of LEDs.  Returns zero in
                                                                ;R0 and garbage in R1.

140044  000167  176366          GETKEY::JMP     KEYGET          ;Turn on LEDs and wait for a keypress.  Return
                                                                ;key number in R1.  Modifies KEYPIV.

140050  000167  176440          BCDKEY::JMP     KEYBCD          ;Translate key number in R1 to a BCD value for
                                                                ;keys 0 to 9, 012 for the CLR key, 013 for the
                                                                ;EX/ENTR key, and -1 for all other keys.

140054  000167  176466          GETNUM::JMP     NUMGET          ;Display number in R2 as an octal value on the
                                                                ;lower row of LEDs.  Activate keypad and allow
                                                                ;user to modify the value in R2 with the keys
                                                                ;0 through 7 and CLR.  Return the value in R2,
```

```
    58                                                  ;changed or not, when user presses EXA.  Uses
    59                                                  ;R2, R1, and R0.
```

```
                        ;+++
                        ;   CONSOLE  LINE  UTILITY  ENTRY  POINTS:
                        ;--

140060  000167  000104          JMP     FIXBP           ;Prompt for a line from the console.  Return
                                                        ;the line in BUFFER with R3 cleared.

140064  000167  173346          JMP     GETBP           ;Transfer the back pointer (BP) to R3.

140070  000167  173222          JMP     GETCH           ;Retrieve character indexed by R3 from BUFFER.
                                                        ;Returns character in R0, R3 incremented by 1.
                                                        ;Returns N set if character is a separator,
                                                        ;C set if it is lower case.

140074  000167  173306          JMP     GETLCH          ;Retrieve character indexed by <R3 - 1> from
                                                        ;BUFFER.  Returns same as GETCH.

140100  000167  173306          JMP     GETCHC          ;Retrieve character indexed by R3 from BUFFER
                                                        ;without folding lower case.  Returns character
                                                        ;in R0, and R3 incremented by 1.

140104  000167  173316          JMP     GETNXT          ;Retrieve next character which is not a
                                                        ;separator from BUFFER starting at location
                                                        ;indexed by R3.  Returns character in R0 with
                                                        ;lower case folded, R3 indexes next character
                                                        ;in BUFFER.

140110  000167  173334          JMP     PURGE           ;Eliminate BUFFER contents below location
                                                        ;indexed by BP.

140114  000167  174022          JMP     ECHO            ;Echo contents of BUFFER to the console
                                                        ;starting with location indexed by R3.  Returns
                                                        ;R3 indexing BUFFER location just beyond last
                                                        ;echoed character.

140120  000167  173400          JMP     CRLF            ;Send a carriage return and line feed to the
                                                        ;console (and printer).

140124  000167  173400          JMP     CHROUT          ;Send a (pair of) character(s) to the console
                                                        ;(and printer).  Character to be sent should
                                                        ;be in lower byte of R0.  If upper byte of R0
                                                        ;is non-zero, it will be sent as a second
                                                        ;character.

140130  000167  173404          JMP     CHRO1           ;Send a single character from the lower byte
                                                        ;of R0 to the console (and printer).  Returns
                                                        ;R0 with its byte swapped.

140134  000167  173414          JMP     CHRO2           ;Send a single character from the lower byte
                                                        ;of R0 to the printer (aux. port) only.
                                                        ;Returns R0 with its bytes swapped.

140140  000167  173462          JMP     ASCOUT          ;Output an ASCII character in the lower 7 bits
                                                        ;of R0 as a visible (string of) character(s)
                                                        ;on the console.  Control characters are output
                                                        ;as ^<letter>, with exceptions <SP>,<ESC>,<DEL>
```

```
                                                ;Output a string of bytes to the console (and
                                                ;printer).  R1 points to start of string, which
                                                ;must end with a blank byte.  Returns R1
                                                ;pointing to byte just after blank byte.

                                ;++
                                ;   PARSING  AND  OUTPUT  UTILITY  ENTRY  POINTS:
                                ;--

140150  000167  004346                  JMP     GETEXP

140154  000167  004332                  JMP     GENEXP

140160  000167  014560                  JMP     TYPOCT

140164  000167  014470                  JMP     TYPDEC

140170  005037  007630          FIXRP:  CLR     @#BP
140174  000167  173040                  JMP     GETLIN
```

```
 1
 2                                          .SBTTL Keypad Monitor
 3
 4 140200  042737  000077  007706  KMONIT::BIC     #000077,@#FLAGS1;clear previous mode
 5 140206  042737  000001  007756          BIC     #1,@#$ADDR      ;make current address and watchpoint even
 6 140214  042737  000001  007754          BIC     #1,@#$WATCH     ;in case we came from console monitor
 7 140222  052737  000010  007706          BIS     #F.REG,@#FLAGS1 ;set register select mode
 8 140230  012704  000007                  MOV     #007,R4         ;index PC
 9 140234  010402                          MOV     R4,R2           ;set up to display "  PC  " on upper LEDs
10 140236  004767  175650                  JSR     PC,DSPNAM       ;display it
11 140242  013705  007750                  MOV     @#$PC,R5        ;get PC contents
12 140246  010502                          MOV     R5,R2           ;set up to display on lower LEDs
13 140250  004767  175570                  JSR     PC,DSPLNM       ;display it
14 140254  032737  000200  007706          BIT     #F.SST,@#FLAGS1 ;were we single stepping?
15 140262  001411                          BEQ     KLOOP           ;no
16 140264  042737  000200  007706          BIC     #F.SST,@#FLAGS1 ;clear condition
17 140272  013702  007754                  MOV     @#$WATCH,R2     ;is there a watchpoint?
18 140276  001403                          BEQ     KLOOP           ;no
19 140300  011202                          MOV     @R2,R2          ;get watchpoint contents
20 140302  004767  175530                  JSR     PC,DSPUNM       ;display watchpoint contents in upper display
21
22 140306  012737  140330  007676  KLOOP:: MOV     #KEYCMD,@#KEYPIV;link command input routine to keypress vector
23 140314  112737  000007  177444          MOVB    #007,@#P$PORC   ;turn on LED display
24 140322  106427  000240                  MTPS    #240            ;enable LED display interrupt
25 140326  000777                  1$:     BR      1$              ;wait for keypress, key code returns in R1
26
27
28 140330  005037  007676          KEYCMD::CLR     @#KEYPIV        ;disconnect keypress vector
29 140334  012706  007462                  MOV     #STACK,SP       ;pop saved registers and return vector
30 140340  005037  007726                  CLR     @#SPCLBF        ;turn off flashing error, if any
31 140344  112737  000010  177444  KEYCM1::MOVB    #010,@#P$PORC   ;turn off LED display for faster execution
32 140352  006301                          ASL     R1              ;make a word index of R1
33 140354  000171  140360                  JMP     @DSPTBL(R1)     ;dispatch to appropriate routine
34
35 140360  141110                  DSPTBL::.WORD   $CLR            ;[CLR]
36 140362  140430                          .WORD   $NUMER          ;[ 1 ]
37 140364  140430                          .WORD   $NUMER          ;[ 4 ]
38 140366  140430                          .WORD   $NUMER          ;[ 7 ]
39 140370  140430                          .WORD   $NUMER          ;[ 0 ]
40 140372  140430                          .WORD   $NUMER          ;[ 2 ]
41 140374  140430                          .WORD   $NUMER          ;[ 5 ]
42 140376  140430                          .WORD   $NUMER          ;[ 8 ]
43 140400  141122                          .WORD   $EXAM           ;[EXA]
44 140402  140430                          .WORD   $NUMER          ;[ 3 ]
45 140404  140430                          .WORD   $NUMER          ;[ 6 ]
46 140406  140430                          .WORD   $NUMER          ;[ 9 ]
47 140410  141232                          .WORD   $ADV            ;[ADV]
48 140412  141372                          .WORD   $BACK           ;[BAC]
49 140414  141610                          .WORD   $REG            ;[REG]
50 140416  141550                          .WORD   $ADDRK          ;[ADD]
51 140420  141706                          .WORD   $SST            ;[SST]
52 140422  141714                          .WORD   $GO             ;[GO ]
53 140424  141462                          .WORD   $BRKP           ;[BPT]
54 140426  141650                          .WORD   $FUNC           ;[FNC]
```

```
                                .SBTTL Key Command Routines

140430  006201          $NUMER::ASR     R1              ;restore key number
140432  004767  176056          JSR     PC,KEYBCD       ;get BCD value for key code
140436  032737  000040  007706  BIT     #F.FUNC,@#FLAGS1;is digit a function selection?
140444  001403                  BEQ     4$              ;no
140446  020127  000004          CMP     R1,#004         ;is digit higher than 4?
140452  101315                  BHI     KLOOP           ;yes, ignore digit
140454  032701  000010  4$:     BIT     #000010,R1      ;is it 8 or 9?
140460  001404                  BEQ     1$              ;no, a legal octal digit
140462  032737  000005  007706  BIT     #F.DATA+F.ADDR,@#FLAGS1 ;no 8 or 9 as data or address input
140470  001306                  BNE     KLOOP           ;ignore them if pressed
140472  032737  000002  007706  1$:     BIT     #F.CHAN,@#FLAGS1;has a digit key already been pressed?
140500  001001                  BNE     3$              ;yes, just scroll digits in
140502  005005                  CLR     R5              ;else initialize digit accumulator
140504  052737  000002  007706  3$:     BIS     #F.CHAN,@#FLAGS1;indicate that a digit has been pressed
140512  032737  000005  007706  BIT     #F.DATA+F.ADDR,@#FLAGS1 ;address and data entry scroll digits
140520  001004                  BNE     2$
140522  042737  000002  007706  BIC     #F.CHAN,@#FLAGS1;others have single digit entry
140530  006305                  ASL     R5              ;prepare for fourth bit (might be 8 or 9)
140532  006305          2$:     ASL     R5              ;scroll digit into R5 (digit accumulator)
140534  006305                  ASL     R5
140536  006305                  ASL     R5
140540  060105                  ADD     R1,R5
                                                        ;Now do execution associated with digit input
                                                        ;Clear key joins us here
140542  032737  000005  007706  DIGEXE::BIT     #F.DATA+F.ADDR,@#FLAGS1 ;Just display new data or address
140550  001511                  BEQ     1$              ;for others, do special displays instead
140552  010502                  MOV     R5,R2           ;set new value
140554  004767  175264          JSR     PC,DSPLNM       ;and display on lower LEDs

140560  032737  000001  007706  BIT     #F.DATA,@#FLAGS1;for addresses, store in $ADDR
140566  001007                  BNE     2$
140570  010537  007756          MOV     R5,@#$ADDR
140574  042737  000001  007756  BIC     #1,@#$ADDR      ;make sure address is even
140602  000167  000362          JMP     KLOOP1          ;take another key

140606  032737  000004  007706  2$:     BIT     #F.ADDR,@#FLAGS1;but data can go many places-are we poking RAM?
140614  001407                  BEQ     3$              ;no
140616  013700  007756          MOV     @#$ADDR,R0      ;yes, set a copy of current address
140622  004767  001330          JSR     PC,KADRCH       ;check that it is not in protected RAM
140626  010510                  MOV     R5,@R0          ;place data at current address
140630  000167  000334          JMP     KLOOP1          ;take another key

140634  032737  000010  007706  3$:     BIT     #F.REG,@#FLAGS1 ;changing registers or watchpoint contents?
140642  001420                  BEQ     4$              ;no
140644  020427  000010          CMP     R4,#000010      ;does R4 index a register (0 thru 7 and PS)?
140650  101006                  BHI     5$              ;no (R4 should be 000011)
140652  006304                  ASL     R4              ;make it a word index
140654  010564  007732          MOV     R5,$R0(R4)      ;and place data in user register
140660  006204                  ASR     R4              ;restore R4
140662  000167  000302          JMP     KLOOP1          ;take another key

140666  013700  007754  5$:     MOV     @#$WATCH,R0     ;assume R4 indexes watchpoint contents
140672  004767  001260          JSR     PC,KADRCH       ;check that it is not in protected RAM
140676  010510                  MOV     R5,@R0          ;deposit data into watchpoint location
```

```
 58 140700  000167  000264                JMP     KLOOP1          ;take another key
 59
 60 140704  032737  000020  007706  4$:   BIT     #F.BRKS,@#FLAGS1;changing breakpoint or watchpoint address?
 61 140712  001526                        BEQ     KLOOP1          ;no, ignore (strange! that was a safety check)
 62 140714  020427  000014                CMP     R4,#000014      ;R4 indexing a breakpoint?
 63 140720  103416                        BLO     6$              ;no, it's not
 64 140722  020427  000017                CMP     R4,#000017
 65 140726  101013                        BHI     6$              ;no, it's not
 66 140730  006304                        ASL     R4              ;make an index for word pairs
 67 140732  006304                        ASL     R4
 68 140734  010564  007700        100$:   MOV     R5,BRKFIL-060(R4)       ;place data in breakpoint address file
 69 140740  042764  000001  007700        BIC     #1,BRKFIL-060(R4)       ;make breakpoint address even
 70 140746  006204                        ASR     R4
 71 140750  006204                        ASR     R4
 72 140752  000167  000212                JMP     KLOOP1          ;take another key
 73 140756  010537  007754        6$:     MOV     R5,@#$WATCH     ;assume R4 indexes watchpoint address
 74 140762  042737  000001  007754        BIC     #1,@#$WATCH     ;make watchpoint address even
 75 140770  000167  000174                JMP     KLOOP1          ;take another key
 76
 77 140774  032737  000040  007706  1$:   BIT     #F.FUNC,@#FLAGS1;are we entering a function code?
 78 141002  001407                        BEQ     7$              ;no, must be entering a register number
 79 141004  010100                        MOV     R1,R0           ;set new digit
 80 141006  012701  000004                MOV     #4,R1           ;index a lower display digit
 81 141012  004767  174754                JSR     PC,DSPDIG       ;display new digit
 82 141016  000167  000146                JMP     KLOOP1          ;take another key
 83
 84 141022  032737  000010  007706  7$:   BIT     #F.REG,@#FLAGS1 ;be sure we are selecting a register
 85 141030  001457                        BEQ     KLOOP1          ;else ignore key
 86 141032  010504                        MOV     R5,R4           ;save selected register number
 87 141034  020427  000011                CMP     R4,#000011      ;are watchpoint contents selected?
 88 141040  001414                        BEQ     8$              ;yes, do special display
 89 141042  010402                        MOV     R4,R2           ;display register's name on upper LEDs
 90 141044  004767  175042                JSR     PC,DSPNAM
 91 141050  006304                        ASL     R4              ;make a word index
 92 141052  016405  007732                MOV     $R0(R4),R5      ;set register's contents
 93 141056  006204                        ASR     R4
 94 141060  010502                9$:     MOV     R5,R2           ;display on lower LEDs
 95 141062  004767  174756                JSR     PC,DSPLNM
 96 141066  000167  000076                JMP     KLOOP1          ;take another key
 97
 98 141072  013702  007754        8$:     MOV     @#$WATCH,R2     ;set watchpoint address
 99 141076  004767  174734                JSR     PC,DSPUNM       ;show it on upper display
100 141102  017705  046646                MOV     @$WATCH,R5      ;set watchpoint contents
101 141106  000764                        BR      9$
102
103
104 141110  005005                $CLR::  CLR     R5              ;clear digit accumulator
105 141112  042737  000002  007706        BIC     #F.CHAN,@#FLAGS1;in case of single digit mode
106 141120  000610                        BR      DIGEXE
107
108                                       .ENABL  LSB
109
110 141122  032737  000004  007706  $EXAM::BIT    #F.ADDR,@#FLAGS1;examining RAM?
111 141130  001421                        BEQ     1$              ;no
112 141132  013702  007756                MOV     @#$ADDR,R2      ;set current address
113 141136  004767  174674                JSR     PC,DSPUNM       ;show it on upper display
114 141142  017705  046610                MOV     @$ADDR,R5       ;set contents
```

```
115 141146  010502                GNEXAM::MOV     R5,R2           ;general examine entry point
116 141150  004767  174670                JSR     PC,DSPLNM       ;show it on lower display
117 141154  052737  000001  007706        BIS     #F.DATA,@#FLAGS1;go to data entry mode
118 141162  042737  000002  007706        BIC     #F.CHAN,@#FLAGS1;indicate no change yet
119 141170  000167  177112          KLOOP1: JMP     KLOOP           ;take another key
120
121 141174  032737  000010  007706  1$:   BIT     #F.REG,@#FLAGS1 ;examining a register?
122 141202  001403                BEQ     2$              ;no
123 141204  005704                TST     R4              ;R4 initialized to -1 by $REG
124 141206  100357                BPL     GNEXAM          ;contents put in R5 by DIGEXE
125 141210  100767                BMI     KLOOP1          ;ignore EXAM, make user push a digit first
126
127 141212  032737  000040  007706  2$:   BIT     #F.FUNC,@#FLAGS1;executions special function?
128 141220  001763                BEQ     KLOOP1          ;ignore all other occurrences of EXAM
129 141222  005705                TST     R5              ;R5 initialized to -1 by $FUNC
130 141224  100761                BMI     KLOOP1          ;ignore EXAM, make user push a digit first
131 141226  000167  000774                JMP     DOFUNC          ;execute special function
132                                 .DSABL  LSB
133
134
135                                 .ENABL  LSB
136 141232  032737  000004  007706  $ADV:: BIT     #F.ADDR,@#FLAGS1;stepping through addresses?
137 141240  001405                BEQ     1$              ;no
138 141242  005237  007756                INC     @#$ADDR         ;go to next word
139 141246  005237  007756                INC     @#$ADDR
140 141252  000723                BR      $EXAM
141
142 141254  032737  000010  007706  1$:   BIT     #F.REG,@#FLAGS1 ;stepping through registers?
143 141262  001425                BEQ     2$              ;no
144 141264  005204                INC     R4              ;register index
145 141266  020427  000011                CMP     R4,#000011      ;don't step past watchpoint contents
146 141272  103411                BLO     3$
147 141274  012704  000011                MOV     #000011,R4      ;select watchpoint contents
148 141300  013702  007754                MOV     @#$WATCH,R2     ;get watchpoint address
149 141304  004767  174526                JSR     PC,DSPUNM       ;show it on upper display
150 141310  017705  046440                MOV     @#$WATCH,R5     ;get watchpoint contents
151 141314  000714                BR      GNEXAM
152
153 141316  010402                3$:   MOV     R4,R2           ;display register's name on upper LEDs
154 141320  004767  174566                JSR     PC,DSPNAM
155 141324  006304                ASL     R4              ;make a word index
156 141326  016405  007732                MOV     $R0(R4),R5      ;get register contents
157 141332  006204                ASR     R4
158 141334  000704                BR      GNEXAM
159
160 141336  032737  000020  007706  2$:   BIT     #F.BRKS,@#FLAGS1;stepping through breakpoints?
161 141344  001711                BEQ     KLOOP1          ;no, ignore advance
162 141346  005204                INC     R4              ;increment breakpoint index
163 141350  020427  000012                CMP     R4,#000012      ;do special increment pattern
164 141354  001001                BNE     4$
165 141356  005724                TST     (R4)+
166 141360  020427  000017          4$:   CMP     R4,#000017
167 141364  101440                BLOS    BRKP1           ;make breakpoint display
168 141366  005304                DEC     R4
169 141370  000436                BR      BRKP1
170
171
```

```
172 141372  032737  000004  007706  $BACK::  BIT     #F.ADDR,@#FLAGS1;steppins through addresses?
173 141400  001405                          BEQ     6$              ;no
174 141402  005337  007756                  DEC     @#$ADDR         ;go to next word
175 141406  005337  007756                  DEC     @#$ADDR
176 141412  000643                          BR      $EXAM
177
178 141414  032737  000010  007706  6$:     BIT     #F.REG,@#FLAGS1 ;steppins through registers?
179 141422  001404                          BEQ     7$              ;no
180 141424  005304                          DEC     R4
181 141426  100333                          BPL     3$              ;prevent underflow
182 141430  005004                          CLR     R4
183 141432  000731                          BR      3$              ;continue in $ADV
184
185 141434  032737  000020  007706  7$:     BIT     #F.BRKS,@#FLAGS1;steppins through breakpoints?
186 141442  001652                          BEQ     KLOOP1          ;no, ignore backup
187 141444  005304                          DEC     R4              ;decrement breakpoint index
188 141446  020427  000014                  CMP     R4,#000014      ;do special decrement pattern
189 141452  103005                          BHIS    BRKP1           ;make breakpoint display
190 141454  012704  000011                  MOV     #000011,R4      ;index watchpoint
191 141460  000402                          BR      BRKP1
192                                         .DSABL  LSB
193
194
195 141462  012704  000014          $BRKP::  MOV     #000014,R4      ;index breakpoint 0
196 141466  010402                  BRKP1:  MOV     R4,R2           ;show name of breakpoint on upper display
197 141470  004767  174416                  JSR     PC,DSPNAM
198 141474  020427  000014                  CMP     R4,#000014      ;indexing watchpoint or a breakpoint?
199 141500  103420                          BLO     1$              ;the watchpoint
200 141502  006304                          ASL     R4              ;make an index for word pairs
201 141504  006304                          ASL     R4
202 141506  016405  007700                  MOV     BRKFIL-060(R4),R5       ;set breakpoint address
203 141512  006204                          ASR     R4
204 141514  006204                          ASR     R4
205 141516  010502                  2$:     MOV     R5,R2           ;display it on lower LEDs
206 141520  004767  174320                  JSR     PC,DSPLNM
207 141524  042737  000077  007706          BIC     #000077,@#FLAGS1;clear previous mode
208 141532  052737  000021  007706          BIS     #F.BRKS+F.DATA,@#FLAGS1 ;set breakpoint and data mode
209 141540  000441                          BR      KLOOP2
210
211 141542  013705  007754          1$:     MOV     @#$WATCH,R5     ;set watchpoint address
212 141546  000763                          BR      2$
213
214
215 141550  012702  000012          $ADDRK::MOV     #012,R2         ;prompt with ' Addr ' on upper display
216 141554  004767  174332                  JSR     PC,DSPNAM
217 141560  013705  007756                  MOV     @#$ADDR,R5      ;set previous address
218 141564  010502                          MOV     R5,R2           ;show it on lower display
219 141566  004767  174252                  JSR     PC,DSPLNM
220 141572  042737  000077  007706          BIC     #000077,@#FLAGS1;clear previous mode
221 141600  052737  000004  007706          BIS     #F.ADDR,@#FLAGS1;set current address entry mode
222 141606  000416                          BR      KLOOP2
223
224
225 141610  012702  000013          $REG::  MOV     #013,R2         ;prompt with '  rEG ' on upper display
226 141614  004767  174272                  JSR     PC,DSPNAM
227 141620  012704  177777                  MOV     #-1,R4          ;initialize register index to illegal value
228 141624  004767  174506                  JSR     PC,BLNKLO       ;and blank lower display
```

```
  229 141630  042737  000077  007706          BIC     #000077,@#FLAGS1;clear previous mode
  230 141636  052737  000010  007706          BIS     #F.REG,@#FLAGS1 ;and set register select mode
  231 141644  000167  176436          KLOOP2: JMP     KLOOP
  232
  233
  234 141650  012702  000020          $FUNC:: MOV     #020,R2         ;prompt with ' Func ' on upper display
  235 141654  004767  174232                  JSR     PC,DSPNAM
  236 141660  012705  177777                  MOV     #-1,R5          ;initialize accumulator to illegal value
  237 141664  004767  174446                  JSR     PC,BLNKLO       ;and blank lower display
  238 141670  042737  000077  007706          BIC     #000077,@#FLAGS1;clear previous mode
  239 141676  052737  000040  007706          BIS     #F.FUNC,@#FLAGS1;and set function select mode
  240 141704  000757                          BR      KLOOP2
  241
  242
  243 141706  052737  000200  007706  $SST:: BIS     #F.SST,@#FLAGS1 ;show we are single stepping
  244
  245 141714  023727  007746  007400  $GO:: CMP     @#$SP,$SCRPAD   ;is user SP in his RAM?
  246 141722  101004                  $GO1:: BHI     1$              ;no, show error message
  247 141724  023727  007746  000004          CMP     @#$SP,#4        ;and is there room for 2 pushes?
  248 141732  103007                          BHIS    2$              ;yes, SP is acceptable
  249 141734  042737  000200  007706  1$:     BIC     #F.SST,@#FLAGS1 ;else abort
  250 141742  012700  000004                  MOV     #4,R0           ;SP Error
  251 141746  000167  175376                  JMP     FERROR          ;go to fatal error handler to reenter monitor
  252
  253 141752  013702  007736          2$:     MOV     @#R2,R2         ;restore user context,
  254 141756  013703  007740                  MOV     @#R3,R3
  255 141762  013704  007742                  MOV     @#R4,R4
  256 141766  013705  007744                  MOV     @#R5,R5
  257 141772  013737  007700  007676          MOV     @#KEYPVS,@#KEYPIV       ;and user keypress vector
  258 142000  013706  007746                  MOV     @#$SP,SP        ;we're on user's stack now
  259 142004  013746  007752                  MOV     @#$PS,-(SP)     ;push PS, PC like from a trap
  260 142010  042716  000020                  BIC     #020,(SP)       ;clear T-bit
  261 142014  032737  000200  007706          BIT     #F.SST,@#FLAGS1 ;are we single stepping?
  262 142022  001422                          BEQ     3$              ;no
  263 142024  052716  000020          4$:     BIS     #020,(SP)       ;yes, set T-bit
  264 142030  012737  137174  000014  9$:     MOV     #BRKPT,@#014    ;make sure BPT trap is still connected
  265 142036  012737  000340  000016          MOV     #340,@#016
  266 142044  013700  007732                  MOV     @#$R0,R0        ;finish restoring context
  267 142050  013701  007734                  MOV     @#$R1,R1
  268 142054  013746  007750                  MOV     @#$PC,-(SP)     ;push PC
  269 142060  052737  000100  007706          BIS     #F.USER,@#FLAGS1;show we are running user code
  270 142066  000006                          RTT                     ;and simulate return from trap
  271
  272 142070                          3$:
  273 142070  032737  001000  007706  5$:     BIT     #F.BRKG,@#FLAGS1;single stepping over a break point
  274 142076  001352                          BNE     4$              ;if yes then don't install
  275
  276 142100  012700  007760                  MOV     #BRKFIL,R0      ;start of break point table
  277 142104  012701  000004                  MOV     #4,R1           ;four entrys
  278 142110  013020                  100$:   MOV     @(R0)+,(R0)+    ;suck up data from break point locations
  279 142112  077102                          SOB     R1,100$         ;
  280 142114  012700  007760                  MOV     #BRKFIL,R0      ;start of break point table
  281 142120  012701  000004                  MOV     #4,R1           ;same as last time
  282 142124  005710                  200$:   TST     (R0)            ;first see if there was really one set
  283 142126  001405                          BEQ     300$            ;branch if not
  284 142130  012730  000003                  MOV     #3,@(R0)+       ;set break point
  285 142134  005720                          TST     (R0)+           ;skip to next
```

```
286 142136  077106                400$:   SOB     R1,200$         ;four entrys
287 142140  000402                        BR      500$
288 142142  032020                300$:   BIT     (R0)+,(R0)+     ;skip this entry
289 142144  000774                        BR      400$            ;go back for next
290 142146  052737  000400  007706  500$:   BIS     #F.BRKA,@#FLAGS1;indicate breakpoints installed
291 142154  000725                        BR      9$              ;and go
292
293
294
295 142156  032737  040000  007706  KADRCH: BIT     #F.PROT,@#FLAGS1;keypad scratch protection on?
296 142164  001017                        BNE     1$              ;no, deposit anywhere
297 142166  020027  020000                CMP     R0,#20000       ;is address above upper instance of scratchpad?
298 142172  103014                        BHIS    1$              ;yes, definitely doesn't address protected RAM
299 142174  020027  007400                CMP     R0,#SCRPAD      ;is it below lower instance of scratchpad?
300 142200  103411                        BLO     1$              ;yes
301 142202  020027  010000                CMP     R0,#10000       ;is it within lower instance of scratchpad?
302 142206  103403                        BLO     2$              ;yes, address is illegal
303 142210  020027  017400                CMP     R0,#SCRPAD+10000;is it between instances of scratchpad RAM?
304 142214  103403                        BLO     1$              ;yes, not within them, so address is OK
305 142216  005000                2$:     CLR     R0              ;index user RAM error message
306 142220  000167  175124                JMP     FERROR          ;go to fatal error handler to reenter monitor
307
308 142224  000207                1$:     RTS     PC              ;address is acceptable
309
```

```
                                        .SBTTL Special Keypad Monitor Functions

142226  006305                  DOFUNC::ASL     R5              ;R5 was 0, 1, 2, 3, or 4
142230  000175  142234                  JMP     @FNCTBL(R5)     ;dispatch to selected function

142234  142246                  FNCTBL::.WORD   CANCEL          ;0 means cancel breakpoints
142236  142270                          .WORD   GO$LED          ;1 means turn on LEDs and go at user PC
142240  142572                          .WORD   CMON1           ;2 means cold start console monitor
142242  142320                          .WORD   SPEEDS          ;3 means select baud rates and console type
142244  142562                          .WORD   NPROT           ;4 means disable keypad monitor scratch protec.

142246  012700  000020          CANCEL::MOV     #020,R0         ;8 words in breakpoint file
142252  105060  007757          1$:     CLRB    BRKFIL-1(R0)    ;clear address/contents pairs
142256  077003                  1$:     SOB     R0,1$
142260  005037  007754                  CLR     @#$WATCH        ;cancel watchpoint also
142264  000167  175710          FNCDON: JMP     KMDWIT          ;go to register select mode

142270  112737  000007  177444 GO$LED::MOVB    #007,@#P$PORC   ;turn on LED displays
142276  000167  177412                  JMP     $GO             ;and go

142302  000454                  SPDTBL::.WORD   300.
142304  001130                          .WORD   600.
142306  002260                          .WORD   1200.
142310  004540                          .WORD   2400.
142312  011300                          .WORD   4800.
142314  022600                          .WORD   9600.
142316  045400                          .WORD   19200.

142320  012702  000021          SPEEDS::MOV     #021,R2         ;index 'ConSol'
142324  004767  173562                  JSR     PC,DSPNAM       ;show prompt on upper display
142330  113705  007710                  MOVB    @#CONFLG,R5     ;get baud rate bits
142334  042705  177707                  BIC     #177707,R5      ;mask out other flags
142340  006205          5$:     ASR     R5              ;shift to word index position
142342  006205                  ASR     R5
142344  016501  142302                  MOV     SPDTBL(R5),R1   ;get corresponding baud rate
142350  012702  000010                  MOV     #010,R2         ;index lower display
142354  004767  174006                  JSR     PC,DSPDEC       ;display decimal number
142360  004767  174052          3$:     JSR     PC,KEYGET       ;wait for a key
142364  020127  000010                  CMP     R1,#010         ;was it "Enter"?
142370  001436                          BEQ     1$              ;yes, go to aux port speed
142372  020127  000016                  CMP     R1,#016         ;was is a function key?
142376  103067                          BHIS    10$             ;yes, exit
142400  020127  000014                  CMP     R1,#014         ;was it advance?
142404  001410                          BEQ     2$              ;yes, modify baud rate
142406  020127  000015                  CMP     R1,#015         ;was it backup?
142412  001362                          BNE     3$              ;no, wait for another key

142414  005305                  4$:     DEC     R5              ;decrease baud rate
142416  005305                  4$:     DEC     R5
142420  100007                          BPL     4$              ;show new rate
142422  005005                          CLR     R5              ;prevent underflow
142424  000405                          BR      4$

142426  005725          2$:     TST     (R5)+           ;increase baud rate
142430  020527  000016                  CMP     R5,#016         ;overflow?
142434  103401                          BLO     4$              ;no
```

```
    58 142436  005745                        TST     -(R5)
    59 142440  006305                4$:     ASL     R5              ;store index in baud rate bits
    60 142442  006305                        ASL     R5
    61 142444  006305                        ASL     R5
    62 142446  106137  007710                ROLB    @#CONFLG        ;preserve high order bit (F,A64X)
    63 142452  110537  007710                MOVB    R5,@#CONFLG
    64 142456  106037  007710                RORB    @#CONFLG
    65 142462  006205                        ASR     R5
    66 142464  000725                        BR      5$
    67
    68 142466  012702  000022          1$:   MOV     #022,R2         ;index 'A,Port'
    69 142472  004767  173414                JSR     PC,DSPNAM       ;show prompt
    70 142476  016501  142302          8$:   MOV     SPDTBL(R5),R1   ;get console baud rate
    71 142502  105737  007710                TSTB    @#CONFLG        ;is 64 X set for aux port?
    72 142506  100002                        BPL     9$              ;no, same speeds
    73 142510  006201                        ASR     R1              ;else console rate / 4
    74 142512  006201                        ASR     R1
    75 142514  012702  000010          9$:   MOV     #010,R2         ;index lower display
    76 142520  004767  173642                JSR     PC,DSPDEC       ;display baud rate
    77 142524  004767  173706                JSR     PC,KEYGET       ;wait for a key
    78 142530  020127  000010                CMP     R1,#010         ;is it 'Enter'?
    79 142534  001653                        BEQ     FNCDON          ;yes, finished
    80 142536  020127  000016                CMP     R1,#016         ;was it a function button?
    81 142542  103005                        BHIS    10$             ;yes, exit
    82 142544  012700  000200                MOV     #F,A64X,R0      ;no, toggle aux port baud rate
    83 142550  074037  007710                XOR     R0,@#CONFLG     ;CONFLG is an even byte
    84 142554  000750                        BR      8$              ;wait for enter key
    85
    86 142556  000167  175562          10$:  JMP     KEYCM1          ;execute function key
    87
    88 142562  052737  040000  007706  NPROT:: BIS   #F,PROT,@#FLAGS1;turn off protection
    89 142570  000635                        BR      FNCDON          ;go to register select mode
```

```
                                        .SBTTL  Console Monitor
                                ;++
                                ;   REGISTER USAGE:
                                ;               R5      last expression value
                                ;               R4      current term value and scratch current address
                                ;               R3      running pointer for input buffer
                                ;               R2      pointer and general passing to routines
                                ;               R1      computational scratch
                                ;               R0      passing to bottom level routines and scratch
                                ;
                                ;
                                ;   Cold entry point:
                                ;--

142572  012737  006500  007746  CMON1::MOV      #@$UR,@#$SP     ;initialize user SP for console monitor
142600  012737  040100  007330          MOV     #400$100+100,@#TMPMOD   ;set default modes
142606  012737  000004  007325          MOV     #F.NULL,@#LASLIN;initialize last line flags
142614  005037  007630                  CLR     @#BP            ;initialize console buffer pointers
142620  105037  007672                  CLRB    @#HFP           ;clear host buffer pointer also
142624  142737  000007  007710          BICB    #007,@#CONFLG   ;clear console line flags (but not speed)
142632  105037  007673                  CLRB    @#HSTFLG        ;clear host flags
142636  012767  133000  035214          MOV     #LINEIN,CONIN   ;hook up console input service routine
142644  113700  007710                  MOVB    @#CONFLG,R0     ;get current baud rate
142650  052700  000002                  BIS     #000002,R0      ;enable prog, baud rate, disable xmit interrupt
142654  010037  177564                  MOV     R0,@#C$XCSR     ;transfer control word to console port
142660  004767  172304                  JSR     PC,SETAUX       ;set aux port baud rate and disable
142664  052737  002000  007706          BIS     #F.KEYP,@#FLAGS1;disable keypad monitor
142672  106427  000000                  MTPS    #000            ;enable interrupts
142676  012737  000100  177560          MOV     #000100,@#C$RCSR;enable console receiver interrupt
142704  004767  170614                  JSR     PC,CRLF         ;start a new line
142710  004767  170610                  JSR     PC,CRLF
142714  012702  143052                  MOV     #GRET,R2        ;point to greeting message
142720  004767  171042                  JSR     PC,PRINT        ;type message
                                ;++
                                ;   Warm entry point:
                                ;--

142724  012767  133000  035126  CMONIT::MOV     #LINEIN,CONIN   ;hook up console input service routine
142732  106427  000000          MTPS    #000            ;enable interrupts
142736  012737  000100  177560          MOV     #000100,@#C$RCSR;enable console receiver interrupt
142744  032737  004000  007706          BIT     #F.HOST,@#FLAGS1;is host mode enabled?
142752  001412                          BEQ     1$              ;no, clear host flags to terminate functions
142754  012737  134540  000120          MOV     #HOSTIN,@#AUXIN ;hook up host input service interrupt
142762  112737  000046  007711          MOVB    #046,@#AUXFLG   ;save a copy of new A$CREG value
142770  112737  000046  177452          MOVB    #046,@#A$CREG   ;reenable aux port receiver interrupt
142776  000402                          BR      2$

143000  105037  007673          1$:     CLRB    @#HSTFLG        ;stop host activity
143004  032737  000200  007706  2$:     BIT     #F.SST,@#FLAGS1 ;were we single stepping?
143012  001501                          BEQ     CMON3           ;no: scrap line
143014  042737  000200  007706          BIC     #F.SST,@#FLAGS1 ;clear flag from $GO1 routine
143022  004767  006702                  JSR     PC,TYPREG       ;yes, display registers
143026  013704  007750                  MOV     @#$PC,R4        ;point to next location
143032  004767  012212                  JSR     PC,TYPADR       ;type address
143036  004767  012126                  JSR     PC,TYPLOI       ;disassemble next instruction
143042  005737  007466                  TST     @#REPEAT        ;were we repeating?
```

```
    58 143046  001463                    BEQ     CMON3           ;no
    59 143050  000476                    BR      CMON4           ;yes, keep command line
```

```
     1
     2 143052  076725  000207  055207  GRET:   .RAD50  /TEM CONSOLE MONITOR V1.0 /
       143060  045710  051646  035557
       143066  070226  143076  000000
     3 143074  000000                  .WORD   0
     4 143076  001640  004540  WHAT:   .RAD50  / WHAT /
     5 143102  000000                  .WORD   0
     6 143104  007716  023132  001156  OVERFL: .RAD50  /BUFFER OVERFLOW/
       143112  021026  046557
     7 143116  000000                  .WORD   0
     8
     9 143120  004767  170400  PRNERR::JSR     PC,CRLF         ;type <CR> <LF>
    10 143124  012700  056007          MOV     #400*134+007,R0 ;type <BELL> \
    11 143130  004767  170374          JSR     PC,CHROUT
    12 143134  004767  170276          JSR     PC,GETBP        ;set running pointer to back pointer
    13 143140  004767  170776          JSR     PC,ECHO         ;echo buffer to console to indicate error
    14 143144  012700  000134          MOV     #134,R0         ;type \ <CR>
    15 143150  004767  170354          JSR     PC,CHROUT
    16 143154  004767  170344          JSR     PC,CRLF
    17 143160  000167  170602          JMP     PRINT           ;print error message
    18
    19                             ;++
    20                             ;   Command error entry point:
    21                             ;--
    22
    23 143164  012706  007462  CMON2:: MOV     #STACK,SP       ;we came here from unspecified depth
    24 143170  012702  143076          MOV     #WHAT,R2        ;point to error message
    25 143174  004767  177720          JSR     PC,PRNERR       ;print erroneous command line and error message
    26 143200  012700  000077          MOV     #077,R0         ;type ? <CR>
    27 143204  004767  170320          JSR     PC,CHROUT
    28 143210  000402                  BR      CMON3
    29
    30                             ;++
    31                             ;   General error entry; scrap rest of command line, terminate host input:
    32                             ;--
    33
    34 143212  004767  177702  ERROR:: JSR     PC,PRNERR       ;print error message
    35 143216  142737  000200  007673 CMON3:: BICB    #F.LOAD,@#HSTFLG;stop loading from host
    36 143224  012706  007462  CMON31: MOV     #STACK,SP       ;we don't know at which level error occurred
    37 143230  005037  007630          CLR     @#BP            ;clear both back pointer and forward pointer
    38 143234  005037  007466          CLR     @#REPEAT        ;don't keep repeating bad command line
    39 143240  152737  000004  007324          BISB    #F.NULL,@#LINFLG;act like line was not empty
    40                             ;++
    41                             ;   Fresh command line and repeat entry point:
    42                             ;--
    43
    44 143246  000337  007324  CMON4:: SWAB    @#LINFLG        ;save old line parsing flags
    45 143252  105037  007324          CLRB    @#LINFLG        ;reset line parsing flags for new line
    46 143256  004767  170166          JSR     PC,PURGE        ;purge bottom of buffer, clear running pointer
    47 143262  005737  007466          TST     @#REPEAT        ;repeat line or prompt for a new one?
    48 143266  001403                  BEQ     1$              ;prompt for a new one
    49 143270  005337  007466          DEC     @#REPEAT        ;count repetitions
    50 143274  000543                  BR      CMON5           ;and re-execute line
    51
    52 143276  113737  007331  007330 1$:     MOVB    @#PERMOD,@#TMPMOD       ;restore permanent modes
    53 143304  004767  170214          JSR     PC,CRLF         ;start a new line
    54 143310  012701  076725          MOV     #<24*50+05>*50+15,R1    ;RAD50 triplet 'TEM'
```

```
 55 143314  004767  170464              JSR     PC,PRINT1       ;type a single RAD50 triplet
 56 143320  012700  020076              MOV     #400*040+076,R0 ;type > <SPACE>
 57 143324  004767  170200              JSR     PC,CHROUT
 58 143330  123703  007631      2$:     CMPB    @#FP,R3         ;see if a character has been typed
 59 143334  001415                      BEQ     3$              ;no, go check host buffer
 60 143336  004767  170600      8$:     JSR     PC,ECHO         ;echo character to console
 61 143342  126327  007467  000015      CMPB    BUFFER-1(R3),#015       ;is last character a <CR>?
 62 143350  001367                      BNE     2$              ;no, wait for one
 63 143352  105037  007324              CLRB    @#LINFLG        ;reset line flags from ECHO
 64 143356  005003                      CLR     R3              ;set running pointer to beginning of line
 65 143360  142737  000001  007673      BICB    #F.BYTB,@#HSTFLG;clear host line byte bucket (^O) flag
 66 143366  000506                      BR      CMON5           ;execute line
 67
 68 143370  105737  007672      3$:     TSTB    @#HFP           ;see if we have a character from the host
 69 143374  001755                      BEQ     2$              ;no, go back and check console
 70 143376  105737  007673              TSTB    @#HSTFLG        ;are we loading or just listening?
 71 143402  100444                      BMI     4$              ;loading
 72 143404  132737  000001  007673      BITB    #F.BYTB,@#HSTFLG;are we ignoring host messages?
 73 143412  001403                      BEQ     9$              ;no
 74 143414  004767  171324              JSR     PC,HGETCH       ;yes, get character from host
 75 143420  000743                      BR      2$              ;and throw it away
 76
 77 143422  004767  170076      9$:     JSR     PC,CRLF         ;start a new line to show message from host
 78 143426  012701  032153              MOV     #<10*50+17>*50+23,R1    ;RAD50 triplet 'HOS'
 79 143432  004767  170346              JSR     PC,PRINT1       ;type a single RAD50 triplet
 80 143436  012700  037124              MOV     #400*076+124,R0 ;'T>'
 81 143442  004767  170062              JSR     PC,CHROUT       ;complete the header
 82 143446  105737  007672      5$:     TSTB    @#HFP           ;see if we have a character
 83 143452  001411                      BEQ     7$              ;no, check console for keypress
 84 143454  004767  171264              JSR     PC,HGETCH       ;get character from host buffer
 85 143460  132737  000001  007673      BITB    #F.BYTB,@#HSTFLG;are we ignoring host messages?
 86 143466  001003                      BNE     7$              ;yes, throw character away
 87 143470  010100                      MOV     R1,R0
 88 143472  004767  170032              JSR     PC,CHROUT       ;else echo it to console
 89 143476  123703  007631      7$:     CMPB    @#FP,R3         ;see if console typed a character
 90 143502  001761                      BEQ     5$              ;if not, continue host message
 91 143504  005003                      CLR     R3              ;prepare to re-echo console input
 92 143506  105037  007324              CLRB    @#LINFLG
 93 143512  000671                      BR      1$              ;redisplay prompt and echo buffer again
 94
 95 143514  004767  171224      4$:     JSR     PC,HGETCH       ;get character from host buffer
 96 143520  106427  000340              MTPS    #340            ;block console interrupt for a while
 97 143524  113702  007631              MOVB    @#FP,R2         ;get console buffer input pointer
 98 143530  042702  177400              BIC     #177400,R2      ;prevent sign extend
 99 143534  001003                      BNE     10$             ;we aren't at beginning of line
100 143536  120127  000012              CMPB    R1,#012         ;throw away line feeds at beginning of line
101 143542  001407                      BEQ     11$
102 143544  120227  000140      10$:    CMPB    R2,#140         ;is buffer full?
103 143550  103007                      BHIS    6$              ;yes, abort load process
104 143552  110162  007470              MOVB    R1,BUFFER(R2)   ;transfer character to console input buffer
105 143556  105237  007631              INCB    @#FP            ;advance buffer input pointer
106 143562  106427  000000      11$:    MTPS    #000            ;restore interrupts
107 143566  000660                      BR      2$              ;echo buffer to console
108
109 143570  106427  000000      6$:     MTPS    #000            ;restore interrupts
110 143574  012702  143104              MOV     #OVERFL,R2      ;point to error message
111 143600  000167  177406              JMP     ERROR           ;and print it
```

```
                                ;++
                                ;   Next command entry point:
                                ;--

143604  004767  167616         CMON5:: JSR     PC,GETNXT       ;get first meaningful character
143610  000402                         BR      CMON6

143612  004767  167570         CONTIN::JSR     PC,GETLCH       ;recover last acquired character

143616  005737  007466         CMON6:: TST     @#REPEAT        ;are we repeating?
143622  001004                         BNE     1$              ;yes, so keep last command
143624  110337  007630                 MOVB    R3,@#BP         ;else throw it away
143630  105337  007630                 DECB    @#BP
143634  000337  007326         1$:     SWAB    @#CURCOM        ;save old command flags
143640  105037  007326                 CLRB    @#CURCOM        ;and initialize them for next command
143644  000402                         BR      CMON7

                                ;++
                                ;   Parse top level:
                                ;--

                                        .ENABL  LSB
143646  004767  167554         COMLUP: JSR     PC,GETNXT       ;get next meaningful character
143652  120027  000015         CMON7:  CMPB    R0,#015         ;is it <CR>?
143656  001544                         BEQ     DOCR            ;yes, go to <CR> handler

143660  152737  000004  007324 1$:     BISB    #F.NULL,@#LINFLG;show that line is not empty
143666  132737  000020  007324         BITB    #F.COMM,@#LINFLG;are we in a comment?
143674  001364                         BNE     COMLUP          ;yes, keep looking for <CR>
143676  120027  000054                 CMPB    R0,#054         ;is it comma?
143702  001761                         BEQ     COMLUP          ;ignore commas at top level
143704  120027  000033                 CMPB    R0,#033         ;is it <ESC>?
143710  001005                         BNE     2$              ;no
143712  000402                         BR      ERROR2

143714  000167  000354         4$:     JMP     DOEXPR          ;go to general expression handler
143720  000167  177240         ERROR2: JMP     CMON2

143724  120027  000042         2$:     CMPB    R0,#042         ;is character control, space, or '!'?
143730  103773                         BLO     ERROR2          ;yes, invalid command
143732  120027  000137                 CMPB    R0,#137         ;is it above underscore?
143736  101370                         BHI     ERROR2          ;yes, invalid command
143740  001006                         BNE     5$              ;not an underscore
143742  010537  007336                 MOV     R5,@#SAVEXP     ;execute underscore
143746  152737  000010  007324         BISB    #F.SAVX,@#LINFLG;show pending underscore
143754  000713                         BR      CMON5           ;get next command

143756  120027  000136         5$:     CMPB    R0,#136         ;is it caret?
143762  001010                         BNE     6$              ;no
143764  005337  007756                 DEC     @#$ADDR         ;execute caret
143770  105737  007330                 TSTB    @#TMPMOD        ;are we in byte mode?
143774  100703                         BMI     CMON5           ;yes, back up a byte
143776  005337  007756                 DEC     @#$ADDR         ;else back up a whole word
144002  000700                         BR      CMON5           ;get next command

144004  120027  000134         6$:     CMPB    R0,#134         ;is it reverse slant?
144010  001017                         BNE     7$              ;no
```

```
169 144012  106437  007327              MTPS    @#LASCOM        ;did the last expression have undefined symbols
170 144016  001010                      BNE     8$              ;yes, refuse setting of the current address
171 144020  010537  007756              MOV     R5,@#$ADDR      ;execute reverse slant
172 144024  010504                      MOV     R5,R4           ;set new address
173 144026  004767  011216              JSR     PC,TYPADR       ;type R4 as number or label
174 144032  004767  011042              JSR     PC,TYPLOC       ;type location addressed by R4
175 144036  000662                      BR      CMDN5           ;get next command
176
177 144040  012702  151372      8$:     MOV     #UNDEFX,R2      ;error, undefined expression
178 144044  000167  177142              JMP     ERROR
179
180 144050  120027  000133      7$:     CMPB    R0,#133         ;is it left bracket?
181 144054  101321                      BHI     ERROR2          ;no, invalid command
182 144056  120027  000100              CMPB    R0,#100         ;is it alphabetic?
183 144062  101314                      BHI     4$              ;yes, beginning of expression or instruction
184 144064  001715                      BEQ     ERROR2          ;no, at sign is invalid command
185                                                             ;we've narrowed R0 to the 042 to 077 range
186 144066  116001  155774              MOVB    PARAMS-040(R0),R1       ;get parsing code
187 144072  042701  177770              BIC     #177770,R1      ;mask out other information
188 144076  006301                      ASL     R1              ;make it a word index
189 144100  000171  144104              JMP     @PARDSP(R1)     ;and dispatch accordingly
190                                     .DSABL  LSB
191
192 144104  143164          PARDSP: .WORD   CMDN2            ;0 means invalid command
193 144106  144274                  .WORD   DOEXPR          ;1 means set expression or instruction
194 144110  151426                  .WORD   DOLABL          ;2 means define label
195 144112  144124                  .WORD   DOCOMM          ;3 means start comment
196 144114  151164                  .WORD   DOSYMB          ;4 means define symbol
197 144116  144134                  .WORD   DONVAL          ;5 means type numerically
198 144120  143164                  .WORD   CMDN2           ;6 means valid as operator within expressions
199 144122  144274                  .WORD   DOEXPR          ;7 means both 1 and 6 are true
200
201
202 144124  152737  000020  007324  DOCOMM: BISB    #F.COMM,@#LINFLG;indicate we're in a comment
203 144132  000624                      BR      CMDN5           ;and continue
204
205
206 144134  004767  167364          DONVAL: JSR     PC,CRLF         ;type last expression numerically
207 144140  016746  043164                  MOV     TMPMOD,-(SP)    ;save flags
208 144144  042767  000200  043156          BIC     #F.BYTM,TMPMOD  ;make word mode
209 144152  010501                      MOV     R5,R1
210 144154  004767  010716              JSR     PC,TYPNM1
211 144160  012667  043144              MOV     (SP)+,TMPMOD    ;restore flags
212 144164  000167  177414              JMP     CMDN5
213
214
215 144170  105737  007673          DOCR:: TSTB    @#HSTFLG        ;are we loading from host?
216 144174  100426                      BMI     3$              ;yes, suppress <CR> command feature
217 144176  106437  007324              MTPS    @#LINFLG        ;get command line flags
218 144202  001423                      BEQ     3$              ;line is not empty, so do nothing
219 144204  106437  007325              MTPS    @#LASLIN
220 144210  103427                      BCS     5$              ;last line caused single step, so step again
221 144212  013704  007756              MOV     @#$ADDR,R4      ;get current address
222 144216  132737  000004  007325          BITB    #F.NULL,@#LASLIN;did last line dump locations?
223 144224  001004                      BNE     6$              ;no, so don't advance
224 144226  013704  007334              MOV     @#ADVADR,R4     ;advance past last dump
225 144232  010437  007756              MOV     R4,@#$ADDR
```

```
   226 144236  016705  033535          6$:     MOV     -1,R5
   227 144242  004767  010734                  JSR     PC,TYPLIN       ;type a line of locations
   228 144246  010437  007334                  MOV     R4,@#ADVADR     ;save next address for subsequent dump
   229
   230 144252  005737  007466          3$:     TST     @#REPEAT        ;are we repeating?
   231 144256  001002                          BNE     4$              ;yes, so keep command line
   232 144260  110337  007630                  MOVB    R3,@#BP         ;no, discard executed commands
   233 144264  000167  176756          4$:     JMP     CMDN4
   234
   235 144270  000167  003122          5$:     JMP     STEP            ;execute single step
```

```
 1
 2                                      .SBTTL  Parsing Routines
 3                                ;++
 4                                ;   DOEXPR parses an expression, instruction, directive, or verb, and handles
 5                                ;   it accordingly.  If appropriate, expressions are deposited at the current
 6                                ;   location.  Note that the old value of R2 (which may be a pointer to a symbol
 7                                ;   from the last invocation of DOEXPR) is saved before parsing an expression.
 8                                ;   This is to accomodate the .ESC directive, whose parsing will change the value
 9                                ;   of R2.  The old value is needed for sequences such as <symbol> .ESC K .
10                                ;   The old value of EXPFLG is also saved, for the same reason.
11                                ;--
12
13                                      .ENABL  LSB
14 144274  004767  000212          DOEXPR::JSR     PC,GENEXP       ;get an expression
15 144300  120027  000072                  CMPB    R0,#072         ;is next character :?
16 144304  001453                          BEQ     14$             ;yes, ignore expression
17 144306  120027  000075                  CMPB    R0,#075         ;is next character =?
18 144312  001450                          BEQ     14$             ;yes, ignore expression
19 144314  106437  007326                  MTPS    @#CURCOM        ;has R5 been set?
20 144320  102010                          BVC     2$              ;yes, not just a name
21 144322  106437  007332                  MTPS    @#EXPFLG        ;what is name?
22 144326  100063                          BPL     8$              ;predefined symbol
23 144330  102003                          BVC     9$              ;defined user symbol, proceed
24 144332  005737  007706                  TST     @#FLAGS1        ;else see if we are in PASS1 mode
25 144336  100031                          BPL     3$              ;user defined name has no value in PASS2, error
26
27 144340  010405                  9$:     MOV     R4,R5           ;get name's value
28 144342  120027  000077          2$:     CMPB    R0,#077         ;is next character '?'?
29 144346  001432                          BEQ     14$             ;yes, do nothing
30 144350  120027  000134                  CMPB    R0,#134         ;is it \?
31 144354  001427                          BEQ     14$             ;yes, do nothing
32 144356  120027  000137                  CMPB    R0,#137         ;is it _?
33 144362  001424                          BEQ     14$             ;yes, do nothing
34 144364  120027  000033                  CMPB    R0,#033         ;is it <ESC>?
35 144370  001421                          BEQ     14$             ;yes, do nothing
36 144372  106437  007324                  MTPS    @#LINFLG        ;has underline been executed?
37 144376  100420                          BMI     6$              ;yes, dump RAM locations
38 144400  004767  010120                  JSR     PC,ADRCH1       ;check if odd address or not in user RAM
39 144404  105737  007330                  TSTB    @#TMPMOD        ;are we in byte mode?
40 144410  100406                          BMI     4$              ;yes
41 144412  010514                          MOV     R5,@R4          ;deposit data word
42 144414  005237  007756                  INC     @#$ADDR
43 144420  000403                          BR      5$
44
45 144422  000167  176536          3$:     JMP     CMON2
46
47 144426  110514                  4$:     MOVB    R5,@R4          ;deposit byte of data
48 144430  005237  007756          5$:     INC     @#$ADDR
49 144434  000167  177152          14$:    JMP     CONTIN          ;recover last character, parse next command
50
51
52 144440  142737  000010  007324  6$:     BICB    #F.SAVX,@#LINFLG
53 144446  013704  007336                  MOV     @#SAVEXP,R4     ;get starting address
54 144452  004767  010524          7$:     JSR     PC,TYPLIN       ;dump a line of locations
55 144456  001366                  11$:    BNE     14$
56 144460  132737  000100  007330  10$:    BITB    #F.INST,@#TMPMOD;avoid typing duplicate addresses
57 144466  001771                          BEQ     7$
```

```
   58 144470  004767  010512              JSR     PC,TYPLIN+4
   59 144474  000770                      BR      11$
   60
   61 144476  102403              8$:     BVS     12$             ;is a directive or verb
   62 144500  103317                      BCC     9$              ;is R0, ., B1, etc.
   63 144502  000167  005500              JMP     GETINS          ;else is an instruction
   64
   65 144506  000167  002460      12$:    JMP     DOVERB          ;handle directives and verbs
   66                                     .DSABL  LSB
   67
```

```
                                ;++
                                ;   GETEXP parses a whole expression and returns its value in R5.
                                ;   GENEXP parses an expression or recognizes an instruction or symbol.
                                ;--

                                        .ENABL  LSB
144512  152737  000002  007326 GENEXP::BISB    #F.VALU,@#CURCOM;set flag to allow non-valued objects
144520  000402                 7$:     BR      7$              ;such as undefined symbols, directives, etc.

144522  004767  000452         GETEXP::JSR     PC,EXINI1       ;initialize and set valued expression
144526  005037  007332         7$:     CLR     @#EXPFLG        ;clear level counter and term flags
144532  152737  000004  007326         BISB    #F.UNDF,@#CURCOM;clear undefined expression flag
144540  005004                 GETEX1: CLR     R4              ;initialize term register
144542  120027  000053                 CMPB    R0,#053         ;is it +?
144546  001464                         BEQ     GETOPV          ;yes, accept operator
144550  120027  000055                 CMPB    R0,#055         ;is it -?
144554  001461                         BEQ     GETOPV
144556  120027  000043         GETERM::CMPB    R0,#043         ;is it #?
144562  001004                         BNE     1$
144564  004767  000402                 JSR     PC,EXINIT       ;set valued expression
144570  004767  166632                 JSR     PC,GETNXT       ;get next character
144574  120027  000074         1$:     CMPB    R0,#074         ;is it <?
144600  001522                         BEQ     LPAREN          ;yes, do left parenthesis
144602  120027  000133                 CMPB    R0,#133         ;is it [?
144606  001517                         BEQ     LPAREN          ;yes, do left parenthesis
144610  120027  000047                 CMPB    R0,#047         ;is it '?
144614  001003                         BNE     3$              ;no
144616  004767  001236                 JSR     PC,GETLIT       ;parse literal term
144622  000436                         BR      GETOPV          ;force valued expression and get operator
144624  004767  007526         3$:     JSR     PC,NUMCH        ;is it numeric?
144630  100403                         BMI     2$              ;no
144632  004767  000450                 JSR     PC,GETNMB       ;get number
144636  000430                         BR      GETOPV          ;force valued expression, get operator
144640  004767  007436         2$:     JSR     PC,RADCH        ;is it RAD50 character?
144644  100476                         BMI     13$             ;no, illegal character
144646  004767  000576                 JSR     PC,GETNAM       ;parse named object
144652  106737  007332                 MFPS    @#EXPFLG        ;save condition flags
144656  106437  007332                 MTPS    @#EXPFLG        ;recover actual values
144662  100406                         BMI     8$              ;user defined symbol or undefined name
144664  102446                         BVS     ENDEXP          ;a directive or verb, try to exit
144666  103016                         BCC     GETOPR          ;predefined symbol, get operator
144670  106437  007326                 MTPS    @#CURCOM        ;is this a valued expression?
144674  102442                         BVS     ENDEXP          ;no, we have an instruction, try to exit
144676  000412                         BR      GETOPR          ;use base value of instruction as data, get op.

144700  102011         8$:     BVC     GETOPR          ;proceed if user symbol if defined
144702  142737  000004  007326         BICB    #F.UNDF,@#CURCOM;show we have encountered an undefined symbol
144710  005737  007706                 TST     @#FLAGS1        ;are we in PASS1?
144714  100032                         BPL     ENDEXP          ;no, don't allow undefined symbol in expression
144716  000402                         BR      GETOPR          ;yes, proceed with expression

144720  004767  000246         GETOPV::JSR     PC,EXINIT       ;initialize data expression
144724  004767  166456         GETOPR::JSR     PC,GETLCH       ;recover last character
144730  120027  000076                 CMPB    R0,#076         ;is it >?
144734  001506                         BEQ     RPAREN          ;yes, do right parenthesis
144736  120027  000135                 CMPB    R0,#135         ;is it ]?
144742  001507                         BEQ     FPAREN          ;yes, do right parenthesis fetch
```

```
 58 144744 120027 000041          CMPB   R0,#041        ;is character below /?
 59 144750 103412                 BLO    6$            ;yes, not an operator
 60 144752 120027 000060          CMPB   R0,#060       ;is it above /?
 61 144756 103007                 BHIS   6$            ;yes, not an operator
 62 144760 116001 155774          MOVB   PARAMS-040(R0),R1     ;set parsing code
 63 144764 042701 177770          BIC    #177770,R1    ;mask out the garbage
 64 144770 020127 000006          CMP    R1,#6         ;is it an operator?
 65 144774 103053                 BHIS   DOOPER        ;yes, do operator
 66
 67 144776 004767 000216    6$:   JSR    PC,EXDOOP     ;no more operators, but do previous one
 68
 69 145002 105737 007333    ENDEXP: TSTB   @#LEVEL       ;are we at top level?
 70 145006 001015                 BNE    13$           ;no, error
 71 145010 106437 007326          MTPS   @#CURCOM      ;is expression supposed to be valued?
 72 145014 102410                 BVS    5$            ;not necessarily
 73 145016 106437 007332          MTPS   @#EXPFLG      ;was term valued?
 74 145022 100401                 BMI    9$            ;no, but it was user defined
 75 145024 102406                 BVS    13$           ;no, error
 76 145026 102003           9$:   BVC    5$            ;was valued, no problem
 77 145030 005737 007706          TST    @#FLAGS1      ;are we in PASS1?
 78 145034 100101                 BPL    12$           ;no, undefined symbol is not allowed
 79 145036 000167 166344    5$:   JMP    GETLCH        ;get last character back in R0
 80
 81 145042 000167 176116    13$:  JMP    CMON2         ;show error
 82
 83 145046 020627 007410    LPAREN: CMP    SP,#BOTTOM+10.+22.+2.   ;is there room to recurse?
 84                                ;(that was 5 words for future JSRs, 11 for interupts, and 1 safety)
 85 145052 103773                 BLO    13$           ;no, parenthesis too deep
 86 145054 004767 000112          JSR    PC,EXINIT     ;force upper expression to be valued
 87 145060 010546                 MOV    R5,-(SP)      ;save accumulator
 88 145062 113746 007343          MOVB   @#OPERAT,-(SP) ;and previous operator
 89 145066 105237 007333          INCB   @#LEVEL       ;show we are going deeper
 90 145072 004767 000102          JSR    PC,EXINI1     ;initialize accum. and operator for next level
 91 145076 004767 166324          JSR    PC,GETNXT     ;get first character of nested expression
 92 145102 004767 177432          JSR    PC,GETEX1     ;get value of nested expression
 93 145106 010504                 MOV    R5,R4         ;nested value becomes operand
 94 145110 112637 007343          MOVB   (SP)+,@#OPERAT ;recover operator
 95 145114 012605                 MOV    (SP)+,R5      ;and accumulator
 96 145116 004767 166304          JSR    PC,GETNXT     ;get character after right paren
 97 145122 000700                 BR     GETOPR        ;and look for next operator
 98
 99 145124 004767 000042    DOOPER: JSR    PC,EXINIT     ;force valued expression
100 145130 004767 000064          JSR    PC,EXDOOP     ;execute previous operator
101 145134 004767 166246          JSR    PC,GETLCH     ;get new operator
102 145140 110037 007343          MOVB   R0,@#OPERAT   ;store it
103 145144 004767 166256          JSR    PC,GETNXT     ;get next character
104 145150 000602                 BR     GETERM        ;look for a term
105
106 145152 105337 007333    RPAREN: DECB   @#LEVEL       ;are we at top level?
107 145156 100731                 BMI    13$           ;yes, too many right parenthesis
108 145160 000417                 BR     EXDOOP        ;do last operator inside parenthesis and return
109
110 145162 004767 177764    FPAREN: JSR    PC,RPAREN
111 145166 011505                 MOV    @R5,R5        ;do a fetch
112 145170 000207                 RTS    PC
113
114 145172 106437 007326    EXINIT: MTPS   @#CURCOM      ;has expression already been initialized?
```

```
    115 145176  102007                        BVC     4$              ;yes
    116 145200  112737  000053  007343  EXINI1: MOVB    #053,@#OPERAT   ;set + as default operator
    117 145206  005005                        CLR     R5              ;clear expression accumulator
    118 145210  142737  000002  007326        BICB    #F.VALU,@#CURCOM;show expression is valued
    119 145216  000207                4$:     RTS     PC
    120
    121 145220  106437  007326        EXDOOP: MTPS    @#CURCOM        ;if expression is valued, do operator
    122 145224  102774                        BVS     4$              ;not valued
    123 145226  113701  007343                MOVB    @#OPERAT,R1     ;set operator
    124 145232  006301                        ASL     R1              ;make a word index
    125 145234  000171  145146                JMP     @OPRTBL-102(R1) ;execute operator
    126
    127 145240  012702  151372        12$:    MOV     #UNDEFX,R2      ;point to undefined expression message
    128 145244  000167  175742                JMP     ERROR           ;show error
    129                                       .DSABL  LSB
    130
    131 145250  152130                OPRTBL: .WORD   LOGOR           ;!
    132 145252  143164                        .WORD   CMON2           ;"
    133 145254  143164                        .WORD   CMON2           ;#
    134 145256  143164                        .WORD   CMON2           ;$
    135 145260  143164                        .WORD   CMON2           ;%
    136 145262  152134                        .WORD   LOGAND          ;&
    137 145264  143164                        .WORD   CMON2           ;'
    138 145266  143164                        .WORD   CMON2           ;(
    139 145270  143164                        .WORD   CMON2           ;)
    140 145272  152142                        .WORD   MULTIP          ;*
    141 145274  152154                        .WORD   ADDIT           ;+
    142 145276  143164                        .WORD   CMON2           ;,
    143 145300  152160                        .WORD   SUBTR           ;-
    144 145302  143164                        .WORD   CMON2           ;.
    145 145304  152164                        .WORD   DIVID           ;/
```

```
                                ;++
                                ;   GETNMB parses a number and returns all condition flags lowered.
                                ;--

145306  005303          GETNMB::DEC     R3              ;save running pointer to peek ahead
145310  010346                  MOV     R3,-(SP)
145312  004767  166000  1$:     JSR     PC,GETCH
145316  004767  007034          JSR     PC,NUMCH        ;is it 0 through 9?
145322  100373                  BPL     1$              ;yes, wait for first non-numeric character
145324  012603                  MOV     (SP)+,R3        ;go back to beginning of number
145326  005001                  CLR     R1
145330  120027  000056          CMPB    R0,#056         ;is first non-numeric character a period?
145334  001427                  BEQ     2$              ;yes, parse a decimal number
145336  004767  006740          JSR     PC,RADCH        ;is it alphabetic?
145342  100402                  BMI     3$              ;no, parse an octal number
145344  000167  175614  4$:     JMP     CMON2           ;illegal, label begins with a number

145350  004767  165742  3$:     JSR     PC,GETCH
145354  004767  006776          JSR     PC,NUMCH        ;is it 0 through 7 or 8 through 9?
145360  100410                  BMI     5$              ;no, end of number
145362  102770                  BVS     4$              ;8 and 9 are illegal in octal numbers
145364  162700  000060          SUB     #060,R0         ;make it BCD
145370  006301                  ASL     R1
145372  006301                  ASL     R1
145374  006301                  ASL     R1
145376  060001                  ADD     R0,R1           ;accumulate digits
145400  000763                  BR      3$              ;get next digit

145402  005303          5$:     DEC     R3
145404  004767  166016  6$:     JSR     PC,GETNXT       ;get character after number
145410  010104                  MOV     R1,R4           ;store value of number
145412  000207                  RTS     PC

145414  004767  165676  2$:     JSR     PC,GETCH
145420  004767  006732          JSR     PC,NUMCH
145424  100767                  BMI     6$              ;trailing decimal point
145426  162700  000060          SUB     #060,R0
145432  006301                  ASL     R1
145434  010146                  MOV     R1,-(SP)
145436  006301                  ASL     R1
145440  006301                  ASL     R1
145442  062601                  ADD     (SP)+,R1
145444  060001                  ADD     R0,R1           ;accumulate digits
145446  000762                  BR      2$              ;get next digit
```

```
                                ;++
                                ;   GETNAM parses a name and converts it into RAD50 at locations TBLTOP and
                                ;   TBLTOP+2.  If the name has a corresponding value, it is placed in R4.
                                ;   R2 is an index to where the name is stored.  It can index either the RAD50
                                ;   table in ROM for predefined symbols, or the user symbol table.  GETNAM
                                ;   returns condition flags to indicate these options as follows:
                                ;   V=1 means the name has no value
                                ;   N=1 means the name is user defined (not predefined)
                                ;   C=1 means the name is a mnemonic, directive, or verb
                                ;   N=0, V=0, C=0 means that the name is R0, SP, PC, B1, UR, etc.
                                ;   N=0, V=0, C=1 means that the name is an instruction
                                ;   N=0, V=1, C=1 means that the name is directive or verb
                                ;   N=1, V=1 means that the name is an undefined symbol
                                ;   N=1, V=0 means that the name is a user symbol
                                ;--

                                        .ENABL  LSB
145450  112737  000003  007341  GETNAM::MOVB    #3,@#COUNT2
145456  005001                  1$:     CLR     R1
145460  004767  006732                  JSR     PC,ASCRAD       ;convert ASCII in R0 to RAD50 in R1
145464  004767  165626                  JSR     PC,GETCH        ;get next character
145470  004767  006606                  JSR     PC,RADCH        ;is it a legal RAD50 character?
145474  100431                          BMI     2$              ;no, end of name
145476  105337  007341                  DECB    @#COUNT2
145502  001366                          BNE     1$
145504  010137  007320                  MOV     R1,@#TBLTOP
145510  112737  000003  007341          MOVB    #3,@#COUNT2
145516  005001                          CLR     R1
145520  004767  006672                  3$:     JSR     PC,ASCRAD
145524  004767  165566                  JSR     PC,GETCH
145530  004767  006546                  JSR     PC,RADCH
145534  100421                          BMI     6$
145536  105337  007341                  DECB    @#COUNT2
145542  001366                          BNE     3$
145544  004767  165546                  4$:     JSR     PC,GETCH        ;discard all characters after 6
145550  004767  006526                  JSR     PC,RADCH        ;is character still part of name?
145554  100373                          BPL     4$              ;yes
145556  000412                          BR      5$

145560  004767  000264                  2$:     JSR     PC,PADRAD       ;pad R1 with spaces
145564  010137  007320                  MOV     R1,@#TBLTOP     ;store first word of name
145570  012737  000003  007341          MOV     #3,@#COUNT2
145576  005001                          CLR     R1
145600  004767  000244                  6$:     JSR     PC,PADRAD
145604  010137  007322                  5$:     MOV     R1,@#TBLTOP+2
145610  005303                          DEC     R3              ;get next meaningful character
145612  004767  165610                  JSR     PC,GETNXT
145616  013700  007320                  MOV     @#TBLTOP,R0     ;R0, R1 contain converted name

145622  005002                          CLR     R2              ;compare name to predefined ones
145624  020062  156142                  10$:    CMP     R0,DSYMS(R2)
145630  001011                          BNE     11$
145632  020162  156144                  CMP     R1,DSYMS+2(R2)
145636  001414                          BEQ     PDSVAL          ;get value of predefined symbol
145640  020127  006200                  CMP     R1,#50*50*02    ;might this be a byte mode mnemonic?
145644  001003                          BNE     11$             ;no
```

```
 58 145646  005762  156144                TST     DSYMS+2(R2)     ;and is name the same without trailing 'B'?
 59 145652  001406                       BEQ     PDSVAL          ;yes, handle byte mode case
 60 145654  022222                11$:   CMP     (R2)+,(R2)+     ;advance to next name
 61 145656  020227  000770                CMP     R2,#TOPNAM      ;end of table?
 62 145662  103760                       BLO     10$             ;not yet
 63 145664  000167  003670         21$:   JMP     GETSYM          ;no match to predefined symbols
 64
 65 145670  020227  000054         PDSVAL::CMP     R2,#DSYMUR-DSYMS;now get symbol's value in R4
 66 145674  103401                       BLO     13$             ;R0 through .
 67 145676  002005                       BGE     14$             ;B1 or higher
 68 145700  006202                13$:   ASR     R2              ;make a word index
 69 145702  016204  007732                MOV     $R0(R2),R4      ;R0 through .
 70 145706  006302                       ASL     R2
 71 145710  000405                       BR      15$
 72
 73 145712  020227  000100         14$:   CMP     R2,#DIRVRB-DSYMS
 74 145716  103004                       BHIS    7$              ;BASIC or higher
 75 145720  016204  007700                MOV     BRKFIL-<DSYMUR+4-DSYMS>(R2),R4  ;B1 through B4
 76 145724  000257                15$:   CCC                     ;flag a predefined symbol
 77 145726  000207                       RTS     PC              ;and return
 78
 79 145730  020227  000300         7$:    CMP     R2,#CMNEMS-DSYMS
 80 145734  103003                       BHIS    17$             ;CLC or higher
 81 145736  000277                       SCC                     ;flag a directive or verb
 82 145740  000250                       CLN
 83 145742  000207                       RTS     PC              ;and return
 84
 85 145744  006202                17$:   ASR     R2
 86 145746  016204  155440                MOV     CBASES-<<CMNEMS-DSYMS>/2>(R2),R4        ;get value of mnemonic
 87 145752  006302                       ASL     R2
 88 145754  020227  000340                CMP     R2,#MNEMS-DSYMS
 89 145760  103003                       BHIS    18$             ;HALT or higher
 90 145762  012702  000064                MOV     #MNCCC-MNEMS,R2 ;index mnemonic CCC
 91 145766  000421                       BR      19$
 92
 93 145770  020127  006200         18$:   CMP     R1,#50*50*02    ;byte mode name?
 94 145774  001014                       BNE     20$             ;no
 95 145776  020027  075131                CMP     R0,#<23*50+27>*50+01    ;SWAB mnemonic?
 96 146002  001411                       BEQ     20$             ;yes, not byte mode
 97 146004  006202                       ASR     R2
 98 146006  006202                       ASR     R2
 99 146010  105762  155744                TSTB    PARAMS-<<MNEMS-DSYMS>/4>(R2)    ;instruction legal in byte mo
100 146014  100323                       BPL     21$             ;no
101 146016  006302                       ASL     R2
102 146020  006302                       ASL     R2
103 146022  052704  100000                BIS     #100000,R4      ;adjust opcode to byte mode
104 146026  162702  000340         20$:   SUB     #MNEMS-DSYMS,R2 ;adjust index to instruction table
105 146032  000257                19$:   CCC
106 146034  000261                       SEC                     ;flag an instruction
107 146036  000207                       RTS     PC
108                                      .DSABL  LSB
109
110 146040  012700  000040         PADR1: MOV     #040,R0
111 146044  004767  006346                JSR     PC,ASCRAD
112 146050  105337  007341         PADRAD: DECB    @#COUNT2        ;routine to pad RAD50 triplet with spaces
113 146054  001371                       BNE     PADR1
114 146056  000207                       RTS     PC
```

```
 1
 2                                ;++
 3                                ;   GETLIT parses ASCII literals.
 4                                ;--
 5
 6 146060  004767  165326         GETLIT::JSR     PC,GETCHC       ;get next character, don't fold case
 7 146064  120027  000015                 CMPB    R0,#015         ;is it <CR>?
 8 146070  001002                         BNE     1$              ;no
 9 146072  000167  175066                 JMP     CMON2           ;error, no character on line
10
11 146076  010004                 1$:     MOV     R0,R4           ;store value
12 146100  000167  165322                 JMP     GETNXT          ;get next character, return
13
14
15 146104  110137  007330         SETMOD: MOVB    R1,@#TMPMOD
16 146110  004767  165312                 JSR     PC,GETNXT
17 146114  005303                         DEC     R3
18 146116  105737  007330                 TSTB    @#TMPMOD
19 146122  100403                         BMI     1$
20 146124  042737  000001  007756         BIC     #1,@##ADDR      ;fix address when leaving byte mode
21 146132  120027  000015         1$:     CMPB    R0,#015         ;is mode command last command on line?
22 146136  001106                         BNE     ECON            ;no
23 146140  113737  007330  007331         MOVB    @#TMPMOD,@#PERMOD       ;yes, set permanent modes
24 146146  000502                         BR      ECON
25
26 146150  152701  000002         EABS::  BISB    #F.ABS,R1
27 146154  000753                         BR      SETMOD
28
29
30 146156  012700  000020         ECAN::  MOV     #20,R0
31 146162  105060  007757         1$:     CLRB    BRKFIL-1(R0)
32 146166  077003                         SOB     R0,1$
33 146170  005037  007754                 CLR     @#$WATCH
34 146174  000467                         BR      ECON
35
36
37 146176  142701  000100         EBYT::  BICB    #F.INST,R1
38 146202  152701  000200                 BISB    #F.BYTM,R1
39 146206  000736                         BR      SETMOD
40
41 146210  142701  000200         EINS::  BICB    #F.BYTM,R1
42 146214  152701  000100                 BISB    #F.INST,R1
43 146220  000731                         BR      SETMOD
44
45 146222  012737  007320  007462 ECLR::  MOV     #TBLTOP,@#TBLBOT;move symble table pointer to empty position
46 146230  000451                         BR      ECON
47
48 146232  132737  000002  007327 EDEL::  BITB    #F.VALU,@#LASCOM;was last "command" valued?
49 146240  001447                 EDEL1:: BEQ     EERR            ;yes, not just a name
50 146242  106437  007332                 MTPS    @#EXPFLG
51 146246  100044                         BPL     EERR            ;can't delete predefined symbols
52 146250  102443                         BVS     EERR            ;can't delete a forward reference
53 146252  162702  000006                 SUB     #6,R2           ;back up to specified entry
54 146256  004767  003620                 JSR     PC,TYPSYM       ;type current value before deleting
55 146262  004767  003406                 JSR     PC,DELSYM       ;delete entry
56 146266  000432                         BR      ECON
57
```

```
    58 146270  142701  000300          ENUM::  BICB    #F.INST+F.BYTM,R1
    59 146274  000703                          BR      SETMOD
    60
    61
    62 146276  010537  007466          EREP::  MOV     R5,@#REPEAT     ;enable repeated execution
    63 146302  110337  007630                  MOVB    R3,@#BP         ;act like a new line starts after <ESC> N
    64 146306  000167  174734                  JMP     CMDN4           ;execute rest of line repeatedly
    65
    66 146312  142701  000002          ESYM::  BICB    #F.ABS,R1
    67 146316  000672                          BR      SETMOD
    68
    69
    70 146320  004767  165102          EEXT::  JSR     PC,GETNXT       ;get character after Z
    71 146324  004767  176172                  JSR     PC,GETEXP       ;parse transfer address
    72 146330  000115                          JMP     @R5
    73
    74 146332  016746  040772          EREG::  MOV     TMPMOD,-(SP)    ;for byte mode
    75 146336  042767  000200  040764          BIC     #F.BYTM,TMPMOD  ;
    76 146344  004767  003360                  JSR     PC,TYPREG       ;type contents of registers and watchpoint
    77 146350  012667  040754                  MOV     (SP)+,TMPMOD    ;restore flags
    78 146354  000167  175224          ECON:   JMP     CMDN5
    79 146360  000167  174600          EERR:   JMP     CMDN2
    80
    81 146364  106437  007324          EMOV::  MTPS    @#LINFLG        ;see if underline has been executed
    82 146370  100373                          BPL     EERR            ;it hasn't--error-- missing parameter
    83 146372  010502                          MOV     R5,R2           ;get final address of source memory block
    84 146374  013701  007336                  MOV     @#SAVEXP,R1     ;get starting address of source
    85 146400  142737  000010  007324          BICB    #F.SAVX,@#LINFLG;show that saved expression has been used
    86 146406  005737  007706                  TST     @#FLAGS1        ;are we in PASS1 mode?
    87 146412  100760                          BMI     ECON            ;yes, don't execute move
    88 146414  020201                          CMP     R2,R1           ;is final address below starting address?
    89 146416  103760                          BLO     EERR            ;yes, show error
    90 146420  105737  007330                  TSTB    @#TMPMOD        ;are we in byte mode?
    91 146424  100404                          BMI     1$              ;yes
    92 146426  042701  000001                  BIC     #1,R1           ;else force starting address to even boundary
    93 146432  052702  000001                  BIS     #1,R2           ;and final address to odd boundary
    94 146436  013704  007756          1$:     MOV     @#$ADDR,R4      ;get starting address of destination block
    95 146442  060204                          ADD     R2,R4           ;calculate final address from length of source
    96 146444  160104                          SUB     R1,R4
    97 146446  010400                          MOV     R4,R0           ;save result for later
    98 146450  105737  007330                  TSTB    @#TMPMOD        ;are we in byte mode?
    99 146454  100401                          BMI     2$              ;yes
   100 146456  005304                          DEC     R4              ;adjust result for previous BIC and BIS
   101 146460  004767  006044          2$:     JSR     PC,ADRCH2       ;check that final destination address is legal
   102 146464  004767  006034                  JSR     PC,ADRCH1       ;get starting destination address and check it
   103                                                 ;now see if destination addresses straddle protected RAM
   104 146470  020027  006500                  CMP     R0,#$UR         ;is final addr below lower instance of prot RAM
   105 146474  103415                          BLO     3$              ;yes, destination range OK
   106 146476  020427  020000                  CMP     R4,#20000       ;is start addr above upper instance of prot RAM
   107 146502  103012                          BHIS    3$              ;yes, destination range OK
   108 146504  020427  010000                  CMP     R4,#10000       ;does destin overlap lower instance of prot RAM
   109 146510  103403                          BLO     4$              ;yes, range is unacceptable
   110 146512  020027  020000                  CMP     R0,#20000       ;is final addr below upper instance of prot RAM
   111                                                 ;this is a trick test -- we know R0 is not
   112                                                 ;within the range $UR+10000--17777 from ADRCH2
   113 146516  103404                          BLO     3$              ;yes, range doesn't overlap upper instance
   114 146520  012702  154476          4$:     MOV     #USERAM,R2      ;point to user RAM error message
```

```
115 146524  000167  174462              JMP     ERROR           ;print error message
116
117 146530  020401              3$:     CMP     R4,R1           ;now see if destination block is above or below
118 146532  101004                      BHI     5$              ;source -- above means use backward transfer
119 146534  112124              6$:     MOVB    (R1)+,(R4)+     ;else do forward transfer
120 146536  020102                      CMP     R1,R2
121 146540  101775                      BLOS    6$              ;do entire block
122 146542  000704                      BR      ECON
123
124 146544  005202              5$:     INC     R2              ;adjust pointers for autodecrement
125 146546  005200                      INC     R0
126 146550  114240              7$:     MOVB    -(R2),-(R0)     ;perform backward transfer
127 146552  020201                      CMP     R2,R1
128 146554  101375                      BHI     7$              ;do entire block
129 146556  000676                      BR      ECON
130
131 146560  106437  007324      EFND:;  MTPS    @#LINFLG        ;see if underline has been executed
132 146564  100275                      BPL     EERR            ;it hasn't--error--missing parameter
133 146566  010537  007334              MOV     R5,@#ADVADR     ;save upper search range limit
134 146572  142737  000010  007324      BICB    #F.SAVX,@#LINFLG;show that saved expression has been used
135 146600  004767  164622              JSR     PC,GETNXT       ;get character after F
136 146604  004767  175712              JSR     PC,GETEXP       ;get value to be searched for
137 146610  024646                      CMP     -(SP),-(SP)     ;make space for two scratch location on stack
138 146612  010516                      MOV     R5,(SP)         ;save value to be searched for on stack
139 146614  005066  000002              CLR     2(SP)           ;initialize complement of search mask to zero
140 146620  120027  000137              CMPB    R0,#137         ;is next character an underscore?
141 146624  001010                      BNE     1$              ;no, optional mask parameter not present
142 146626  004767  164574              JSR     PC,GETNXT       ;get character after underscore
143 146632  004767  175664              JSR     PC,GETEXP       ;get search mask
144 146636  010566  000002              MOV     R5,2(SP)        ;store it on stack
145 146642  005166  000002              COM     2(SP)           ;complement mask
146 146646  013704  007336      1$:     MOV     @#SAVEXP,R4     ;get starting address of search range
147 146652  105737  007330      2$:     TSTB    @#TMPMOD        ;are we in byte mode
148 146656  100430                      BMI     4$              ;yes, perform bytewise search
149 146660  042704  000001              BIC     #1,R4           ;for word search, make sure address is even
150 146664  011401                      MOV     @R4,R1          ;get a word
151 146666  011600                      MOV     (SP),R0         ;get search value
152 146670  074001                      XOR     R0,R1           ;compare values
153 146672  046601  000002              BIC     2(SP),R1        ;ignore bits that are masked out
154 146676  001005              5$:     BNE     3$              ;no match
155 146700  004767  006344              JSR     PC,TYPADR       ;type address of matched location
156 146704  004767  006204              JSR     PC,TYPLO1       ;type contents, but not as an instruction
157 146710  000405                      BR      6$              ;TYPLO1 already incremented R4
158 146712  005204              3$:     INC     R4              ;advance to next location
159 146714  105737  007330              TSTB    @#TMPMOD        ;are we in byte mode?
160 146720  100401                      BMI     6$              ;yes, advance by one
161 146722  005204                      INC     R4              ;else advance a whole word
162 146724  020437  007334      6$:     CMP     R4,@#ADVADR     ;see if entire range has been checked
163 146730  101750                      BLOS    2$              ;continue searching
164 146732  022626                      CMP     (SP)+,(SP)+     ;discard stacked values
165 146734  000167  174652              JMP     CONTIN          ;recover character in R0, parse next command
166
167 146740  111401              4$:     MOVB    @R4,R1          ;get a byte
168 146742  011600                      MOV     (SP),R0         ;get search value
169 146744  074001                      XOR     R0,R1           ;compare values
170 146746  046601  000002              BIC     2(SP),R1        ;ignore bits that are masked out
171 146752  042701  177400              BIC     #177400,R1      ;ignore discrepancies in high byte
```

```
172 146756  000747                        BR      5$
173
174
175 146760  004767  164540        EMOD::  JSR     PC,CRLF         ;start a new line
176 146764  013704  007706                MOV     @#FLAGS1,R4     ;get a copy of some mode flags
177 146770  012702  156256                MOV     #DIRVB1,R2      ;point to PASS1 command
178 146774  032704  100000                BIT     #F.PAS1,R4      ;see if we're in PASS1 or PASS2
179 147000  004767  000132                JSR     PC,1$           ;print proper mode and point to NOPROT
180 147004  032704  004000                BIT     #F.HOST,R4      ;see if HOST or NOHOST is active
181 147010  004767  000122                JSR     PC,1$           ;print proper mode
182 147014  113704  007330                MOVB    @#TMPMOD,R4     ;get a copy of the rest of the mode flags
183 147020  012702  156366                MOV     #DIRVBI,R2      ;point to INSTRU command
184 147024  132704  000100                BITB    #F.INST,R4      ;see if instruction mode is active
185 147030  001402                        BEQ     4$              ;branch if not
186 147032  004767  000100                JSR     PC,1$           ;print proper mode
187 147036                          4$:
188 147036  012702  156346                MOV     #DIRVBA,R2      ;point to ABSOLU command
189 147042  132704  000002                BITB    #F.ABS,R4       ;see if absolute or symbolic mode is active
190 147046  001002                        BNE     6$              ;absolute mode
191 147050  012702  156412                MOV     #DIRVBS,R2      ;point to symbolic mode
192 147054  004767  000056          6$:   JSR     PC,1$           ;print proper mode
193 147060  012702  156362                MOV     #DIRVBH,R2      ;point to BYTE command
194 147064  132704  000200                BITB    #F.BYTM,R4      ;see if byte mode is active
195 147070  001402                        BEQ     7$              ;it isn't, print nothing
196 147072  004767  164676                JSR     PC,PRINT2       ;else print BYTE command
197 147076  012702  156376          7$:   MOV     #DIRVBN-4,R2    ;point to word mode
198 147102  132704  000300                BITB    #F.INST!F.BYTM,R4       ;if not byte or instruction then word
199 147106  001002                        BNE     20$
200 147110  004767  000022                JSR     PC,1$
201 147114  012702  156432          20$:  MOV     #DIRVBT+14,R2   ;point to vtmode
202 147120  032767  004000  040203        BIT     #F.VT,PERMOD    ;see if set
203 147126  004767  000004                JSR     PC,1$           ;go show wich vt mode
204 147132  000167  177216                JMP     ECON            ;and return
205
206 147136  106746                  1$:   MFPS    -(SP)           ;save Z flag
207 147140  106416                        MTPS    (SP)            ;get back a copy
208 147142  001001                        BNE     2$              ;print command pointed to by R2
209 147144  022222                        CMP     (R2)+,(R2)+     ;else advance to next command
210 147146  004767  164622          2$:   JSR     PC,PRINT2       ;print command, advance R2
211 147152  012700  004440                MOV     #400$011+040,R0 ;<space> <tab>
212 147156  004767  164346                JSR     PC,CHROUT
213 147162  106426                        MTPS    (SP)+           ;recover Z flag
214 147164  001401                        BEQ     3$              ;if we advanced before, don't do it again
215 147166  022222                        CMP     (R2)+,(R2)+     ;skip over next command
216 147170  000207                  3$:   RTS     PC
```

```
                                        .SBTTL  Directive and Verb Handling Routines

147172  162702  000100          DOVERB::SUB     #DIRVRB-DSYMS,R2;remove offset from index to verb
147176  006202                          ASR     R2              ;make it a word index
147200  020227  000042                  CMP     R2,#VRBDS1-VRBDSP       ;is this verb an <ESC> seq. replacement
147204  103403                          BLO     1$              ;no
147206  005303                          DEC     R3              ;make it so that we can use previous routines
147210  013701  007330                  MOV     @#TMPMOD,R1     ;from the escape sequence handler
147214  000172  147220          1$:     JMP     @VRBDSP(R2)     ;dispatch to proper handling routine


147220                          VRBDSP::
147220  147320                          .WORD   HELP
147222  147432                          .WORD   GO
147224  147416                          .WORD   STEP
147226  150202                          .WORD   PASS1
147230  150212                          .WORD   PASS2
147232  150222                          .WORD   HOST
147234  150306                          .WORD   NOHOST
147236  150504                          .WORD   TALK
147240  150442                          .WORD   LOAD
147242  143164                          .WORD   CMON2           ;.START
147244  143216                          .WORD   CMON3           ;.END
147246  147776                          .WORD   $.EVEN
147250  147700                          .WORD   $.ASCI
147252  147466                          .WORD   $.BYTE
147254  147560                          .WORD   $.WORD
147256  147634                          .WORD   $.BLKB
147260  147654                          .WORD   $.BLKW
147262  146150          VRBDS1: .WORD   EABS            ;ABSOLU  point to the start of escape
147264  146156                          .WORD   ECAN            ;CANCEL
147266  136752                          .WORD   $HALT           ;EXIT
147270  146176                          .WORD   EBYT            ;BYTE
147272  146210                          .WORD   EINS            ;INSTRU
147274  146222                          .WORD   ECLR            ;CLEAR$
147276  147444                          .WORD   DELETE          ;DELETE
147300  146270                          .WORD   EWUM            ;WORD
147302  150012                          .WORD   $RPEAT          ;REPEAT
147304  146312                          .WORD   ESYM            ;SYMBOL
147306  146760                          .WORD   EMOD            ;SHOWMD
147310  146332                          .WORD   EREG            ;SHOWRE
147312  152040                          .WORD   TYPTBL          ;SHOWSY
147314  147374                          .WORD   VTON            ;VTON
147316  147406                          .WORD   VTOFF           ;VTOFF

147320  012702  156242          HELP::  MOV     #DIRVRB,R2      ;type the verb/directive table on the console
147324  004767  164174          2$:     JSR     PC,CRLF         ;start a new line
147330  112737  000010  007341          MOVB    #8.,@#COUNT2    ;put 8 commands on a line
147336  004767  164432          1$:     JSR     PC,PRINT2       ;print a command
147342  020227  156442                  CMP     R2,#CMNEMS      ;have we done the whole table?
147346  103010                          BHIS    3$              ;yes
147350  105337  007341                  DECB    @#COUNT2        ;have we finished a line?
147354  001763                          BEQ     2$              ;yes
147356  012700  004440                  MOV     #400*011+040,R0 ;type <space> <tab>
147362  004767  164142                  JSR     PC,CHROUT
147366  000763                          BR      1$
```

```
                58
 147370 000167 174216          3$:     JMP     CONTIN          ;recover character in R0, continue parsing line
                60
 147374 052767 004000 037726   VTON:   BIS     #F.VT,TMPMOD    ;turn vt mode on
 147402 000167 174176          VTJMP:  JMP     CMON5
                63
 147406 042767 004000 037714   VTOFF:  BIC     #F.VT,TMPMOD    ;turn vt off
 147414 000772                         BR      VTJMP
                66
 147416 052737 000200 007706   STEP::  BIS     #F.SST,@#FLAGS1 ;show we are single stepping
 147424 152737 000001 007324           BISB    #F.SST1,@#LINFLG
 147432 023727 007746 006500   GO::    CMP     @#$SP,#$UR      ;is user SP in his RAM?
 147440 000167 172256                  JMP     $GO1            ;use keypad monitor GO routine
                71
                72
 147444 005203                 DELETE::INC     R3              ;counteract earlier DEC R3 in this case
 147446 004767 175040                  JSR     PC,GENEXP       ;get symbol name to be deleted
 147452 005303                         DEC     R3              ;now prepare to use <ESC> sequence routine
 147454 132737 000002 007326           BITB    #F.VALU,@#CURCOM;replaces test on LASCOM in EDEL
 147462 000167 176552                  JMP     EDEL1           ;go to routine to delete a symbol
                78
                79
 147466 013737 007756 007334   $.BYTE::MOV     @#$ADDR,@#ADVADR;get a scratch copy of current address
 147474 004767 175022          1$:     JSR     PC,GETEXP       ;get a value to be deposited
 147500 113746 007330                  MOVB    @#TMPMOD,-(SP)  ;fool ADRCHK into thinking we are in byte mode
 147504 052737 000200 007330           BIS     #F.BYTM,@#TMPMOD
 147512 013704 007334                  MOV     @#ADVADR,R4     ;get running copy of current address
 147516 004767 005006                  JSR     PC,ADRCH2       ;check that it's not in protected RAM
 147522 112637 007330                  MOVB    (SP)+,@#TMPMOD  ;restore proper mode bits
 147526 110514                         MOVB    R5,@R4          ;deposit a byte
 147530 005237 007334                  INC     @#ADVADR        ;advance running address
 147534 120027 000054                  CMPB    R0,#054         ;is next character a comma?
 147540 001003                         BNE     2$              ;no
 147542 004767 163660                  JSR     PC,GETNXT       ;get character after comma
 147546 000752                         BR      1$              ;deposit another byte
                93
 147550 013737 007334 007756   2$:     MOV     @#ADVADR,@#$ADDR;update current address
 147556 000571                         BR      VCON
                96
                97
 147560 013737 007756 007334   $.WORD::MOV     @#$ADDR,@#ADVADR;get a scratch copy of current address
 147566 004767 174730          1$:     JSR     PC,GETEXP       ;get a value to be deposited
 147572 013704 007334                  MOV     @#ADVADR,R4     ;get running address
 147576 004767 004726                  JSR     PC,ADRCH2       ;check that it's not in protected RAM
 147602 010524                         MOV     R5,(R4)+        ;deposit a word
 147604 010437 007334                  MOV     R4,@#ADVADR     ;advance running copy of current address
 147610 120027 000054                  CMPB    R0,#054         ;is next character a comma?
 147614 001003                         BNE     2$              ;no
 147616 004767 163604                  JSR     PC,GETNXT       ;get character after comma
 147622 000761                         BR      1$              ;deposit another word
               108
 147624 013737 007334 007756   2$:     MOV     @#ADVADR,@#$ADDR;update current address
 147632 000543                         BR      VCON
               111
               112
 147634 004767 174662          $.BLKB::JSR     PC,GETEXP       ;get argument
 147640 106437 007326                  MTPS    @#CURCOM        ;check if it contained undefined symbols
```

```
115 147644  001146                        BNE     VERR1           ;it did, refuse .BLKB directive
116 147646  060537  007756                ADD     R5,@#$ADDR      ;add it to current address
117 147652  000533                        BR      VCON
118
119
120 147654  004767  174642  $.BLKW::      JSR     PC,GETEXP       ;get argument
121 147660  106437  007326                MTPS    @#CURCOM        ;check if it contained undefined symbols
122 147664  001136                        BNE     VERR1           ;it did, refuse .BLKW directive
123 147666  010504                        MOV     R5,R4           ;make a scratch copy
124 147670  006304                        ASL     R4              ;double it
125 147672  060437  007756                ADD     R4,@#$ADDR      ;add it to current address
126 147676  000521                        BR      VCON
127
128
129 147700  110037  007345  $.ASCI::      MOVB    R0,@#DELIM      ;save delimiter
130 147704  013737  007756  007334        MOV     @#$ADDR,@#ADVADR;get a scratch copy of current address
131 147712  004767  163474  1$:           JSR     PC,GETCHC       ;get next character, don't fold to upper case
132 147716  120037  007345                CMPB    R0,@#DELIM      ;have we reached delimiter yet?
133 147722  001417                        BEQ     2$              ;yes, done
134 147724  113746  007330                MOVB    @#TMPMOD,-(SP)  ;fool ADRCHK into thinking we are in byte mode
135 147730  052737  000200  007330        BIS     #F.BYTM,@#TMPMOD
136 147736  013704  007334                MOV     @#ADVADR,R4     ;get running copy of current address
137 147742  004767  004562                JSR     PC,ADRCH2       ;check that it's not in protected RAM
138 147746  112637  007330                MOVB    (SP)+,@#TMPMOD  ;restore proper mode bits
139 147752  110014                        MOVB    R0,@R4          ;deposit a byte
140 147754  005237  007334                INC     @#ADVADR        ;advance running address
141 147760  000754                        BR      1$
142
143 147762  013737  007334  007756  2$:   MOV     @#ADVADR,@#$ADDR;update current address
144 147770  004767  163432                JSR     PC,GETNXT       ;get character after delimiter
145 147774  000462                        BR      VCON
146
147
148 147776  005237  007756  $.EVEN::      INC     @#$ADDR
149 150002  042737  000001  007756        BIC     #1,@#$ADDR
150 150010  000454                        BR      VCON
151
152
153 150012  005203  $RPEAT::              INC     R3              ;counteract earlier DEC R3 in this case
154 150014  004767  174502                JSR     PC,GETEXP       ;get repeat count
155 150020  106437  007326                MTPS    @#CURCOM        ;check if it contained undefined symbols
156 150024  001056                        BNE     VERR1           ;it did, refuse REPEAT command
157 150026  005705                        TST     R5              ;see if a repeat of zero was given
158 150030  001450                        BEQ     RERR            ;refuse zero
159 150032  120027  000054                CMPB    R0,#054         ;check that a comma follows
160 150036  001043                        BNE     VERR            ;no comma, error, missing parameter
161 150040  000167  176232                JMP     EREP            ;go to repeat command line routine
162
163
164                                       .ENABL  LSB
165 150044  005203  MOVE::                INC     R3              ;counteract earlier DEC R3 in this case
166 150046  004767  000006                JSR     PC,1$           ;get address pair
167 150052  005303                        DEC     R3              ;prepare to use <ESC> sequence rountine
168 150054  000167  176304                JMP     EMOV            ;go to routine to move a memory block
169
170 150060  004767  174436  1$:           JSR     PC,GETEXP       ;get first address
171 150064  120027  000137                CMPB    R0,#137         ;is it followed by an underline?
```

```
172 150070  001026                        BNE     VERR            ;no, missing parameter
173 150072  010537  007336                MOV     R5,@#SAVEXP     ;save the first address
174 150076  152737  000010  007324        BISB    #F.SAVX,@#LINFLG;show we have saved something in SAVEXP
175 150104  004767  163316                JSR     PC,GETNXT       ;get character after underline
176 150110  000167  174406                JMP     GETEXP          ;get second address
177
178
179 150114  005203                FIND::  INC     R3              ;counteract earlier DEC R3 in this case
180 150116  004767  177736                JSR     PC,1$           ;get address pair
181 150122  120027  000054                CMPB    R0,#054         ;is it followed by a comma?
182 150126  001007                        BNE     VERR            ;no, missing parameter
183 150130  000167  176424                JMP     EFND            ;go to routine to find a value (search memory)
184                                       .DSABL  LSB
185
186
187 150134  052737  040000  007706  NOPROT::BIS   #F.PROT,@#FLAGS1;turn off monitor scratch protection
188                                                               ;fall into VCON
189 150142  000167  173450          VCON:   JMP     CMON6           ;continue parsing
190
191 150146  000167  173012          VERR:   JMP     CMON2           ;general error
192
193 150152  012702  151412          RERR:   MOV     #REPDF0,R2      ;repeat of zero error
194 150156  000167  173030                  JMP     ERROR
195
196 150162  012702  151372          VERR1:  MOV     #UNDEFX,R2      ;undefined expression error
197 150166  000167  173020                  JMP     ERROR
198
199 150172  042737  040000  007706  PROTEC::BIC   #F.PROT,@#FLAGS1;turn on monitor scratch protection
200 150200  000760                        BR      VCON
201
202 150202  052737  100000  007706  PASS1:: BIS   #F.PAS1,@#FLAGS1;show we are in PASS1 mode
203 150210  000754                        BR      VCON
204
205 150212  042737  100000  007706  PASS2:: BIC   #F.PAS1,@#FLAGS1;show we are in PASS2 mode
206 150220  000750                        BR      VCON
207
208
209 150222  032737  004000  007706  HOST::  BIT   #F.HOST,@#FLAGS1;are we already in host mode?
210 150230  001346                        BNE     VERR            ;yes, error
211 150232  105037  007672                CLRB    @#HFP           ;initialize host input buffer
212 150236  105037  007673                CLRB    @#HSTFLG        ;and host flags
213 150242  004767  164656                JSR     PC,SETAX2       ;match aux port baud rate to console port
214 150246  052737  004000  007706        BIS     #F.HOST,@#FLAGS1;set host mode
215 150254  105737  177550                TSTB    @#A$RBUF        ;discard any garbage in the port
216 150260  012737  134540  000120        MOV     #HOSTIN,@#AUXIN ;hook up host input service routine
217 150266  112737  000046  007711        MOVB    #046,@#AUXFLG   ;save a new copy of A$CREG value
218 150274  112737  000046  177452        MOVB    #046,@#A$CREG   ;enable aux port receiver interrupt
219 150302  000167  173304                JMP     CONTIN          ;recover character in R0
220
221
222 150306  105737  007673  NOHOST::TSTB    @#HSTFLG        ;are we in host load mode?
223 150312  100715                        BMI     VERR            ;yes, refuse NOHOST command
224 150314  105037  007673                CLRB    @#HSTFLG        ;clear host flags
225 150320  112737  000042  007711        MOVB    #042,@#AUXFLG   ;save a copy of new A$CREG value
226 150326  112737  000042  177452        MOVB    #042,@#A$CREG   ;disable aux port receiver interrupt
227 150334  042737  004000  007706        BIC     #F.HOST,@#FLAGS1;show we are not in host mode
228 150342  000677                        BR      VCON
```

```
                                                                                
                                                                                
150344  056  123  124  $.STRT: .ASCII  /.START/        ;string to match for enabling of load mode
150347  101  122  124
                        OPTION: .BYTE   015,012        ;<CR>, <LF>
150354  105  040  050           .ASCIZ  /E (EXIT), R (RESUME), B (SEND BREAK), ^A (SEND ^A) ?/
150357  105  130  111
150362  124  051  054
150365  040  122  040
150370  050  122  105
150373  123  125  115
150376  105  051  054
150401  040  102  040
150404  050  123  105
150407  116  104  040
150412  102  122  105
150415  101  113  051
150420  054  040  136
150423  101  040  050
150426  123  105  116
150431  104  040  136
150434  101  051  040
150437  077  000
150441  000                    .BYTE   0              ;because the linker won't zero fill
                                                    
                               .ENABL  LSB
150442                 BLOAD::
150442  032737  004000  007706 LOAD::  BIT    #F.HOST,@#FLAGS1;is host mode enabled?
150450  001410                 BEQ     LERR           ;no, refuse LOAD command
150452  105737  007673         TSTB    @#HSTFLG       ;are we in host load mode?
150456  100405                 BMI     LERR           ;yes, refuse LOAD command
150460  152737  000100  007673 BISB    #F.LDST,@#HSTFLG;show we want to start loading upon .START
150466  005002                 CLR     R2             ;initialize index to match .START strings
150470  000417                 BR      TALK1
                                                    
150472  032737  020000  007706 LERR:  BIT    #F.TBAS,@#FLAGS1;are we running Tiny Basic?
150500  001622                 BEQ     VERR           ;no
150502  000207         12$:    RTS     PC             ;yes, return to BASIC
                                                    
150504  032737  004000  007706 TALK::  BIT    #F.HOST,@#FLAGS1;is host mode enabled?
150512  001615                 BEQ     VERR           ;no, refuse LOAD command
150514  105737  007673         TSTB    @#HSTFLG       ;are we in host load mode?
150520  100612                 BMI     VERR           ;yes, refuse TALK command
150522  142737  000100  007673 BICB    #F.LDST,@#HSTFLG;show we want to ignore .START
                                                    
150530  106427  000300 TALK1:: MTPS    #300           ;disable interrupts except console break
150534  005737  177562         TST     @#C$RBUF       ;clear any garbage in the ports
150540  105737  177550         TSTB    @#A$RBUF
150544  004767  162754         JSR     PC,CRLF        ;start a new line
150550  112737  000011  177444 MOVB    #011,@#P$PORC  ;turn on LED during virtual terminal operation
                                                    
150556  004767  000364  6$:    JSR     PC,CLRAPE      ;clear aux port error
150562  105737  177560  1$:    TSTB    @#C$RCSR       ;user type a character?
150566  100017                 BPL     2$             ;no
150570  113701  177552         MOVB    @#A$SREG,R1    ;check host port status
150574  000240                 NOP                    ;### place holder for the above line ###
150576  006201                 ASR     R1
```

```
268 150600 103012                      BCC     2$              ;CTS not asserted or transmitter not empty
269 150602 013700 177562               MOV     @#C$RBUF,R0     ;get character from console
270 150606 100407                      BMI     2$              ;ignore error characters
271 150610 042700 177600               BIC     #177600,R0      ;make sure no parity bit set
272 150614 120027 000001               CMPB    R0,#1           ;is it ^A ?
273 150620 001450                      BEQ     3$              ;yes, exit talk mode
274 150622 110037 177450       9$:     MOVB    R0,@#A$XBUF     ;no, output character to host
275
276 150626 113701 177552       2$:     MOVB    @#A$SREG,R1     ;check host port status
277 150632 132701 000002               BITB    #002,R1         ;do we have a character?
278 150636 001751                      BEQ     1$              ;no
279 150640 113700 177550               MOVB    @#A$RBUF,R0     ;get character from host
280 150644 042700 177400               BIC     #177400,R0      ;prevent sign extend
281 150650 132701 000170               BITB    #170,R1         ;is it break or an error?
282 150654 001340                      BNE     6$              ;yes, ignore character
283 150656 132737 000100 007673        BITB    #F.LOST,@#HSTFLG;are we looking for .START?
284 150664 001420                      BEQ     5$              ;no
285 150666 010001                      MOV     R0,R1           ;make a scratch copy of character
286 150670 005702                      TST     R2              ;don't fold the period
287 150672 001402                      BEQ     14$
288 150674 042701 000040               BIC     #040,R1         ;fold lower case to upper case
289 150700 120162 150344       14$:    CMPB    R1,$.STRT(R2)   ;does character match?
290 150704 001007                      BNE     4$              ;no, go back to the '.' in .START and try again
291 150706 005202                      INC     R2
292 150710 020227 000006               CMP     R2,#6           ;have we matched entire string?
293 150714 103404                      BLO     5$              ;no, continue with next character
294 150716 110037 177566               MOVB    R0,@#C$XBUF     ;send the character without delay!
295 150722 000470                      BR      7$              ;a match, start loading
296
297 150724 005002              4$:     CLR     R2
298 150726 105737 177564       5$:     TSTB    @#C$XCSR        ;is console port ready for a character
299 150732 100313                      BPL     1$              ;no, drop character
300 150734 110037 177566               MOVB    R0,@#C$XBUF     ;yes, echo character to console
301 150740 000710                      BR      1$
302
303 150742 012701 150352       3$:     MOV     #OPTION,R1      ;point to message
304 150746 004767 163002               JSR     PC,PRINTA       ;print ASCII string on console
305 150752 105737 177560       8$:     TSTB    @#C$RCSR        ;wait for a character
306 150756 100375                      BPL     8$
307 150760 013700 177562               MOV     @#C$RBUF,R0     ;get character from console
308 150764 100772                      BMI     8$              ;character caused an error, try again
309 150766 042700 177600               BIC     #177600,R0      ;make sure no parity bit set
310 150772 110037 177566               MOVB    R0,@#C$XBUF     ;echo character to console
311 150776 120027 000001               CMPB    R0,#1           ;is it ^A?
312 151002 001707                      BEQ     9$              ;yes, send it to host
313 151004 042700 000040               BIC     #040,R0         ;fold lower case to upper
314 151010 120027 000102               CMPB    R0,#102         ;is it B?
315 151014 001012                      BNE     10$             ;no
316 151016 012701 100000               MOV     #100000,R1
317 151022 112737 000057 177452        MOVB    #057,@#A$CREG   ;send break
318 151030 077101              11$:    SOB     R1,.            ;wait a while
319 151032 112737 000047 177452        MOVB    #047,@#A$CREG
320 151040 000650                      BR      1$              ;resume two-way communication
321
322 151042 120027 000105       10$:    CMPB    R0,#105         ;is it E?
323 151046 001245                      BNE     1$              ;no, resume communication
324 151050 112737 000010 177444        MOVB    #010,@#P$PORC   ;turn off LED indicator
```

```
   325 151056  112737  000046  177452          MOVB    #046,@#A$CREG   ;disable aux port transmitter interrupt
   326 151064  106427  000000                  MTPS    #000            ;reenable interrupts
   327 151070  032737  020000  007706          BIT     #F.TBAS,@#FLAGS1;are we running Tiny Basic?
   328 151076  001201                  13$:    BNE     12$             ;yes, return to BASIC
   329 151100  000167  172112                  JMP     CMON3           ;return to console monitor
   330
   331 151104  152737  000200  007673  7$:     BISB    #F.LOAD,@#HSTFLG;set host load mode
   332 151112  112737  000010  177444          MOVB    #010,@#P$PORC   ;turn off LED indicator
   333 151120  112737  000046  177452          MOVB    #046,@#A$CREG   ;disable aux port transmitter interrupt
   334 151126  106427  000000                  MTPS    #000            ;reenable interrupts A.S.A.P.
   335 151132  032737  020000  007706          BIT     #F.TBAS,@#FLAGS1;are we running Tiny Basic?
   336 151140  001356                          BNE     13$             ;yes, return to BASIC
   337 151142  000167  172056                  JMP     CMON31          ;return to console monitor
   338
   339 151146  112737  000067  177452  CLRAPE: MOVB    #067,@#A$CREG   ;clear aux port error flags
   340 151154  112737  000047  177452          MOVB    #047,@#A$CREG   ;asser DTR, RTS, enable aux port xmit and recv
   341 151162  000207                          RTS     PC
   342                                         .DSABL  LSB
```

```
 1
 2                                          .SBTTL  Symbol and Label Handling Routines
 3
 4                                          .ENABL  LSB
 5 151164  132737  000002  007327  DOSYMB::BITB    #F.VALU,@#LASCOM;check that last 'command' was not valued
 6 151172  001423                          BEQ     3$              ;was evaluated, error
 7 151174  010237  007334                  MOV     R2,@#ADVADR     ;store index here
 8 151200  004767  162222                  JSR     PC,GETNXT       ;get next meaningful character after =
 9 151204  106437  007332                  MTPS    @#EXPFLG        ;see what kind of symbol we are defining
10 151210  100434                          BMI     1$              ;user defined name
11 151212  103413                          BCS     3$              ;was a mnemonic, directive, or verb--error
12 151214  004767  173302                  JSR     PC,GETEXP       ;get value to be equated
13 151220  106437  007326                  MTPS    @#CURCOM        ;check if it contained undefined symbols
14 151224  001010                          BNE     13$             ;it did, refuse symbol definition
15 151226  013702  007334                  MOV     @#ADVADR,R2     ;get back index
16 151232  020227  000054                  CMP     R2,#DSYMUR-DSYMS;what is name?
17 151236  103407                          BLO     4$              ;R0 through .
18 151240  101012                          BHI     5$              ;R1 through R4
19 151242  000167  171716          3$:     JMP     CMDN2           ;else show error
20
21 151246  012702  151372          13$:    MOV     #UNDEFX,R2      ;undefined expression error
22 151252  000167  171734                  JMP     ERROR
23
24
25 151256  006202                  4$:     ASR     R2              ;make a word index
26 151260  010562  007732                  MOV     R5,$R0(R2)      ;set appropriate register, watchpoint, or '.'
27 151264  000404                          BR      6$
28
29
30 151266  042705  000001          5$:     BIC     #1,R5           ;breakpoints have even addresses
31 151272  010562  007700                  MOV     R5,BRKFIL-<DSYMUR+4-DSYMS>(R2)  ;set appropriate breakpoint
32 151276  000167  172314          6$:     JMP     CMDN6
33
34 151302  102021                  1$:     BVC     2$              ;symbol already defined
35 151304  013746  007320                  MOV     @#TBLTOP,-(SP)  ;save name of symbol we are defining
36 151310  013746  007322                  MOV     @#TBLTOP+2,-(SP)
37 151314  004767  173202                  JSR     PC,GETEXP       ;get value to be set
38 151320  106437  007326                  MTPS    @#CURCOM        ;check if it contained undefined symbols
39 151324  001006                          BNE     12$             ;it did, ignore symbol definition
40 151326  010504                          MOV     R5,R4           ;get value to be set
41 151330  012637  007322                  MOV     (SP)+,@#TBLTOP+2;recover name
42 151334  012637  007320                  MOV     (SP)+,@#TBLTOP
43 151340  000446                          BR      9$
44
45 151342  022626                  12$:    CMP     (SP)+,(SP)+     ;pop saved name
46 151344  000754                          BR      6$              ;quietly ignore symbol definition
47
48 151346  010446                  2$:     MOV     R4,-(SP)        ;save present value of symbol
49 151350  004767  173146                  JSR     PC,GETEXP       ;get value to be set
50 151354  106437  007326                  MTPS    @#CURCOM        ;check if it contained undefined symbols
51 151360  001332                          BNE     13$             ;it did, refuse symbol definition
52 151362  010504                          MOV     R5,R4           ;put value in R4
53 151364  022604                  10$:    CMP     (SP)+,R4        ;see if symbol or label is being changed
54 151366  001325                          BNE     3$              ;it is, which is not permitted
55 151370  000742                          BR      6$              ;no change, so quietly ignore command
56
57 151372  102564  020071  054114  UNDEFX: .RAD50  /UNDEFINED EXPRESSION/
```

```
       151400  000340  063325  074701
       151406  057760
    58 151410  000000                          .WORD   0
    59 151412  070530  017574  001136  REPOF0: .RAD50  /REPEAT OF ZERO/
       151420  002025  071330
    60 151424  000000                          .WORD   0
    61
    62 151426  132737  000002  007327  DOLABL::BITB    #F.VALU,@#LASCOM
    63 151434  001702                          BEQ     3$
    64 151436  004767  161764                  JSR     PC,GETNXT
    65 151442  106437  007332                  MTPS    @#EXPFLG        ;see what kind of label we are defining
    66 151446  100275                          BPL     3$              ;predefined symbols can't be labels
    67 151450  102037                          BVC     8$              ;user name already defined
    68 151452  013704  007756                  MOV     @#$ADDR,R4      ;set value to be set
    69
    70 151456  013702  007462          9$:     MOV     @#TBLBOT,R2     ;set bottom of symbol table
    71 151462  162702  000006                  SUB     #6,R2           ;go down one entry
    72 151466  020227  006500                  CMP     R2,#$UR ;is there space for new entry?
    73 151472  101011                          BHI     11$             ;yes
    74 151474  012702  151504                  MOV     #TBLFUL,R2      ;point to message
    75 151500  000167  171506                  JMP     ERROR           ;print error message
    76 151504  076452  045710  024324  TBLFUL: .RAD50  /TABLE FULL/
       151512  045400
    77 151514  000000                          .WORD   0
    78
    79 151516  106427  000340          11$:    MTPS    #340            ;make symbol table alterations atomic
    80 151522  010237  007462                  MOV     R2,@#TBLBOT     ;by blocking console break, etc.
    81 151526  013722  007320                  MOV     @#TBLTOP,(R2)+  ;store first word of name
    82 151532  013722  007322                  MOV     @#TBLTOP+2,(R2)+;and second word
    83 151536  010422                          MOV     R4,(R2)+        ;store symbol's value
    84 151540  106427  000000                  MTPS    #000            ;restore interrupt service
    85 151544  000167  172042                  JMP     CONTIN          ;recover character in R0, get next command
    86
    87 151550  010446                  8$:     MOV     R4,-(SP)        ;save present value of label
    88 151552  013704  007756                  MOV     @#$ADDR,R4      ;get current address, which is value to be set
    89 151556  000702                          BR      10$
    90                                         .DSABL  LSB
```

```
 1                              ;++
 2                              ;   GETSYM matches a new name to the symbol table.
 3                              ;--
 4
 5 151560  013702  007462       GETSYM::MOV     @#TBLBOT,R2     ;start searching at bottom of table
 6 151564  020227  007320       2$:     CMP     R2,#TBLTOP      ;any more entries?
 7 151570  103403                       BLO     1$              ;yes
 8 151572  005004                       CLR     R4
 9 151574  000277                       SCC                     ;flag name not found
10 151576  000207                       RTS     PC
11
12 151600  022237  007320       1$:     CMP     (R2)+,@#TBLTOP  ;does first word of name match?
13 151604  001007                       BNE     3$              ;no
14 151606  022237  007322               CMP     (R2)+,@#TBLTOP+2;second word match?
15 151612  001005                       BNE     4$              ;no
16 151614  012204                       MOV     (R2)+,R4        ;set value
17 151616  000270                       SEN                     ;show this is a user defined symbol
18 151620  000242                       CLV                     ;and that is has a value
19 151622  000207                       RTS     PC
20
21 151624  005722               3$:     TST     (R2)+
22 151626  005722               4$:     TST     (R2)+           ;advance to next entry
23 151630  000755                       BR      2$
24
25                              ;++
26                              ;   MATSYM matches the number in R1 to symbol values, starting with the most
27                              ;   recently defined.  Returns a pointer in R2 if matched.  Returns N set if
28                              ;   no match.
29                              ;--
30
31 151632  132737  000002  007330 MATSYM::BITB    #F.ABS,@#TMPMOD ;absolute mode?
32 151640  001013                       BNE     1$              ;yes, indicate no match
33 151642  013702  007462               MOV     @#TBLBOT,R2     ;set bottom of table
34 151646  020227  007320       2$:     CMP     R2,#TBLTOP      ;any more entries?
35 151652  103006                       BHIS    1$              ;no
36 151654  026201  000004               CMP     4(R2),R1        ;do we have a match?
37 151660  001404                       BEQ     3$              ;yes
38 151662  062702  000006       4$:     ADD     #6,R2           ;go to next name
39 151666  000767                       BR      2$
40
41 151670  000270               1$:     SEN
42 151672  000207               3$:     RTS     PC
43
```

```
                                ;++
                                ;   DELSYM deletes the symbol table entry just below R2.
                                ;--

151674  062737  000006  007462  DELSYM::ADD     #6,@#TBLBOT
151702  020237  007462          2$:     CMP     R2,@#TBLBOT     ;done yet?
151706  101001                          BHI     1$              ;no, move up all lower entries
151710  000207                          RTS     PC

151712  016242  177770          1$:     MOV     -10(R2),-(R2)   ;move three words for each entry
151716  016242  177770                  MOV     -10(R2),-(R2)
151722  016242  177770                  MOV     -10(R2),-(R2)
151726  000765                          BR      2$

                                ;++
                                ;   TYPREG types the contents of registers R0 through PS and the watchpoint
                                ;   address and contents if the address is not zero.
                                ;--

151730  112737  000011  007340  TYPREG::MOVB    #9.,@#COUNT1    ;count 9 registers
151736  012737  156142  007334          MOV     #DSYMS,@#ADVADR ;borrow ADVADR as a pointer
151744  004767  161554          1$:     JSR     PC,CRLF         ;start a new line
151750  013702  007334                  MOV     @#ADVADR,R2
151754  004767  162014                  JSR     PC,PRINT2       ;type name of register
151760  010237  007334                  MOV     R2,@#ADVADR
151764  162702  156146                  SUB     #DSYMS+4,R2     ;go back to register name
151770  004767  173674                  JSR     PC,PDSVAL       ;get contents of register
151774  012700  020075                  MOV     #400$040+075,R0 ;type = <space>
152000  004767  161524                  JSR     PC,CHROUT
152004  010401                          MOV     R4,R1           ;get register contents
152006  004767  003064                  JSR     PC,TYPNM1       ;type numerically
152012  105337  007340                  DECB    @#COUNT1
152016  001352                          BNE     1$
152020  013704  007754                  MOV     @#$WATCH,R4     ;get watchpoint address
152024  001404                          BEQ     2$              ;watchpoint not set
152026  004767  003216                  JSR     PC,TYPADR       ;type watchpoint address
152032  000167  003056                  JMP     TYPLO1          ;type in current mode
152036  000207          2$:     RTS     PC

                                ;++
                                ;  TYPTBL types the entire user symbol table.
                                ;--

152040  016746  035264          TYPTBL::MOV     TMPMOD,-(SP)    ;make symbols show up in word mode
152044  042767  000200  035256          BIC     #F.BYTM,TMPMOD  ;
152052  013702  007462                  MOV     @#TBLBOT,R2     ;start at the bottom of the table
152056  020227  007320          7$:     CMP     R2,#TBLTOP      ;done yet?
152062  103003                          BHIS    1$              ;yes
152064  004767  000012                  JSR     PC,TYPSYM       ;type the name and value of one symbol
152070  000772                          BR      7$
152072  012667  035232          1$:     MOV     (SP)+,TMPMOD    ;put back to watever mode it was in
152076  000167  171502                  JMP     CMON5           ;get next command

152102  004767  161416          TYPSYM::JSR     PC,CRLF         ;start a new line
152106  004767  161662                  JSR     PC,PRINT2       ;type symbol name
152112  012700  020075                  MOV     #400$040+075,R0 ;type = <space>
152116  004767  161406                  JSR     PC,CHROUT
```

```
    58 152122  012201                        MOV     (R2)+,R1        ;set value
    59 152124  000167  002746                JMP     TYPNM1          ;type it numerically
```



```
     1
     2                                  .SBTTL  Arithmetic Routines
     3
     4 152130  050405           LOGOR:: BIS     R4,R5
     5 152132  000207                   RTS     PC
     6
     7 152134  005104           LOGAND::COM     R4
     8 152136  040405                   BIC     R4,R5
     9 152140  000207                   RTS     PC
    10
    11 152142  010500           MULTIP::MOV     R5,R0           ;make a copy of first factor
    12 152144  005005                   CLR     R5              ;clear accumulator
    13 152146  060005           1$:     ADD     R0,R5           ;multiply by successive addition
    14 152150  077402                   SOB     R4,1$           ;count down second factor
    15 152152  000207                   RTS     PC
    16
    17 152154  060405           ADDIT:: ADD     R4,R5
    18 152156  000207                   RTS     PC
    19
    20 152160  160405           SUBTR:: SUB     R4,R5
    21 152162  000207                   RTS     PC
    22
    23 152164  005000           DIVID:: CLR     R0              ;initialize quotient
    24 152166  005704                   TST     R4              ;are we dividing by zero?
    25 152170  001403                   BEQ     2$              ;yes, return 177777
    26 152172  005200           1$:     INC     R0              ;increment quotient
    27 152174  160405                   SUB     R4,R5           ;try subtracting divisor from dividend
    28 152176  103375                   BCC     1$              ;successful, no underflow
    29 152200  010005           2$:     MOV     R0,R5           ;replace accumulator with quotient
    30 152202  005305                   DEC     R5              ;adjust for excessive increment of R0
    31 152204  000207                   RTS     PC
```

```
 1
 2                                       .SBTTL  Instruction Encode/Decode Routines
 3                                ;++
 4                                ;    GETINS takes an index to a mnemonic in R2, and the mnemonic's base value
 5                                ;    in R4.  It parses any needed operands and stores the resulting code at the
 6                                ;    current address.
 7                                ;--
 8
 9 152206  010446                GETINS::MOV     R4,-(SP)        ;save the base opcode value
10 152210  004767  002310                JSR     PC,ADRCHK       ;check that it's even and in user RAM
11 152214  006202                        ASR     R2              ;make a byte index
12 152216  006202                        ASR     R2              ;for the PARAMS table
13 152220  010437  007336                MOV     R4,@#SAVEXP     ;save opcode address here
14 152224  142737  000010  007324        BICB    #F,SAVX,@#LINFLG;prevent interference with normal use of SAVEXP
15 152232  012624                        MOV     (SP)+,(R4)+     ;store base opcode value
16 152234  010437  007334                MOV     R4,@#ADVADR     ;first operand address
17 152240  105037  007342                CLRB    @#MODE          ;initialize addressing mode scratch
18 152244  116201  156034                MOVB    PARAMS(R2),R1   ;get format code
19 152250  006201                        ASR     R1              ;make a word index
20 152252  006201                        ASR     R1
21 152254  042701  177741                BIC     #177741,R1      ;mask out the garbage
22 152260  004771  152276                JSR     PC,@INSDSP(R1)  ;get appropriate operand sequence
23 152264  013737  007334  007756        MOV     @#ADVADR,@#$ADDR;update current address
24 152272  000167  171314                JMP     CONTIN          ;recover next character, parse next command
25
26 152276  153172              INSDSP: .WORD   CONCOD          ;00 means decode condition codes
27 152300  143164                      .WORD   CMON2           ;01 means not an instruction
28 152302  152770                      .WORD   INSDON          ;02 means no parameters
29 152304  153152                      .WORD   EMTRAP          ;03 means NNN for EMT and TRAP
30 152306  153024                      .WORD   BRDISP          ;04 means 8-bit branch displacement
31 152310  152724                      .WORD   REGDST          ;05 means R,DD for JSR and XOR
32 152312  153016                      .WORD   OPRAND          ;06 means SS or DD
33 152314  153006                      .WORD   SRCDST          ;07 means SS,DD
34 152316  152714                      .WORD   RTSREG          ;10 means R for RTS
35 152320  153102                      .WORD   SOBDSP          ;11 means R,NN for SOB
36
37                                      .ENABL  LSB
38 152322  004767  173122        GETREG::JSR     PC,GETNAM       ;parse a symbolic name
39 152326  100414                        BMI     3$              ;user defined name, error
40 152330  103413                        BCS     3$              ;instruction mnemonic, error
41 152332  004767  161050                JSR     PC,GETLCH       ;get next character in R0
42 152336  020227  000040                CMP     R2,#DSYMPS-DSYMS;is it R0 through PC?
43 152342  103006                        BHIS    3$              ;no, error
44 152344  006202                        ASR     R2              ;get register number
45 152346  006202                        ASR     R2
46 152350  060237  007342                ADD     R2,@#MODE       ;put it in bottom 3 bits of addressing mode
47 152354  000250                        CLN
48 152356  000207                        RTS     PC
49
50 152360  000270              3$:     SEN
51 152362  000207                        RTS     PC
52
53
54 152364  120027  000100        FULOPR::CMPB    R0,#100         ;is first character @?
55 152370  001005                        BNE     5$              ;no
56 152372  062737  000010  007342        ADD     #10,@#MODE      ;yes, deferred mode
57 152400  004767  161022                JSR     PC,GETNXT       ;get character after @
```

```
    58 152404  004767  001672          5$:   JSR     PC,RADCH        ;might it be a register name?
    59 152410  100407                        BMI     6$              ;no, definitely not a register
    60 152412  010046                        MOV     R0,-(SP)        ;save character
    61 152414  010346                        MOV     R3,-(SP)        ;save running pointer
    62 152416  004767  177700                JSR     PC,GETREG       ;and try to get a register name
    63 152422  100044                        BPL     7$              ;successful, mode 0 or 1
    64 152424  012603                        MOV     (SP)+,R3        ;restore running pointer
    65 152426  012600                        MOV     (SP)+,R0        ;restore character in R0
    66 152430  120027  000050          6$:   CMPB    R0,#050         ;is it (?
    67 152434  001445                        BEQ     4$              ;yes, mode 1, 2, or 3
    68 152436  120027  000055                CMPB    R0,#055         ;is next character -?
    69 152442  001011                        BNE     9$              ;no definitely not autodecrement
    70 152444  010346                        MOV     R3,-(SP)        ;save running pointer
    71 152446  004767  160754                JSR     PC,GETNXT       ;get character after -
    72 152452  120027  000050                CMPB    R0,#050         ;is it (?
    73 152456  001430                        BEQ     10$             ;yes, mode 4 or 5
    74 152460  012603                        MOV     (SP)+,R3        ;restore running pointer
    75 152462  012700  000055                MOV     #055,R0         ;restore - in R0
    76 152466  120027  000043          9$:   CMPB    R0,#043         ;is it #?
    77 152472  001454                        BEQ     11$             ;yes, do immediate and absolute
    78 152474  004767  000142                JSR     PC,GETARG       ;get an index or relative address
    79 152500  062737  000060  007342        ADD     #60,@#MODE      ;indexed addressing mode
    80 152506  120027  000050                CMPB    R0,#050         ;is it an index?
    81 152512  001421                        BEQ     12$             ;yes
    82 152514  013704  007334                MOV     @#ADVADR,R4     ;get next operand address
    83 152520  163744  007334                SUB     @#ADVADR,-(R4)  ;make this operand a PC relative address
    84 152524  062737  000007  007342        ADD     #07,@#MODE      ;implicit PC reference
    85 152532  000207                        RTS     PC
    86
    87 152534  022626                  7$:   CMP     (SP)+,(SP)+     ;discard saved character and running pointer
    88 152536  000207                        RTS     PC              ;return mode 0 or 1
    89
    90 152540  062737  000030  007342  10$:  ADD     #30,@#MODE      ;for -(, add 40 total to addressing mode
    91 152546  005726                        TST     (SP)+           ;discard saved running pointer
    92 152550  062737  000010  007342  4$:   ADD     #10,@#MODE      ;for (, add 10 to addressing mode
    93 152556  004767  160644          12$:  JSR     PC,GETNXT       ;get character after (
    94 152562  004767  177534                JSR     PC,GETREG       ;should be a register name
    95 152566  100501                        BMI     2$              ;not a register name, error
    96 152570  120027  000051                CMPB    R0,#051         ;should be followed by )
    97 152574  001076                        BNE     2$              ;no, error
    98 152576  004767  160624                JSR     PC,GETNXT       ;get character after )
    99 152602  120027  000053                CMPB    R0,#053         ;is it +?
   100 152606  001005                        BNE     8$              ;no, done
   101 152610  062737  000010  007342        ADD     #10,@#MODE      ;mode 2 or 3
   102 152616  004767  160604                JSR     PC,GETNXT       ;get character after +
   103 152622  000207                  8$:   RTS     PC
   104                                                               /
   105 152624  062737  000027  007342  11$:  ADD     #27,@#MODE      ;immediate, absolute are modes 2 and 3 with PC
   106 152632  004767  160570                JSR     PC,GETNXT       ;get character after #
   107 152636  000167  000000                JMP     GETARG          ;store immediate data or absolute address
   108
   109 152642  004767  171654  GETARG::JSR     PC,GETEXP       ;get an argument in R5
   110 152646  013704  007334                MOV     @#ADVADR,R4     ;get address of operand
   111 152652  004767  001652                JSR     PC,ADRCH2       ;check that we are still in user RAM
   112 152656  010514                        MOV     R5,@R4          ;store argument at operand address
   113 152660  062737  000002  007334        ADD     #2,@#ADVADR     ;increment address
   114 152666  000207                        RTS     PC
```

```
                                                                
                                                                
152670  120027  000054  COMACH: CMPB    R0,#054         ;is first operand followed by a comma?
152674  001036                 BNE     2$              ;no, error
152676  004767  000042         JSR     PC,INSDN1       ;store first operand mode
152702  004767  160520         JSR     PC,GETNXT       ;get character after comma
152706  105037  007342         CLRB    @#MODE
152712  000207                 RTS     PC
                                                                
152714  004767  177402  RTSREG:: JSR    PC,GETREG       ;get a register number
152720  100424                 BMI     2$              ;error, not a register name
152722  000416                 BR      INSDN2          ;add it to opcode
                                                                
152724  004767  177372  REGDST:: JSR    PC,GETREG       ;get a register number
152730  100420                 BMI     2$              ;error, not a register name
152732  004767  177732         JSR     PC,COMACH       ;check for comma between operands
152736  004767  177422         JSR     PC,FULOPR       ;get a full operand
152742  000406                 BR      INSDN2
                                                                
152744  113701  007342  INSDN1: MOVB    @#MODE,R1       ;get addressing mode bits
152750  000301                 SWAB    R1              ;shift it 6 bits to the left
152752  006201                 ASR     R1
152754  006201                 ASR     R1
152756  000402                 BR      1$
                                                                
152760  113701  007342  INSDN2: MOVB    @#MODE,R1       ;get addressing mode bits
152764  060177  034346  1$:    ADD     R1,@SAVEXP      ;add them to opcode
                                                                
152770  000207         INSDON: RTS     PC
                                                                
152772  000167  170166  2$:    JMP     CMDN2
                                                                
152776  012702  153266  20$:   MOV     #BRANCH,R2      ;point to branch error message
153002  000167  170204         JMP     ERROR
                                                                
153006  004767  177352  SRCDST:: JSR    PC,FULOPR       ;get first operand
153012  004767  177652         JSR     PC,COMACH       ;check for comma between operands
153016  004767  177342  OPRAND:: JSR    PC,FULOPR       ;get second operand
153022  000756                 BR      INSDN2          ;store second operand mode
                                                                
                                                                
153024  004767  171472  BRDISP:: JSR    PC,GETEXP       ;get branch destination
153030  106437  007326         MTPS    @#CURCOM        ;did expression contain undefined symbols?
153034  001402                 BEQ     14$             ;no, no problem
153036  013705  007756         MOV     @#$ADDR,R5      ;yes, make instruction 'BR .' so no range error
153042  163705  007334  14$:   SUB     @#ADVADR,R5     ;make it relative
153046  006205                 ASR     R5              ;make it a word offset
153050  032705  177600         BIT     #177600,R5      ;does upper byte match bit 7?
153054  001405                 BEQ     13$             ;yes
153056  005105                 COM     R5
153060  032705  177600         BIT     #177600,R5
153064  001344                 BNE     20$             ;no, branch range error
153066  005105                 COM     R5
153070  042705  177400  13$:   BIC     #177400,R5      ;make it an 8-bit number
153074  060577  034236         ADD     R5,@SAVEXP      ;add displacement to op-code
153100  000207                 RTS     PC
                                                                
```

```
172 153102  004767  177214          SDBDSP::JSR     PC,GETREG       ;get register
173 153106  100731                          BMI     2$              ;error, not a register name
174 153110  004767  177554                  JSR     PC,COMACH       ;check for comma between operands
175 153114  004767  171402                  JSR     PC,GETEXP
176 153120  106437  007326                  MTPS    @#CURCOM        ;did expression contain undefined symbols?
177 153124  001402                          BEQ     21$             ;no, no problem
178 153126  013705  007756                  MOV     @#$ADDR,R5      ;yes, make instruction 'BR .' so no range error
179 153132  163705  007334          21$:    SUB     @#ADVADR,R5     ;make it relative
180 153136  006205                          ASR     R5
181 153140  005405                          NEG     R5              ;SOB instruction uses negated displacement
182 153142  032705  177700                  BIT     #177700,R5      ;6-bit displacement
183 153146  001313                          BNE     20$             ;range or direction error
184 153150  000747                          BR      13$
185
186 153152  004767  171344          EMTRAP::JSR     PC,GETEXP       ;get trap number
187 153156  032705  177400                  BIT     #177400,R5      ;should be <256.
188 153162  001303                          BNE     2$              ;>255., error
189 153164  000741                          BR      13$
190
191 153166  004767  160234  .       19$:    JSR     PC,GETNXT       ;get character after comma
192 153172  120027  000103          CONCOD::CMPB    R0,#103         ;R1 must be 0 when entering -- is it C?
193 153176  001003                          BNE     16$
194 153200  052701  000001                  BIS     #1,R1           ;set C bit
195 153204  000421                          BR      15$
196 153206  120027  000126          16$:    CMPB    R0,#126         ;is it V?
197 153212  001003                          BNE     17$
198 153214  052701  000002                  BIS     #2,R1           ;set V bit
199 153220  000413                          BR      15$
200 153222  120027  000132          17$:    CMPB    R0,#132         ;is it Z?
201 153226  001003                          BNE     18$
202 153230  052701  000004                  BIS     #4,R1           ;set Z bit
203 153234  000405                          BR      15$
204 153236  120027  000116          18$:    CMPB    R0,#116         ;is it N?
205 153242  001253                          BNE     2$              ;no, illegal character
206 153244  052701  000010                  BIS     #10,R1          ;set N bit
207
208 153250  004767  160152          15$:    JSR     PC,GETNXT       ;get next character
209 153254  120027  000054                  CMPB    R0,#054         ;is it a comma?
210 153260  001742                          BEQ     19$             ;yes, get some more
211 153262  005301                          DEC     R1              ;compensate for opcode base value = 241 or 261
212 153264  000637                          BR      1$              ;add condition bits to opcode
213                                         .DSABL  LSB
214
215 153266  007521  054000  001155  BRANCH: .RAD50  /BRANCH OUT OF RANGE/
    153274  076417  022622  004167
    153302  017500
216 153304  000000                          .WORD   0
```

```
                                ;++
                                ;   TYPINS decodes the instruction at address R4 and types it followed on the
                                ;   next line by the next address.
                                ;--

153306  011405                  TYPINS::MOV     @R4,R5          ;get opcode
153310  010500                          MOV     R5,R0
153312  006300                          ASL     R0              ;get bits 6 through 13
153314  006300                          ASL     R0
153316  000300                          SWAB    R0
153320  042700  177700                  BIC     #177700,R0
153324  110037  007342                  MOVB    R0,@#MODE       ;store them here for operand decode
153330  005705                          TST     R5
153332  100027                          BPL     5$              ;not a byte mode instruction
153334  042705  100000                  BIC     #100000,R5      ;first see if it's a byte mode instruction
153340  004767  000130                  JSR     PC,1$           ;match to table, get index
153344  006202                          ASR     R2
153346  105762  156034                  TSTB    PARAMS(R2)
153352  100017                          BPL     5$              ;not byte mode, do it normally
153354  006302                          ASL     R2              ;restore R2
153356  012405                          MOV     (R4)+,R5        ;fix R4, restore R5
153360  010246                          MOV     R2,-(SP)        ;save index
153362  006302                          ASL     R2              ;make index to mnemonic
153364  062702  156502                  ADD     #MNEMS,R2
153370  011201                          MOV     @R2,R1          ;get 3 chracter mnemonic
153372  004767  160406                  JSR     PC,PRINT1       ;type it
153376  012602                          MOV     (SP)+,R2        ;restore R2
153400  012701  006200                  MOV     #50$50$2,R1     ;type 2 <SP> <SP>
153404  004767  160374                  JSR     PC,PRINT1
153410  000412                          BR      6$

153412  012405                  5$:     MOV     (R4)+,R5        ;get opcode
153414  004767  000054                  JSR     PC,1$           ;match to table
153420  010246                          MOV     R2,-(SP)        ;save index
153422  006302                          ASL     R2              ;make index to mnemonic
153424  062702  156502                  ADD     #MNEMS,R2
153430  004767  160340                  JSR     PC,PRINT2       ;type mnemonic
153434  012602                          MOV     (SP)+,R2        ;get index back
153436  012700  000011          6$:     MOV     #011,R0         ;type <tab>
153442  004767  160062                  JSR     PC,CHROUT
153446  006202                          ASR     R2              ;make byte instruction index
153450  116201  156034                  MOVB    PARAMS(R2),R1   ;get format code
153454  006201                          ASR     R1
153456  006201                          ASR     R1
153460  042701  177741                  BIC     #177741,R1      ;mask out the garbage
153464  004771  153514                  JSR     PC,@INTDSP(R1)  ;type operands
153470  000167  001554                  JMP     TYPADR          ;type next address and a tab

153474  012702  000212          1$:     MOV     #PARAMS-BASES-2,R2      ;index last base value
153500  020562  155620          3$:     CMP     R5,BASES(R2)    ;compare opcode to base value
153504  103002                          BHIS    4$              ;match
153506  005742                          TST     -(R2)           ;keep looking
153510  000773                          BR      3$
153512  000207                  4$:     RTS     PC

153514  154132                  INTDSP: .WORD   TCONCD          ;CVZN
153516  153540                          .WORD   NOPCOD          ;16 bit value, not an opcode
```

```
 58 153520  153564                          .WORD   INTDON          ;no operands
 59 153522  153722                          .WORD   TEMTRP          ;EMT and TRAP
 60 153524  153734                          .WORD   TBRDSP          ;8-bit displacement
 61 153526  153574                          .WORD   TRGDST          ;R,DD
 62 153530  153554                          .WORD   TOPRND          ;SS or DD
 63 153532  153544                          .WORD   TSRDST          ;SS,DD
 64 153534  153566                          .WORD   TRTSRG          ;R
 65 153536  153676                          .WORD   TSOBDS          ;6-bit positive displacement
 66
 67                                         .ENABL  LSB
 68 153540  005744                 NOPCOD::TST     -(R4)           ;back up to number
 69 153542  000553                         BR      12$             ;type it as data
 70
 71 153544  004767  000200         TSRDST::JSR     PC,TFULOP       ;type an operand
 72 153550  004767  000026         13$:    JSR     PC,TCOMMA       ;type comma
 73 153554  004767  000102         TOPRND::JSR     PC,GETDST       ;get bits 0 through 5 of opcode
 74 153560  004767  000164                 JSR     PC,TFULOP       ;type operand
 75 153564  000207                 INTDON: RTS     PC
 76
 77 153566  004767  000070         TRTSRG::JSR     PC,GETDST
 78 153572  000421                         BR      TREGIS          ;type register name
 79
 80 153574  004767  000036         TRGDST::JSR     PC,TREGIS       ;type register
 81 153600  000763                         BR      13$             ;type comma and second operand
 82
 83 153602  012700  000054         TCOMMA: MOV     #054,R0
 84 153606  000167  157716                 JMP     CHROUT
 85
 86 153612  012700  000050         TPREG:: MOV     #050,R0         ;type (
 87 153616  004767  157706                 JSR     PC,CHROUT
 88 153622  004767  000010                 JSR     PC,TREGIS       ;type register name
 89 153626  012700  000051                 MOV     #051,R0
 90 153632  000167  157672                 JMP     CHROUT
 91
 92 153636  113700  007342         TREGIS::MOVB    @#MODE,R0       ;get bits 0 through 2
 93 153642  042700  177770                 BIC     #177770,R0
 94 153646  006300                         ASL     R0              ;index register name
 95 153650  006300                         ASL     R0
 96 153652  016001  156142                 MOV     DSYMS(R0),R1    ;get RAD50 triplet
 97 153656  000167  160126                 JMP     PRINT4          ;type it
 98
 99 153662  110537  007342         GETDST: MOVB    R5,@#MODE
100 153666  142737  000300  007342         BICB    #300,@#MODE
101 153674  000207                 11$:    RTS     PC
102
103 153676  004767  177734         TSOBDS::JSR     PC,TREGIS       ;type register name
104 153702  004767  177674                 JSR     PC,TCOMMA       ;type comma
105 153706  010501                         MOV     R5,R1           ;get lower 6 bits
106 153710  042701  177700                 BIC     #177700,R1
107 153714  006301                         ASL     R1              ;make it a byte displacement
108 153716  005401                         NEG     R1
109 153720  000407                         BR      6$
110
111 153722  010501                 TEMTRP::MOV     R5,R1           ;get lower 8 bits without sign extend
112 153724  042701  177400                 BIC     #177400,R1
113 153730  005744                         TST     -(R4)           ;TYPLD2 will advance R4
114 153732  000404                         BR      7$
```

```
                115
153734  110501          TBRDSP::MOVB    R5,R1           ;set lower 8 bits with sign extend
153736  006301                  ASL     R1              ;make it a byte displacement
153740  060401          6$:     ADD     R4,R1           ;add in the 'PC'
153742  005744                  TST     -(R4)           ;TYPLO2 will advance R4
153744  000167  001162          7$:     JMP     TYPLO2          ;type this value
                121
153750  113702  007342  TFULOP::MOVB    @#MODE,R2       ;addressing mode scratch
153754  032702  000010          BIT     #10,R2          ;deferred?
153760  001404                  BEQ     1$              ;no
153762  012700  000100          MOV     #100,R0         ;type @
153766  004767  157536          JSR     PC,CHROUT
153772  120227  000020          1$:     CMPB    R2,#20          ;mode 0 or 1?
153776  103717                  BLO     TREGIS          ;yes, just type register name
154000  120227  000060          CMPB    R2,#60          ;mode 6 or 7?
154004  103034                  BHIS    2$              ;yes, indexed
154006  120227  000027          CMPB    R2,#27          ;immediate?
154012  001423                  BEQ     3$              ;yes
154014  120227  000037          CMPB    R2,#37          ;absolute?
154020  001420                  BEQ     3$              ;yes
154022  120227  000040          CMPB    R2,#40          ;autodecrement?
154026  103404                  BLO     4$              ;no
154030  012700  000055          MOV     #055,R0         ;type -
154034  004767  157470          JSR     PC,CHROUT
154040  004767  177546          4$:     JSR     PC,TPREG        ;type register name in parenthesis
154044  120227  000040          CMPB    R2,#40          ;autoincrement?
154050  103245                  BHIS    INTDON          ;no, finished
154052  012700  000053          MOV     #053,R0         ;type +
154056  000167  157446          JMP     CHROUT
                144
154062  012700  000043          3$:     MOV     #043,R0         ;type #
154066  004767  157436          JSR     PC,CHROUT
154072  000167  001016          12$:    JMP     TYPLO1          ;type next location
                148
154076  120227  000067          2$:     CMPB    R2,#67          ;relative?
154102  001406                  BEQ     5$              ;yes
154104  120227  000077          CMPB    R2,#77          ;relative deferred?
154110  001403                  BEQ     5$              ;yes
154112  004767  000776          JSR     PC,TYPLO1       ;type next location
154116  000635                  BR      TPREG           ;type register name in parenthesis
                155
154120  012401          5$:     MOV     (R4)+,R1        ;get next location
154122  060401                  ADD     R4,R1           ;add in the 'PC'
154124  005744                  TST     -(R4)           ;TYPLO2 will increment R4, don't do it now
154126  000167  001000          JMP     TYPLO2          ;type the value
                160
154132  010501  TCONCD::MOV     R5,R1           ;get opcode
154134  006201                  ASR     R1              ;C bit set?
154136  103004                  BCC     8$              ;no
154140  012700  000103          MOV     #103,R0         ;type C
154144  004767  157360          JSR     PC,CHROUT
154150  006201          8$:     ASR     R1              ;V bit set?
154152  103004                  BCC     9$
154154  012700  000126          MOV     #126,R0
154160  004767  157344          JSR     PC,CHROUT
154164  006201          9$:     ASR     R1              ;Z bit set?
154166  103004                  BCC     10$
```

```
   172 154170  012700  000132                MOV     #132,R0
   173 154174  004767  157330                JSR     PC,CHROUT
   174 154200  006201                  10$:  ASR     R1              ;N bit set?
   175 154202  103234                        BCC     11$
   176 154204  012700  000116                MOV     #116,R0
   177 154210  000167  157314                JMP     CHROUT
   178                                       .DSABL  LSB
```

```
                                        .SBTTL  Conversion and Typeout Routines
                                ;++
                                ;   BINASC strips the thousands digit from the value in R1 and multiplies R1
                                ;   by 10.  Use BINAS1 to get the 10000.s digit.
                                ;--

154214  005000          BINASC::CLR     R0              ;divide by successive subtraction
154216  005200          1$:     INC     R0
154220  162701  001750          SUB     #1000.,R1       ;try to subtract 1000.
154224  103374                  BCC     1$              ;worked, no borrow
154226  005300                  DEC     R0              ;fix R0
154230  062701  001750          ADD     #1000.,R1       ;and R1
154234  006301                  ASL     R1              ;multiply R1 by 10
154236  010146                  MOV     R1,-(SP)
154240  006301                  ASL     R1
154242  006301                  ASL     R1              ;times 8
154244  062601                  ADD     (SP)+,R1        ;plus 2 makes 10 X
154246  062700  000060          ADD     #060,R0         ;add 060 to make it an ASCII digit
154252  000207                  RTS     PC


154254  005000          BINAS1::CLR     R0              ;divide by successive subtraction
154256  005200          1$:     INC     R0
154260  162701  023420          SUB     #10000.,R1      ;try to subtract 10000.
154264  103374                  BCC     1$              ;worked, no borrow
154266  005300                  DEC     R0              ;fix R0
154270  062701  023420          ADD     #10000.,R1      ;and R1
154274  062700  000060          ADD     #060,R0         ;make an ASCII digit
154300  000207                  RTS     PC

                                ;++
                                ;   RADCH checks if the character in R0 is a legal RAD50 character.  Returns
                                ;   N=1 if not.
                                ;--

154302  120027  000133  RADCH:: CMPB    R0,#133         ;higher than Z?
154306  103017                  BHIS    2$
154310  120027  000101          CMPB    R0,#101         ;A or higher?
154314  103016                  BHIS    1$
154316  120027  000072          CMPB    R0,#072         ;: or higher?
154322  103011                  BHIS    2$
154324  120027  000060          CMPB    R0,#060         ;0 or higher?
154330  103010                  BHIS    1$
154332  120027  000056          CMPB    R0,#056         ;period?
154336  001405                  BEQ     1$
154340  120027  000044          CMPB    R0,#044         ;dollar sign?
154344  001402                  BEQ     1$
154346  000270          2$:     SEN
154350  000207                  RTS     PC
154352  000250          1$:     CLN
154354  000207                  RTS     PC
```

```
                                ;++
                                ;   NUMCH checks if the character in R0 is numeric and returns flags as follows:
                                ;   N=0, V=0 character is 0 through 7
                                ;   N=0, V=1 character is 8 or 9
                                ;   N=1 any other character
                                ;--

154356  120027  000060        NUMCH:: CMPB    R0,#060         ;is it 0 or higher?
154362  103413                        BLO     1$              ;no, non-numeric
154364  120027  000072                CMPB    R0,#072         ;is it higher than 9?
154370  103010                        BHIS    1$              ;yes, non-numeric
154372  120027  000070                CMPB    R0,#070         ;is it higher than 7?
154376  103002                        BHIS    2$              ;yes, 8 or 9
154400  000257                        CCC                     ;flag 0 through 7
154402  000207                        RTS     PC
154404  000257                2$:     CCC
154406  000262                        SEV                     ;flag 8 or 9
154410  000207                        RTS     PC
154412  000270                1$:     SEN
154414  000207                        RTS     PC

                                ;++
                                ;   ASCRAD multiplies R1 by 40 and adds the RAD50 equivalent of R0.
                                ;--

154416  004767  157500        ASCRAD::JSR     PC,R1X40        ;multiply R1 by 40
154422  120027  000040                CMPB    R0,#040
154426  001416                        BEQ     1$              ;spaces converts to 0
154430  120027  000056                CMPB    R0,#056
154434  001414                        BEQ     4$              ;period is 34
154436  120027  000044                CMPB    R0,#044
154442  001412                        BEQ     5$              ;dollar sign is 33
154444  060001                        ADD     R0,R1
154446  162701  000100                SUB     #100,R1
154452  120027  000101                CMPB    R0,#101
154456  103002                        BHIS    1$              ;alphabetics are 1 through 32
154460  062701  000056                ADD     #056,R1         ;numerics are 36 through 47
154464  000207                1$:     RTS     PC

154466  005201                4$:     INC     R1
154470  062701  000033        5$:     ADD     #033,R1
154474  000207                        RTS     PC


154476  054754  000566  001533 USERAM: .RAD50  /NOT IN USER RAM/
154504  021020  070265
154510  000000                        .WORD   0

154512  057144  000054  015725 ODDADR: .RAD50  /ODD ADDRESS/
154520  074670
154522  000000                        .WORD   0
```

```
                                ;++
                                ;   TYPDEC types the value in R1 as a signed, 5-digit decimal number followed
                                ;   by a period.  TYPDE1 can be used to type unsigned numbers.
                                ;--

154660  012700  000040        TYPDEC::MOV     #040,R0
154664  005701                        TST     R1
154666  100003                        BPL     1$
154670  005401                        NEG     R1
154672  012700  000055                MOV     #055,R0
154676  004767  156626        1$:     JSR     PC,CHROUT
154702  112737  000005  007341        MOVB    #5,@#COUNT2
154710  004767  177340                JSR     PC,BINASC
154714  000402                        BR      3$
154716  004767  177272        5$:     JSR     PC,BINASC
154722  004767  156602        3$:     JSR     PC,CHROUT
154726  105337  007341                DECB    @#COUNT2
154732  001371                        BNE     5$
154734  012700  000056                MOV     #056,R0         ;type a period
154740  000167  156564                JMP     CHROUT

                                ;++
                                ;   TYPOCT types R1 as an octal word.
                                ;--

154744  005000                TYPOCT::CLR     R0
154746  032767  000200  032354        BIT     #F.BYTM,TMPMOD  ;is it in byte mode
154754  001407                        BEQ     1$              ;branch if yes
154756  112767  000003  032355        MOVB    #3,COUNT2       ;if byte mode only three digits
154764  000301                        SWAB    R1              ;only low byte out
154766  006301                        ASL     R1
154770  006100                        ROL     R0
154772  000411                        BR      3$
154774  112767  000006  032337  1$:     MOVB    #6,COUNT2
155002  000405                        BR      3$
155004  005000                2$:     CLR     R0
155006  006301                        ASL     R1
155010  006100                        ROL     R0
155012  006301                4$:     ASL     R1
155014  006100                        ROL     R0
155016  006301                3$:     ASL     R1
155020  006100                        ROL     R0
155022  062700  000060                ADD     #060,R0
155026  004767  156476                JSR     PC,CHROUT
155032  105337  007341                DECB    @#COUNT2
155036  001362                        BNE     2$
155040  000207                        RTS     PC
```

```
                                ;++
                                ;   TYPSPC types a tab, except in instruction mode (type nothing) .
                                ;--

155042  132737  000100  007330  TYPSPC::BITB    #F,INST,@#TMPMOD
155050  001004                  BNE     1$
155052  012700  004440          MOV     #400!011!040,R0 ;space, tab
155056  000167  156446  2$:     JMP     CHROUT
155062  000207          1$:     RTS     PC

                                ;++
                                ;   TYPNUM types the value in R1 as a symbol or number.
                                ;   TYPNM1 types the value in R1 as a number only.
                                ;--

155064  004767  174542  TYPNUM::JSR     PC,MATSYM       ;try to match a symbol
155070  100402                  BMI     TYPNM1          ;unsuccessful, type numerically
155072  000167  156676          JMP     PRINT2          ;else type symbol's name
155076  000722  TYPNM1::BR      TYPOCT

                                ;++
                                ;   TYPLOC types the location addressed by R4 in the current mode.  R4 is advanced
                                ;   to the next location.  TYPLO1 can be used within instruction typeout.
                                ;--

155100  004767  177504  TYPLOC::JSR     PC,ADRCHK
155104  132737  000100  007330          BITB    #F,INST,@#TMPMOD
155112  001026                  BNE     TYPLOI
155114  011401  TYPLO1::MOV     @R4,R1          ;get current location as a word
155116  105737  007330          TSTB    @#TMPMOD        ;are we in byte mode?
155122  100003                  BPL     TYPLO2          ;no
155124  111401                  MOVB    @R4,R1          ;else get location as a byte
155126  042701  177400          BIC     #177400,R1      ;prevent sign extension
155132  004767  174474  TYPLO2::JSR     PC,MATSYM       ;try to match a symbol
155136  100403                  BMI     2$              ;unsuccessful
155140  012700  133774  3$:     MOV     #PRINT2,R0
155144  000402                  BR      5$
155146  012700  155076  2$:     MOV     #TYPNM1,R0
155152  004710  5$:     JSR     PC,(R0)
155154  005204                  INC     R4
155156  105737  007330          TSTB    @#TMPMOD
155162  100401                  BMI     6$
155164  005204                  INC     R4
155166  000207  6$:     RTS     PC

155170  010546  TYPLOI::MOV     R5,-(SP)        ;save R5 because TYPINS uses it
155172  004767  176110          JSR     PC,TYPINS       ;type an instruction
155176  012605                  MOV     (SP)+,R5        ;restore R5
155200  000207                  RTS     PC
```

```
                                ;++
                                ;   TYPLIN types the next 8 locations or four locations if in binary mode.
                                ;--
                                
155202  004767  000042         TYPLIN::JSR     PC,TYPADR       ;type address in R4 as label or octal number
155206  112737  000010  007340         MOVB    #8.,@#COUNT1
155214  004767  177660         1$:     JSR     PC,TYPLOC       ;type location in current mode, advance R4
155220  004767  177616                 JSR     PC,TYPSPC
155224  005704                         TST     R4              ;for 177776 to 0 case
155226  001406                         BEQ     3$
155230  020405                         CMP     R4,R5           ;done yet?
155232  101003                         BHI     2$              ;yes
155234  005337  007340                 DEC     @#COUNT1
155240  001365                         BNE     1$
155242  000207                 2$:     RTS     PC
155244  000244                 3$:     CLZ
155246  000207                         RTS     PC
                                ;++
                                ;   TYPADR types the value in R4 as a label or octal number, followed by ! <SP>
                                ;--
                                
155250  016746  032054         TYPADR::MOV     TMPMOD,-(SP)    ;for byte mode
155254  042767  000200  032046         BIC     #F.BYTM,TMPMOD  ;
155262  004767  156236                 JSR     PC,CRLF
155266  010401                         MOV     R4,R1
155270  132737  000002  007330         BITB    #F.ABS,@#TMPMOD
155276  001006                         BNE     1$
155300  004767  174326                 JSR     PC,MATSYM
155304  100403                         BMI     1$
155306  004767  156462                 JSR     PC,PRINT2
155312  000402                         BR      2$

155314  004767  177424         1$:     JSR     PC,TYPOCT
155320  012700  020072         2$:     MOV     #400$040+072,R0
155324  012667  032000                 MOV     (SP)+,TMPMOD    ;restor mode
155330  000167  156174                 JMP     CHROUT
```

```
                                        .SBTTL  Power-up Diagnostics
                                ;
                                .ENABL  LSB
                                ;
155334  005203                DIAGNO::INC     R3              ;use r3 as digit to display number
155336  012737  000377  177440        MOV     #377,@#P$PORA   ;light all segments
155344  012737  000011  177444        MOV     #11,@#P$PORC    ;turn on led
155352  012705  003133                MOV     #400$006+133,R5 ;initialize error code '12'
155356  012701  007776                MOV     #7776,R1        ;fill RAM with pattern, saving location for JSR
155362  010102                        MOV     R1,R2
155364  005000                        CLR     R0
155366  010041                1$:     MOV     R0,-(R1)
155370  005200                        INC     R0
155372  005201                        INC     R1
155374  077104                        SOB     R1,1$
155376  012706  010000                MOV     #10000,SP       ;set SP to top of RAM
155402  012700  005777                MOV     #5777,R0        ;checksum complement for RAM pattern
155406  004767  000146                JSR     PC,CHKSUM       ;checksum words from R1 (=0) to R2 (=7776)
155412  042703  177770                BIC     #177770,R3      ;mask of all but digit select
155416  110337  177444                MOVB    R3,@#P$PORC     ;turn off led and turn on digit
155422  012701  133000                MOV     #133000,R1      ;index ROMs
155426  012702  160000                MOV     #END,R2         ;set upper checksum limit to top of ROMs
155432  005000                        CLR     R0              ;perform checksum of ROM
155434  004767  000120                JSR     PC,CHKSUM
155440  005705                        TST     R5              ;do we have an error yet?
155442  001035                        BNE     2$              ;yes, exit and show it
155444  012705  000117                MOV     #400$000+117,R5 ;initialize error code ' 3'
                                ;
155450  012700  177560                MOV     #177560,R0      ;point to console
155454  105760  000002        SLUTST: TSTB    2(R0)           ;clear out and recieved garbage
155460  152760  000004  000004        BISB    #4,4(R0)        ;set mainenace bit
155466  112701  000060                MOVB    #60,R1          ;init character to xmit
155472  105760  000004        SLU.1:  TSTB    4(R0)           ;ready to xmit
155476  100375                        BPL     SLU.1           ;no - wait
155500  110160  000006                MOVB    R1,6(R0)        ;send char to reciever
155504  105710                SLU.2:  TSTB    (R0)            ;received a char
155506  100376                        BPL     SLU.2           ;no - wait
155510  126001  000002                CMPB    2(R0),R1        ;got what you xmitted
155514  001010                        BNE     2$              ;no - error
155516  105201                        INCB    R1              ;produce next ascii character
155520  120127  000072                CMPB    R1,#72          ;
155524  001362                        BNE     SLU.1           ;loop until checked 0 to 177
155526  142760  000004  000004        BICB    #4,4(R0)        ;reset maintenace bit
155534  105005                        CLRB    R5              ;yes, clear error
155536  005705                2$:     TST     R5              ;check for error
155540  001005                        BNE     4$              ;branch if error
155542  132737  000002  177564        BITB    #2,@#177564     ;see if in diagno mode
155550  001401                        BEQ     4$              ;if not then goodby
155552  000670                        BR      DIAGNO          ;loop for ever
155554  000167  161100        4$:     JMP     $START          ;initialize scratchpad RAM and start monitor
                                ;
                                .ENABL  LSB
                                ;
155560  062100                CHKSUM::ADD     (R1)+,R0        ;accumulate checksum
155562  020102                        CMP     R1,R2           ;done yet?
155564  103775                        BLO     CHKSUM          ;no
```

```
     58 155566  000305                    SWAB    R5
     59 155570  005700                    TST     R0              ;test result
     60 155572  001001                    BNE     1$              ;checksum failed
     61 155574  105005                    CLRB    R5              ;else clear error
     62 155576  000207            1$:     RTS     PC
```

```
                        .SBTTL  Special Data Structures

                ;++
                ;   INSTRUCTION ENCODE/DECODE and COMMAND DECODE TABLES:
                ;   The five parameters listed for each opcode are:
                ;           1.      Base value of the opcode
                ;           2.      String name of the opcode
                ;           3.      Parameter organization:
                ;                   00 - decode condition code bits (N,Z,V,C)
                ;                   01 - nnnnnn (16 bit number)
                ;                   02 - no parameters
                ;                   03 - nnn (8 bit number)
                ;                   04 - xxx (8 bit displacement)
                ;                   05 - r,dd
                ;                   06 - dd or ss
                ;                   07 - ss,dd
                ;                   10 - r
                ;                   11 - r,nn (6 bit displacement)
                ;           4.      Equals 1 if instruction is legal in byte mode
                ;
                ;   The fifth parameter is a code used by the top-level parser to decode ASCII
                ;   characters in the 040 to 077 range.  The values of this parameter are:
                ;           0 - Illegal character at top level
                ;           1 - Interpret as the first character of an expression or instruction
                ;           2 - :, or label definition
                ;           3 - ;, or comment
                ;           4 - =, or symbol definition
                ;           5 - ?, or type as a number
                ;           6 - Valid as an operator within expressions
                ;           7 - Both 1 and 6 apply
                ;--

                .MACRO  INSTRS
                CODE    000000,<HALT  >,2,0,0   ;space
                CODE    000001,<WAIT  >,2,0,6   ;!
                CODE    000002,<RTI   >,2,0,0   ;"
                CODE    000003,<BPT   >,2,0,1   ;#
                CODE    000004,<IOT   >,2,0,1   ;$
                CODE    000005,<RESET >,2,0,0   ;%
                CODE    000006,<RTT   >,2,0,6   ;&
                CODE    000007,<      >,1,0,1   ;'
                CODE    000100,<JMP   >,6,0,0   ;(
                CODE    000200,<RTS   >,10,0,0  ;)
                CODE    000210,<      >,1,0,6   ;*
                CODE    000240,<NOP   >,2,0,7   ;+
                CODE    000241,<CL    >,0,0,0   ;,
                CODE    000257,<CCC   >,2,0,7   ;-
                CODE    000260,<      >,1,0,1   ;.
                CODE    000261,<SE    >,0,0,6   ;/
                CODE    000277,<SCC   >,2,0,1   ;0
                CODE    000300,<SWAB  >,6,0,1   ;1
                CODE    000400,<BR    >,4,0,1   ;2
                CODE    001000,<BNE   >,4,0,1   ;3
                CODE    001400,<BEQ   >,4,0,1   ;4
                CODE    002000,<BGE   >,4,0,1   ;5
                CODE    002400,<BLT   >,4,0,1   ;6
```

```
                                        CODE    003000,<BGT   >,4,0,1   ;7
                                        CODE    003400,<BLE   >,4,0,1   ;8
                                        CODE    004000,<JSR   >,5,0,1   ;9
                                        CODE    005000,<CLR   >,6,1,2   ;:
                                        CODE    005100,<COM   >,6,1,3   ;;
                                        CODE    005200,<INC   >,6,1,1   ;<
                                        CODE    005300,<DEC   >,6,1,4   ;=
                                        CODE    005400,<NEG   >,6,1,0   ;>
                                        CODE    005500,<ADC   >,6,1,5   ;?
                                        CODE    005600,<SBC   >,6,1,0
                                        CODE    005700,<TST   >,6,1,0
                                        CODE    006000,<ROR   >,6,1,0
                                        CODE    006100,<ROL   >,6,1,0
                                        CODE    006200,<ASR   >,6,1,0
                                        CODE    006300,<ASL   >,6,1,0
                                        CODE    006400,<      >,1,0,0
                                        CODE    006700,<SXT   >,6,0,0
                                        CODE    007000,<      >,1,0,0
                                        CODE    010000,<MOV   >,7,1,0
                                        CODE    020000,<CMP   >,7,1,0
                                        CODE    030000,<BIT   >,7,1,0
                                        CODE    040000,<BIC   >,7,1,0
                                        CODE    050000,<BIS   >,7,1,0
                                        CODE    060000,<ADD   >,7,0,0
                                        CODE    070000,<      >,1,0,0
                                        CODE    074000,<XOR   >,5,0,0
                                        CODE    075000,<      >,1,0,0
                                        CODE    077000,<SOB   >,11,0,0
                                        CODE    100000,<BPL   >,4,0,0
                                        CODE    100400,<BMI   >,4,0,0
                                        CODE    101000,<BHI   >,4,0,0
                                        CODE    101400,<BLOS  >,4,0,0
                                        CODE    102000,<BVC   >,4,0,0
                                        CODE    102400,<BVS   >,4,0,0
                                        CODE    103000,<BCC   >,4,0,0
                                        CODE    103000,<BHIS  >,4,0,0
                                        CODE    103400,<BCS   >,4,0,0
                                        CODE    103400,<BLO   >,4,0,0
                                        CODE    104000,<EMT   >,3,0,0
                                        CODE    104400,<TRAP  >,3,0,0
                                        CODE    105000,<      >,1,0,0
                                        CODE    106400,<MTPS  >,6,0,0
                                        CODE    106500,<      >,1,0,0
                                        CODE    106700,<MFPS  >,6,0,0
                                        CODE    107000,<      >,1,0,0
                                        CODE    160000,<SUB   >,7,0,0
                                        CODE    170000,<      >,1,0,0
                                        .ENDM

155600  000241          CBASES::.WORD   000241          ;CLC
155602  000242                  .WORD   000242          ;CLV
155604  000244                  .WORD   000244          ;CLZ
155606  000250                  .WORD   000250          ;CLN
155610  000261                  .WORD   000261          ;SEC
155612  000262                  .WORD   000262          ;SEV
155614  000264                  .WORD   000264          ;SEZ
155616  000270                  .WORD   000270          ;SEN
```

```
                                        .MACRO  CODE    BASVAL,MNEM,FORMAT,BYTMOD,MISC
                                        .WORD   BASVAL
                                        .ENDM
155620                          BASES:: INSTRS

                                        .MACRO  CODE    BASVAL,MNEM,FORMAT,BYTMOD,MISC
                                        .BYTE   <BYTMOD*200>+<FORMAT*10>+MISC
                                        .ENDM
156034                          PARAMS::INSTRS

156142  072460  000000          DSYMS:: .RAD50  /R0    /        ;Predefined symbols must not be 3 characters in
156146  072530  000000                  .RAD50  /R1    /        ;length, or else a 'byte mode' version of each
156152  072600  000000                  .RAD50  /R2    /        ;name will also match, i.e. XYZB will match to
156156  072650  000000                  .RAD50  /R3    /        ;XYZ.  Only byte mode mnemonics should be 3
156162  072720  000000                  .RAD50  /R4    /        ;characters long.
156166  072770  000000                  .RAD50  /R5    /
156172  074500  000000                  .RAD50  /SP    /
156176  062170  000000                  .RAD50  /PC    /
156202  063370  000000          DSYMPS: .RAD50  /PS    /
156206  111100  000000                  .RAD50  /WP    /
156212  127400  000000                  .RAD50  /.     /
156216                          DSYMUR:
156216  000000  000000                  .RAD50  /      /
156222  010530  000000                  .RAD50  /R1    /
156226  010600  000000                  .RAD50  /R2    /
156232  010650  000000                  .RAD50  /R3    /
156236  010720  000000                  .RAD50  /R4    /

156242  031324  062000          DIRVRR::.RAD50  /HELP  /
156246  027030  000000                  .RAD50  /GO    /
156252  074745  062000                  .RAD50  /STEP  /
156256  062073  075630          DIRVRI: .RAD50  /PASS1 /
156262  062073  075700                  .RAD50  /PASS2 /
156266  032153  076400                  .RAD50  /HOST  /
156272  054740  060314                  .RAD50  /NOHOST/
156276  076464  042300                  .RAD50  /TALK  /
156302  046531  014400                  .RAD50  /LOAD  /
156306  131014  004444                  .RAD50  /.START/
156312  127726  014400                  .RAD50  /.END  /
156316  127736  020560                  .RAD50  /.EVEN /
156322  127473  012061                  .RAD50  /.ASCII/
156326  127551  076710                  .RAD50  /.BYTE /
156332  131247  070440                  .RAD50  /.WORD /
156336  127534  042420                  .RAD50  /.BLKB /
156342  127534  044130                  .RAD50  /.BLKW /
156346  003243  057665          DIRVBA: .RAD50  /ABSOLU/
156352  011366  011624          DIRVBB: .RAD50  /CANCEL/
156356  021411  076400          DIRVBD: .RAD50  /EXIT  /
156362  010174  017500          DIRVBH: .RAD50  /BYTE  /
156366  035203  077745          DIRVBI: .RAD50  /INSTRU/
156372  012245  004420                  .RAD50  /CLEAR /
156376  014724  021145                  .RAD50  /DELETE/
156402  111052  014400          DIRVBW: .RAD50  /WORD  /
156406                          DIRVBQ:
156406  070530  017574          DIRVBP: .RAD50  /REPEAT/
156412  075265  007344          DIRVBS: .RAD50  /SYMBOL/
```

```
   172 156416  074017  110727          DIRVRT: .RAD50  /SHOWMO/
   173 156422  074017  111225                  .RAD50  /SHOWRE/
   174 156426  074017  111321                  .RAD50  /SHOWSY/
   175 156432  106257  053600                  .RAD50  /VTON  /
   176 156436  106257  023160                  .RAD50  /VTOFF /
   177
   178 156442  012243  000000          CMNEMS::.RAD50  /CLC   /
   179 156446  012266  000000                  .RAD50  /CLV   /
   180 156452  012272  000000                  .RAD50  /CLZ   /
   181 156456  012256  000000                  .RAD50  /CLN   /
   182 156462  073613  000000                  .RAD50  /SEC   /
   183 156466  073636  000000                  .RAD50  /SEV   /
   184 156472  073642  000000                  .RAD50  /SEZ   /
   185 156476  073626  000000                  .RAD50  /SEN   /
   186
   187                                         .MACRO  CODE    BASVAL,MNEM,FORMAT,BYTMOD,MISC
   188                                         .RAD50  'MNEM'
   189                                         .ENDM
   190 156502                          MNEMS:: INSTRS
   191         156566                  MNCCC   ==      MNEMS+064
   192         000770                  TOPNAM  ==      . - DSYMS       ;length of preceding RAD50 table
```



```
     1
     2                                          .SBTTL  Spare Locations, Checksum, and ROM I.D.
     3                                  ;++
     4                                  ;   The locations defined by the following directive are free and must be
     5                                  ;   zero for the power-up diagnostics to work properly.  When adding code
     6                                  ;   in this space or changing any of the previous code, adjust the checksum
     7                                  ;   value at CHECKS = 157774 so that the ROMs as a whole will have a zero
     8                                  ;   word checksum.
     9                                  ;--
    10
    11         000642                          .REPT   <157774-.>
    12                                         .BYTE   0
    13                                         .ENDR
    14                                 ;++
    15                                 ;   The following word adjusts the ROM checksum to zero.
    16                                 ;--
    17
    18 157774  052744                  CHECKS::.WORD   52744           ;12-MAY-83 R. Arnott
    19
    20                                 ;++
    21                                 ;   The last byte in each of the ROMs is used to identify the ROMs.
    22                                 ;--
    23
    24 157776     010                  LO.ID:: .BYTE   010             ;Version 1.0, low byte
    25 157777     010                  HI.ID:: .BYTE   010             ;Version 1.0, high byte
    26
    27 160000  140000                  END::   .END    START
```

Symbol table

```
ADDIT   152154 G        CONOUT= 000064 G        EDEL    146232 G        F.LOAD= 000200          IOINIT  135076 G
ADRCHK  154610 G        CONTIN  143612 G        EDEL1   146240          F.MNEM= 000001          IOVECT  135224 G
ADRCH1  154524 G        COUNT1= 007340 G        EERR    146360          F.NULL= 000004          ITRAP   137334 G
ADRCH2  154530 G        COUNT2= 007341 G        EEXT    146320 G        F.PAS1= 100000          KADRCH  142156
ADVADR= 007334 G        CRLF    133524 G        EFND    146560 G        F.PROT= 040000          KEYBCD  136514 G
ASCOUT  133626 G        CURCOM= 007326 G        EINS    146210 G        F.REG = 000010          KEYCMD  140330 G
ASCRAD  154416 G        C$RBUF= 177562 G        EMOD    146760 G        F.SAVX= 000010          KEYCM1  140344 G
AUXFLG= 007711 G        C$RCSR= 177560 G        EMOV    146364 G        F.SST = 000200          KEYGET  136436 G
AUXIN = 000120 G        C$XBUF= 177566 G        EMTRAP  153152 G        F.SST1= 000001          KEYGE1  136470
AUXOUT= 000124 G        C$XCSR= 177564 G        END     160000 G        F.STOP= 000002          KEYPIV= 007676 G
A$CREG= 177452 G        DERNCE= 007704 G        ENDEXP  145002          F.TRAS= 020000          KEYPVS= 007700 G
A$RBUF= 177550 G        DECDSP  140030 G        ENUM    146270 G        F.UNDF= 000004          KLOOP   140306 G
A$SREG= 177552 G        DELETE  147444 G        EREG    146332 G        F.USER= 000100          KLOOP1  141170
A$XBUF= 177450 G        DELIM = 007345 G        EREP    146276 G        F.USRD= 000010          KLOOP2  141644
BASES   155620 G        DELSYM  151674 G        ERROR   143212 G        F.VALU= 000002          KMONIT  140200 G
BCDKEY  140050 G        DGDISP  140014 G        ERROR2  143720          F.VT  = 004000          LASCOM= 007327 G
BCDTBL  136522          DIAGMO  155334 G        ERRSEG  135756          GENEXP  144512 G        LASLIN= 007325 G
BINASC  154214 G        DIGEXE  140542 G        ESYM    146312 G        GETARG  152642 G        LEDIV = 000104 G
BINAS1  154254 G        DIRVBA  156346          EXDOOP  145220          GETBP   133436 G        LERR    150472
BLNKDS  136350          DIRVBB  156352          EXINIT  145172          GETCH   133316 G        LEVEL = 007333 G
BLNKHI  136344 G        DIRVBD  156356          EXINI1  145200          GETCHC  133412 G        LINEIN  133000 G
BLNKLO  136336 G        DIRVBH  156362          EXPFLG= 007332 G        GETDST  153662          LINFLG= 007324 G
BLOAD   150442 G        DIRVBI  156366          FERCHR  137542 G        GETERM  144556 G        LOAD    150442 G
BOTTOM= 007346 G        DIRVBN  156402          FERROR  137350 G        GETEXP  144522 G        LOBLNK  140040 G
BP    = 007630 G        DIRVBO  156406          FIND    150114 G        GETEX1  144540          LODISP  140024 G
BRANCH  153266          DIRVBP  156406          FIXBP   140170          GETINS  152206 G        LOGAND  152134 G
BRDISP  153024 G        DIRVBS  156412          FLAGS1= 007706 G        GETKEY  140044 G        LOGOR   152130 G
BREAK   137114 G        DIRVBT  156416          FMESAG  137424 G        GETLCH  133406 G        LO.ID   157776 G
BRKFIL= 007760 G        DIRVB1  156256          FMESG1  137434          GETLIN  133240 G        LPAREN  145046
BRKPT   137174 G        DIRVRB  156242 G        FMESG2  137450          GETLIT  146060 G        MATSYM  151632 G
BRKP1   141466          DISPLA  135344 G        FMESG3  137472          GETNAM  145450 G        MFB251= 007464 G
BUFFER= 007470 G        DIVID   152164 G        FMESG4  137522          GETNMB  145306 G        MNCCC = 156566 G
CANCEL  142246 G        DOCOMM  144124          FNCDON  142264          GETNUM  140054 G        MNEMS   156502 G
CBASES  155600 G        DOCR    144170 G        FNCTBL  142234 G        GETNXT  133426 G        MODE  = 007342 G
CHECKS  157774 G        DOEXPR  144274 G        FP    = 007631 G        GETOPR  144724 G        MONITR  140010 G
CHKSUM  155560 G        DOFUNC  142226 G        FPAREN  145162          GETOPV  144720 G        MONIT1  137556 G
CHROUT  133530 G        DOLABL  151426 G        FULOPR  152364 G        GETREG  152322 G        MOVE    150044 G
CHRO1   133540 G        DOMVAL  144134          F.ABS = 000002          GETSYM  151560 G        MULTIP  152142 G
CHRO2   133554 G        DOOPER  145124          F.ADDR= 000004          GNEXAM  141146 G        NAMTBL  136154 G
CLRAPE  151146          DOSYMB  151164 G        F.APPL= 010000          GO      147432 G        NOHOST  150306 G
CMNEMS  156442 G        DOVERB  147172 G        F.A64X= 000200          GO$LED  142270 G        NOPCOD  153540 G
CMONIT  142724 G        DSPDEC  136366 G        F.BRKA= 000400          GRET    143052          NOPROT  150134 G
CMON1   142572 G        DSPDIG  135772 G        F.BRKG= 001000          HELP    147320 G        NPROT   142562 G
CMON2   143164 G        DSPLNM  136044 G        F.BRKS= 000020          HEXSEG  136016 G        NUMCH   154356 G
CMON3   143216 G        DSPNAM  136112 G        F.BYTR= 000001          HFP   = 007672 G        NUMGET  136546 G
CMON31  143224          DSPNUM  136050          F.BYTM= 000200          HGETCH  134744 G        OBDADR  154512
CMON4   143246 G        DSPTBL  140360 G        F.CHAN= 000002          HI.ID   157777 G        OPERAT= 007343 G
CMON5   143604 G        DSPUNM  136036 G        F.COMM= 000020          HOST    150222 G        OPRAND  153916 G
CMON6   143616 G        DSYMPS  156202          F.CPB0= 000010          HOSTBF= 007632 G        OPRTBL  145250
CMON7   143652          DSYMS   156142 G        F.CPB1= 000020          HOSTIN  134540 G        OPTION  150352
CNTLC = 007344 G        DSYMUR  156216          F.CPB2= 000040          HSTFLG= 007673 G        OVERFL  143104
COMACH  152670          EABS    146150 G        F.DATA= 000001          INSDN1  152744          PADRAD  146050
COMLUP  143646          EBYT    146176 G        F.FUNC= 000040          INSDN2  152760          PADR1   146040
CONBRK= 000140 G        ECAN    146156 G        F.HOST= 004000          INSDON  152770          PARAMS  156034 G
CONCOD  153172 G        ECHO    134142 G        F.INST= 000100          INSDSP  152276          PARDSP  144104
CONFLG= 007710 G        ECLR    146222 G        F.KEYP= 002000          INTDON  153564          PASS1   150202 G
CONIN = 000060 G        ECON    146354          F.LDST= 000100          INTDSP  153514          PASS2   150212 G
```

```
T-11 Evaluation Module Monitor  MACRO V05.00  Sunday 13-Mar-83 04:10  Page 59-2
Symbol table

PDSVAL  145670 G        SAVEXP= 007336 G        TCONCD  154132 G        TYPSYM  152102 G        $GO1    141722 G
PERMOD= 007331 G        SCRPAD= 007400 G        TEXTRP  153722 G        TYPTBL  152040 G        $HALT   136752 G
PFVEC = 000024 G        SCRPD1= 006500 G        TFULOP  153750 G        UCSAVE  137004 G        $MONIT  137570 G
PRINT   133766 G        SEGBUF= 007712 G        TIME  = 007730 G        UNDEFX  151372          $NULLI  135676 G
PRINTA  133754 G        SETAUX  135170 G        TMPMOD= 007330 G        UPBLNK  140034 G        $NUMER  140430 G
PRINT1  134004 G        SETAX1  135126          TOPNAM= 000770 G        UPDISP  140020 G        $PC   = 007750 G
PRINT2  133774 G        SETAX2  135124          TOPRND  153554 G        USERAM  154476          $PS   = 007752 G
PRINT3  134014 G        SETMOD  146104          TPREG   153612 G        USERIV= 000100 G        $REG    141610 G
PRINT4  134010          SLUTST  155454          TREGIS  153636 G        USERVS= 007702 G        $RPEAT  150012 G
PRNERR  143120 G        SLU.1   155472          TRGDST  153574 G        VCON    150142          $R0   = 007732 G
PROTEC  150172 G        SLU.2   155504          TRTSRG  153566 G        VERR    150146          $R1   = 007734 G
PURGE   133450 G        SOBDSP  153102 G        TSOBDS  153676 G        VERR1   150162          $R2   = 007736 G
PWRFVS= 007674 G        SPCLBF= 007726 G        TSRDST  153544 G        VRBDSP  147220 G        $R3   = 007740 G
P$CREG= 177446 G        SPDTBL  142302 G        TYPADR  155250 G        VRBDS1  147262          $R4   = 007742 G
P$PDRA= 177440 G        SPEEDS  142320 G        TYPASC  154634 G        VTJMP   147402          $R5   = 007744 G
P$PDRC= 177444 G        SRCDST  153006 G        TYPDEC  154660 G        VTOFF   147406          $SP   = 007746 G
P$PDRD= 177544 G        STACK = 007462 G        TYPINS  153306 G        VTON    147374          $SST    141706 G
P$PDRI= 177542 G        START   140000 G        TYPLIN  155202 G        WHAT    143076          $START  138660 G
P$PDRO= 177442 G        STEP    147416 G        TYPLOC  155100 G        $ADDR = 007756 G        $UR   = 006500 G
RADCH   154302 G        SUBTR   152160 G        TYPLOI  155170 G        $ADDRK  141550 G        $WATCH= 007754 G
REGDST  152724 G        TALK    150504 G        TYPLO1  155114 G        $ADV    141232 G        $.ASCI  147700 G
REPEAT= 007466 G        TALK1   150530          TYPLO2  155132 G        $BACK   141372 G        $.BLKB  147634 G
REPOF0  151412          TBLBOT= 007462 G        TYPNM1  155076 G        $BRKP   141462 G        $.BLKW  147654 G
RERR    150152          TBLFUL  151504          TYPNUM  155064 G        $CLR    141110 G        $.BYTE  147466 G
RPAREN  145152          TBLTOP= 007320 G        TYPOCT  154744 G        $EXAM   141122 G        $.EVEN  147776 G
RSTART  140004 G        TBRDSP  153734 G        TYPREG  151730 G        $FUNC   141650 G        $.STRT  150344
RTSREG  152714 G        TCOMMA  153602          TYPSPC  155042 G        $GO     141714 G        $.WORD  147560 G
R1X40   134122 G

. ABS.  160000    000   (RW,I,GBL,ABS,OVR)
        000000    001   (RW,I,LCL,REL,CON)
Errors detected:  0

### Assembler statistics


Work  file  reads:  0
Work  file writes:  0
Size of work file:  10760 Words  ( 43 Pages)
Size of core pool:  13312 Words  ( 52 Pages)
Operating  system:  RT-11

Elapsed time:  00:02:30.51
DK:MON2,DK:MON2/C=DK:MON2
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APPENDIX B
SCHEMATIC DRAWINGS

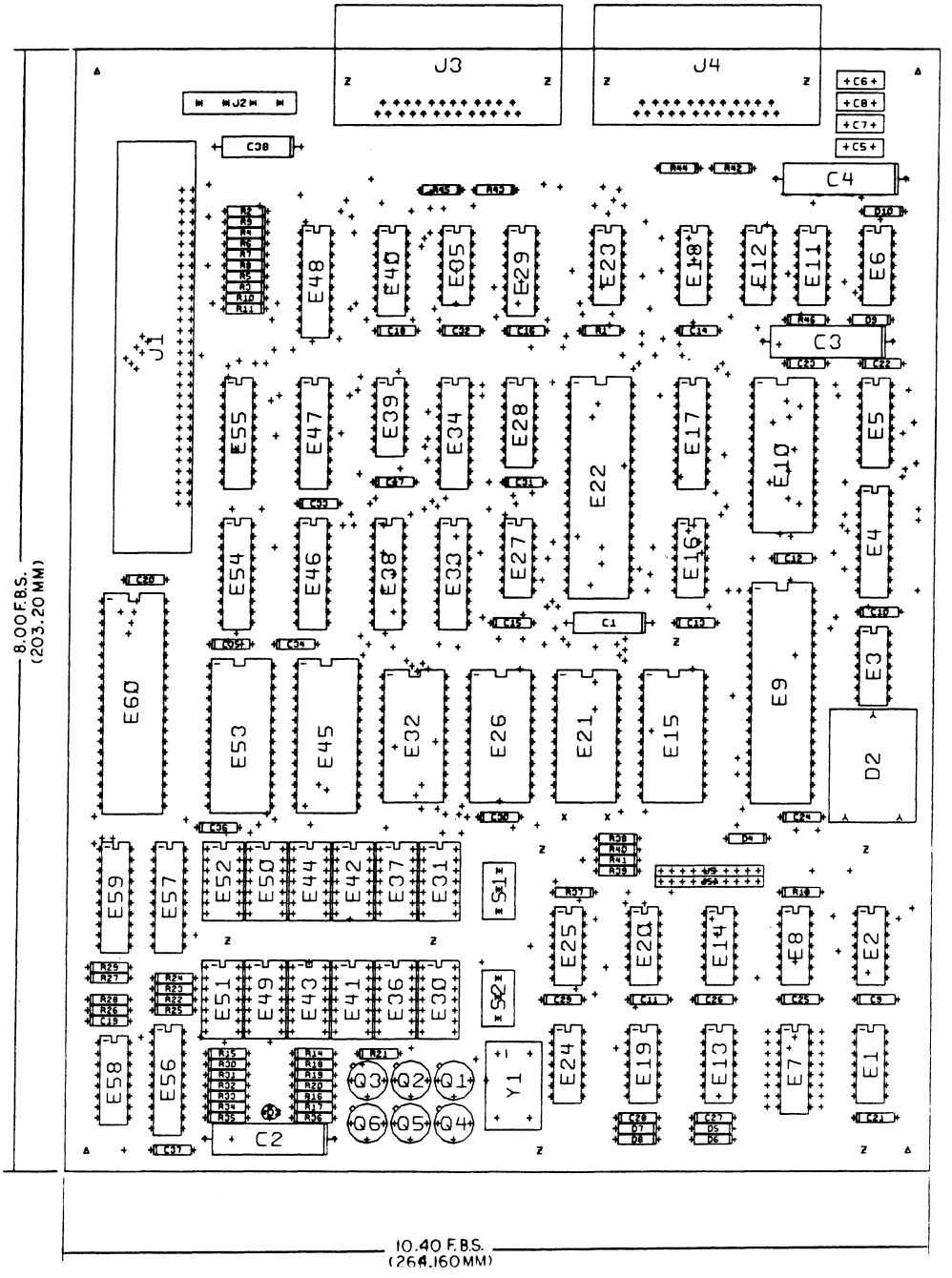
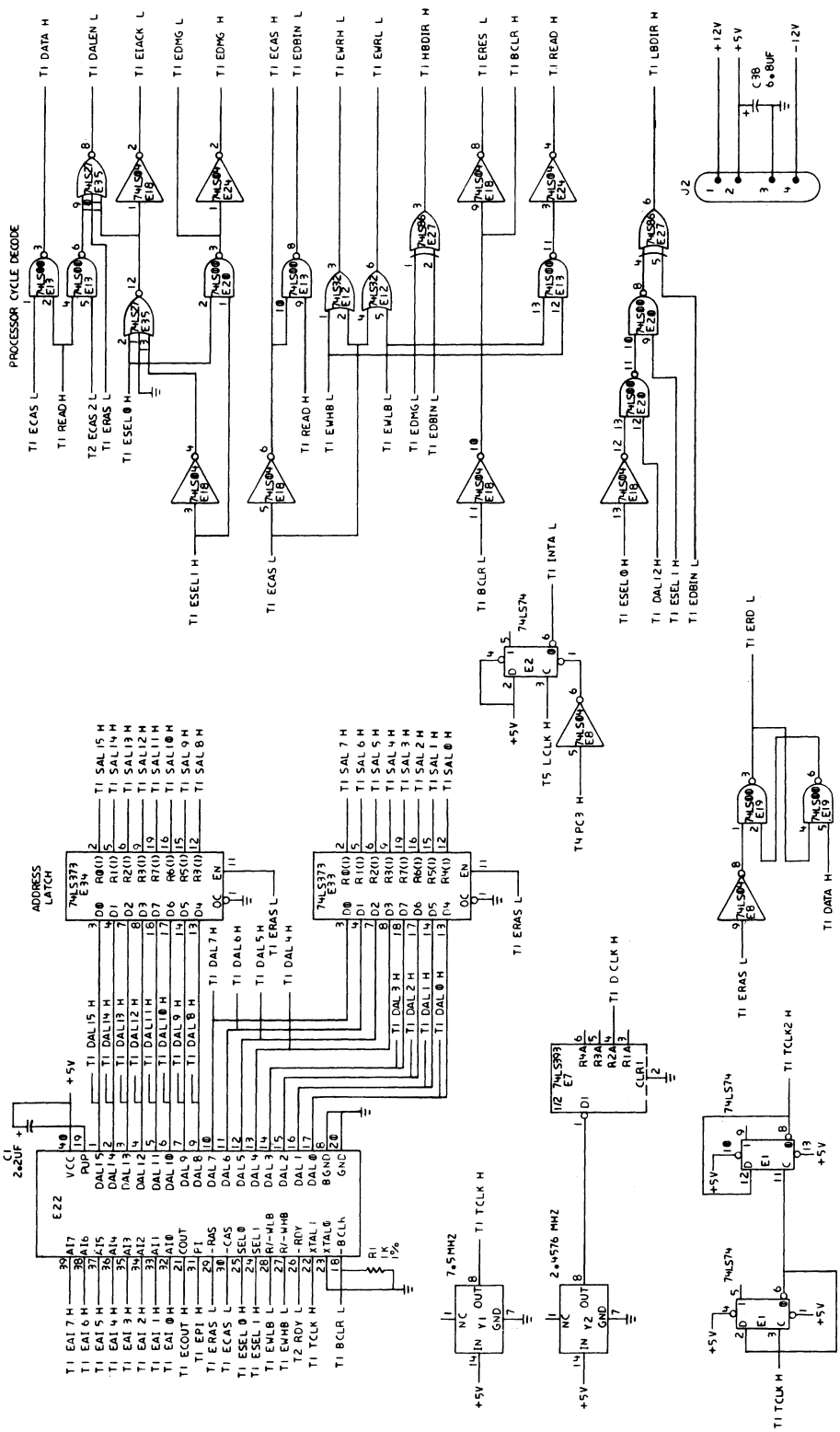
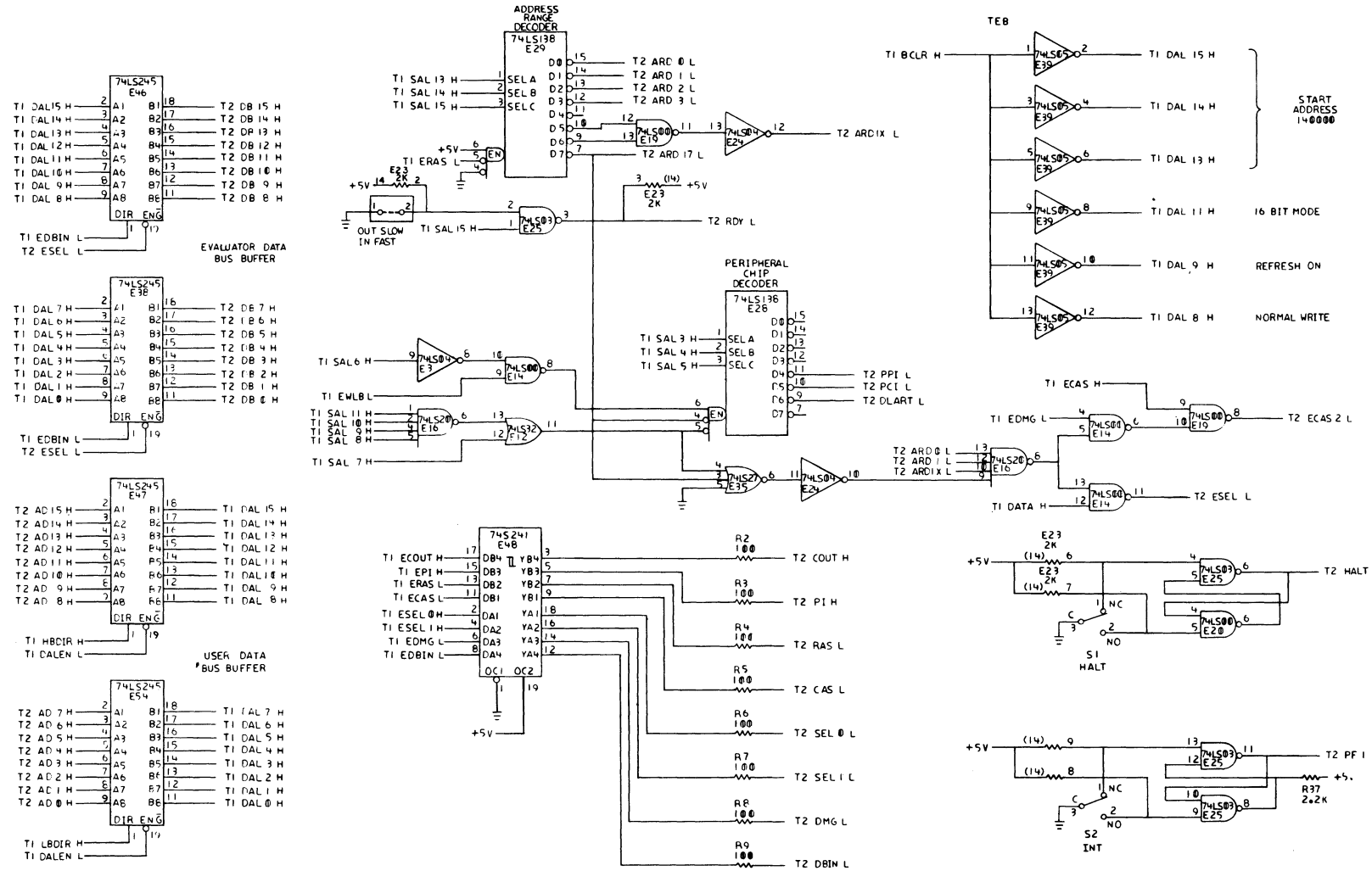
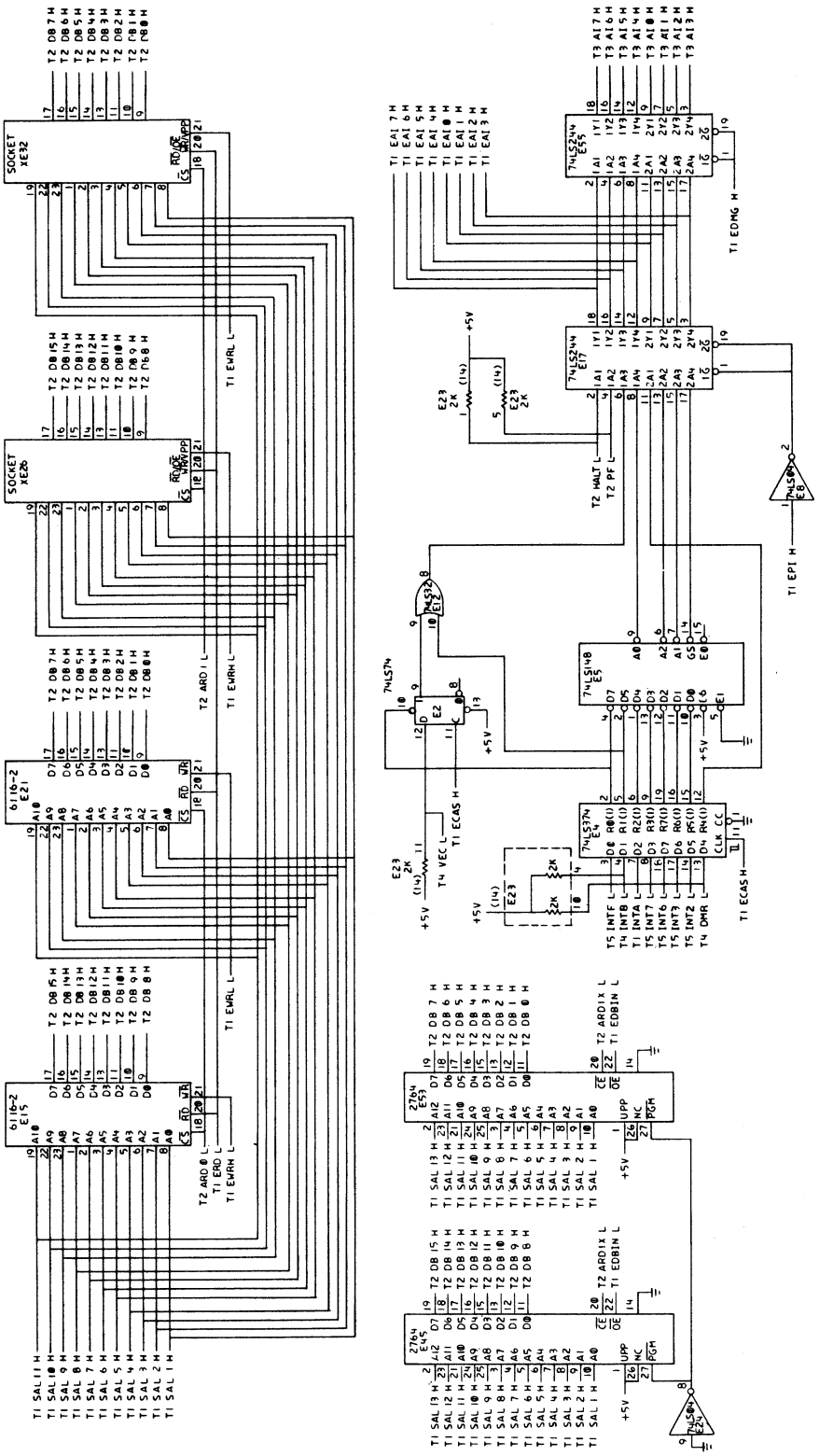
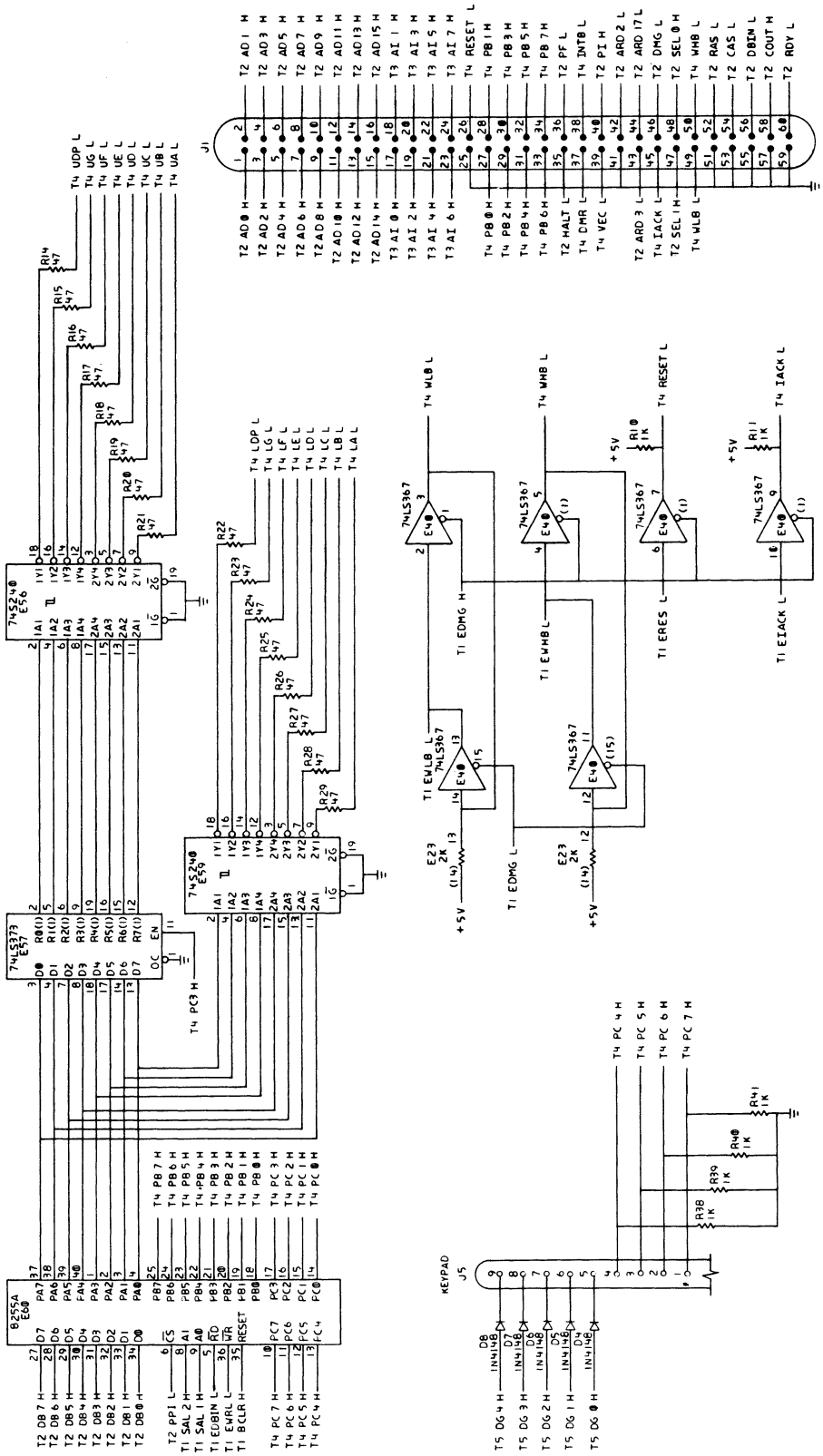


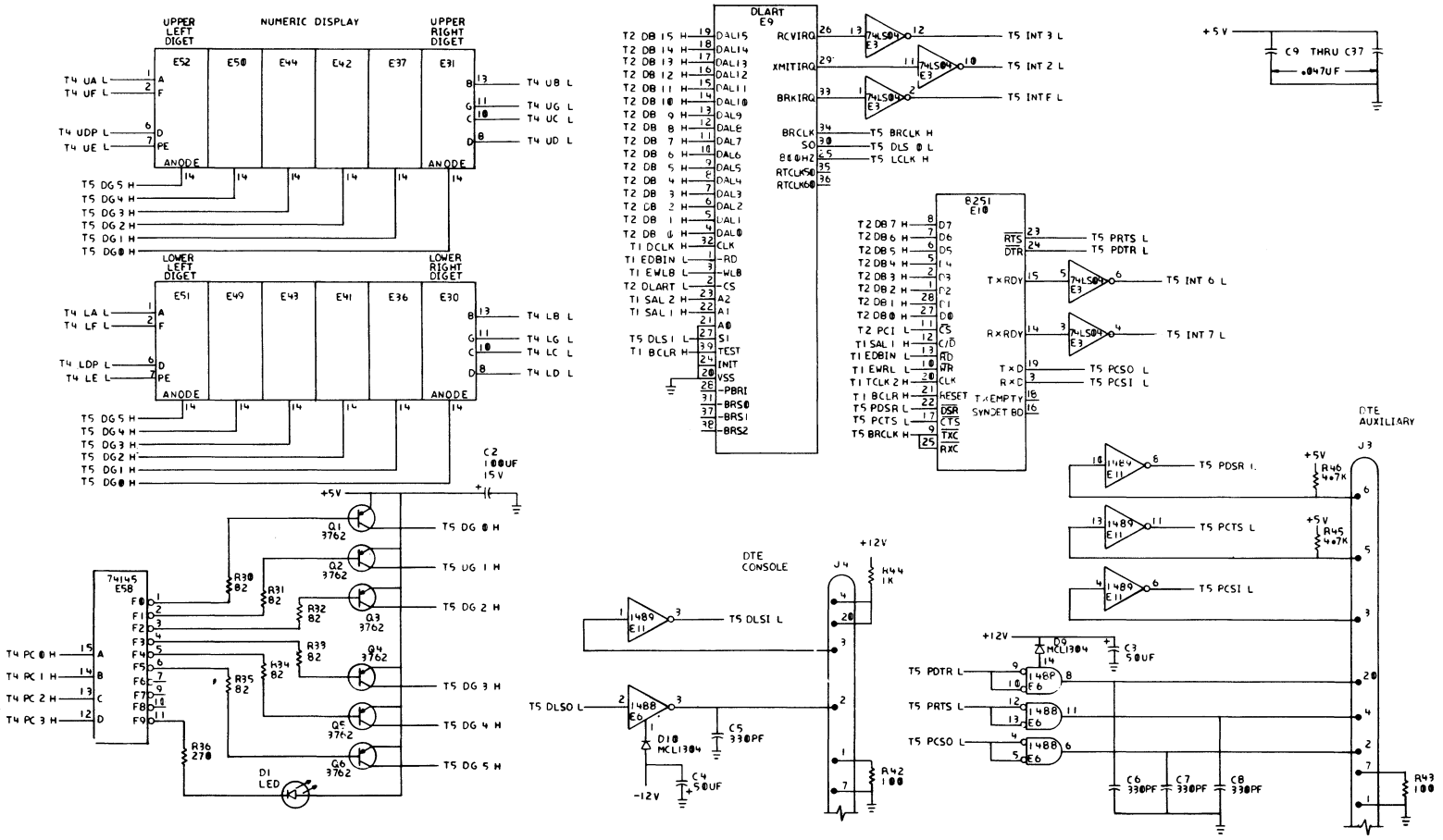
Figure B-1 DCT11-EM Component Placement


PROCESSOR CYCLE DECODE
ADDRESS LATCH
T1 DATA H
T1 DALEN L
T1 EIACK L
T1 EDMG L
T1 EDMG H
T1 ECAS H
T1 EDBIN L
T1 EWRH L
T1 EWRL L
T1 HBDIR H
T1 ERES L
T1 BCLR H
T1 READ H
T1 LBDIR H
T1 INTA L
T1 ERD L
T1 ESEL 0 H
T1 DAL12 H
T1 ESEL 1 H
T1 EDBIN L
T1 ECAS L
T1 READ H
T2 ECAS 2 L
T1 ERAS L
T1 ESEL 0 H
T1 ESEL 1 H
T1 EDMG L
T1 EWHB L
T1 EWLB L
T1 EDBIN L
T1 BCLR L
T5 LCLK H
T4 PC3 H
T1 ERAS L
T1 DCLK H
T1 TCLK H
T1 TCLK2 H
T1 DATA H
T1 EAI 7 H
T1 EAI 6 H
T1 EAI 5 H
T1 EAI 4 H
T1 EAI 3 H
T1 EAI 2 H
T1 EAI 1 H
T1 EAI 0 H
T1 ECOUT H
T1 EPI H
T1 ERAS L
T1 ECAS L
T1 ESEL 0 H
T1 ESEL 1 H
T1 EWLB L
T2 RDY L
T1 TCLK H
T1 BCLR L
T1 SAL 15 H
T1 SAL 14 H
T1 SAL 13 H
T1 SAL 12 H
T1 SAL 11 H
T1 SAL 10 H
T1 SAL 9 H
T1 SAL 8 H
T1 SAL 7 H
T1 SAL 6 H
T1 SAL 5 H
T1 SAL 4 H
T1 SAL 3 H
T1 SAL 2 H
T1 SAL 1 H
T1 SAL 0 H
T1 DAL 15 H
T1 DAL 14 H
T1 DAL 13 H
T1 DAL 12 H
T1 DAL 11 H
T1 DAL 10 H
T1 DAL 9 H
T1 DAL 8 H
T1 DAL 7 H
T1 DAL 6 H
T1 DAL 5 H
T1 DAL 4 H
T1 DAL 3 H
T1 DAL 2 H
T1 DAL 1 H
T1 DAL 0 H
+12V
+5V
-12V
C38
6.8UF
J2


74LS245 E46
TI DAL15 H
TI DAL14 H
TI DAL13 H
TI DAL12 H
TI DAL11 H
TI DAL10 H
TI DAL 9 H
TI DAL 8 H
T2 DB 15 H
T2 DB 14 H
T2 DB 13 H
T2 DB 12 H
T2 DB 11 H
T2 DB 10 H
T2 DB 9 H
T2 DB 8 H
DIR ENG
TI EDBIN L
T2 ESEL L
EVALUATOR DATA BUS BUFFER
74LS245 E38
TI DAL 7 H
TI DAL 6 H
TI DAL 5 H
TI DAL 4 H
TI DAL 3 H
TI DAL 2 H
TI DAL 1 H
TI DAL 0 H
T2 DB 7 H
T2 DB 6 H
T2 DB 5 H
T2 DB 4 H
T2 DB 3 H
T2 DB 2 H
T2 DB 1 H
T2 DB 0 H
74LS245 E47
T2 AD 15 H
T2 AD 14 H
T2 AD 13 H
T2 AD 12 H
T2 AD 11 H
T2 AD 10 H
T2 AD 9 H
T2 AD 8 H
TI DAL 15 H
TI DAL 14 H
TI DAL 13 H
TI DAL 12 H
TI DAL 11 H
TI DAL 10 H
TI DAL 9 H
TI DAL 8 H
TI HBDIR H
TI DALEN L
USER DATA BUS BUFFER
74LS245 E54
T2 AD 7 H
T2 AD 6 H
T2 AD 5 H
T2 AD 4 H
T2 AD 3 H
T2 AD 2 H
T2 AD 1 H
T2 AD 0 H
TI DAL 7 H
TI DAL 6 H
TI DAL 5 H
TI DAL 4 H
TI DAL 3 H
TI DAL 2 H
TI DAL 1 H
TI DAL 0 H
TI LBDIR H
TI DALEN L
ADDRESS RANGE DECODER 74LS138 E29
TI SAL 13 H
TI SAL 14 H
TI SAL 15 H
SEL A
SEL B
SEL C
T2 ARD 0 L
T2 ARD 1 L
T2 ARD 2 L
T2 ARD 3 L
T2 ARD 17 L
T2 ARDIX L
TI ERAS L
+5V
E23 2K
OUT SLOW IN FAST
TI SAL 15 H
T2 RDY L
TEB
TI BCLR H
TI DAL 15 H
TI DAL 14 H
TI DAL 13 H
START ADDRESS 140000
TI DAL 11 H
16 BIT MODE
TI DAL 9 H
REFRESH ON
TI DAL 8 H
NORMAL WRITE
PERIPHERAL CHIP DECODER 74LS138 E26
TI SAL 3 H
TI SAL 4 H
TI SAL 5 H
T2 PPI L
T2 PCI L
T2 DLART L
TI SAL 6 H
TI EWLB L
TI SAL 11 H
TI SAL 10 H
TI SAL 9 H
TI SAL 8 H
TI SAL 7 H
TI ECAS H
TI EDMG L
T2 ECAS 2 L
T2 ARD 0 L
T2 ARD 1 L
T2 ARDIX L
TI DATA H
T2 ESEL L
74S241 E48
TI ECOUT H
TI EPI H
TI ERAS L
TI ECAS L
TI ESEL 0 H
TI ESEL 1 H
TI EDMG L
TI EDBIN L
R2 100
T2 COUT H
R3 100
T2 PI H
R4 100
T2 RAS L
R5 100
T2 CAS L
R6 100
T2 SEL 0 L
R7 100
T2 SEL 1 L
R8 100
T2 DMG L
R9 100
T2 DBIN L
E23 2K
T2 HALT L
S1 HALT
NC
NO
T2 PF I
R37 2.2K
S2 INT






NUMERIC DISPLAY
UPPER LEFT DIGET
UPPER RIGHT DIGET
LOWER LEFT DIGET
LOWER RIGHT DIGET
E52
E50
E44
E42
E37
E31
E51
E49
E43
E41
E36
E30
ANODE
T4 UA L
T4 UF L
T4 UDP L
T4 UE L
T4 UB L
T4 UG L
T4 UC L
T4 UD L
T4 LA L
T4 LF L
T4 LDP L
T4 LE L
T4 LB L
T4 LG L
T4 LC L
T4 LD L
T5 DG5 H
T5 DG4 H
T5 DG3 H
T5 DG2 H
T5 DG1 H
T5 DG0 H
C2
100UF
15V
+5V
Q1
3762
Q2
3762
Q3
3762
Q4
3762
Q5
3762
Q6
3762
74145
E58
R30
82
R31
82
R32
82
R33
82
R34
82
R35
82
R36
270
D1
LED
T4 PC 0 H
T4 PC 1 H
T4 PC 2 H
T4 PC 3 H
T5 DG 0 H
T5 DG 1 H
T5 DG 2 H
T5 DG 3 H
T5 DG 4 H
T5 DG 5 H
DLART
E9
T2 DB 15 H
T2 DB 14 H
T2 DB 13 H
T2 DB 12 H
T2 DB 11 H
T2 DB 10 H
T2 DB 9 H
T2 DB 8 H
T2 DB 7 H
T2 DB 6 H
T2 DB 5 H
T2 DB 4 H
T2 DB 3 H
T2 DB 2 H
T2 DB 1 H
T2 DB 0 H
T1 DCLK H
T1 EDBIN L
T1 EWLB L
T2 DLART L
T1 SAL 2 H
T1 SAL 1 H
T5 DLSI L
T1 BCLR H
RCVIRQ
XMITIRQ
BRKIRQ
BRCLK
SO
BE0HZ
RTCLK50
RTCLK60
T5 INT 3 L
T5 INT 2 L
T5 INTF L
T5 BRCLK H
T5 DLS 0 L
T5 LCLK H
+5V
C9 THRU C37
.047UF
8251
E10
T2 DB 7 H
T2 DB 6 H
T2 DB 5 H
T2 DB 4 H
T2 DB 3 H
T2 DB 2 H
T2 DB 1 H
T2 DB 0 H
T2 PCI L
T1 SAL 1 H
T1 EDBIN L
T1 EWRL L
T1 TCLK 2 H
T1 BCLR H
T5 PDSR L
T5 PCTS L
T5 BRCLK H
RTS
DTR
T X RDY
R X RDY
T X D
R X D
T X EMPTY
SYNDET BD
T5 PRTS L
T5 PDTR L
T5 INT 6 L
T5 INT 7 L
T5 PCSO L
T5 PCSI L
DTE
AUXILIARY
J3
T5 PDSR L
T5 PCTS L
T5 PCSI L
R46
4.7K
R45
4.7K
R44
1K
R43
100
R42
100
C3
50UF
C4
50UF
C5
330PF
C6
330PF
C7
330PF
C8
330PF
D8
MCL1304
D10
MCL1304
DTE
CONSOLE
J4
T5 DLSI L
T5 DLSO L
T5 PDTR L
T5 PRTS L
T5 PCSO L
+12V
-12V

APPENDIX C
ERROR MESSAGES

C.1 DIAGNOSTIC ERROR MESSAGES

The following flashing error messages are displayed if the DCT11-EM fails its diagnostic tests. These are fundamental errors and must be corrected before you attempt to do anything else.

UPPER DISPLAY	LOWER DISPLAY	MEANING
1	Error	RAM checksum test failed. Try replacing RAM chips.
2	Error	ROM checksum test failed. Try replacing ROM chips.
12	Error	RAM and ROM checksum tests failed. Board may have major problems.
3	Error	DLART feedback test failed. Board may have major problems.

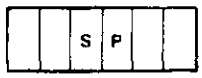
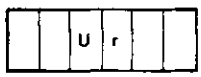
C.2 KEYPAD ERROR MESSAGES

If the DCT11-EM detects an error while you are using the keypad, it displays a flashing error message on the upper and lower rows of LEDs. The upper row of LEDs displays a two-character error code and the lower row of LEDs displays:

The entire error message disappears and the DCT11-EM is returned to register mode when you press the HALT switch or any key on the keypad.

The keypad error messages are as follows.

UPPER DISPLAY	LOWER DISPLAY	MEANING
bP	Error	You tried to execute a program with a BPT instruction in it.
Cb	Error	A break was detected on the console terminal port while the keypad was active.

		You tried to execute a program with an invalid instruction in it.
		You tried to execute a program and used an unacceptable value for the SP. See chapter 5 for more information.
		You tried to alter a protected location in the keypad monitor scratch pad (locations 7400 through 7776).

C.3 CONSOLE MESSAGES

The console displays 12 different messages (Table C-1). Most of these are error messages that indicate a problem with your input or with the execution of your program. This paragraph explains each of the messages and its probable causes.

Some of the error messages are preceded by the portion of your input that caused the error. If this is the case, your erroneous input is displayed between backslashes on the line above the error message.

Table C-1 Console Messages

Message	Meaning
BRANCH OUT OF RANGE	You input a branch instruction which was too far from the branch destination. Recall that branch instructions have a range of −128 to 127 (decimal) words.
BREAK POINT ENCOUNTERED	A breakpoint (B1, B2, B3, or B4) or a BPT instruction was encountered while your program was executing.
BUFFER OVERFLOW	The console monitor was accepting input from a host and a line exceeding 96 characters was received. As with all errors generated during host loading, this error stops the DCT11-EM from loading further input from the host.
CONSOLE BREAK	The BREAK key on the console keyboard was pressed. If you are executing a program, execution stops and the DCT11-EM internal register values at the time of the break are saved. If you are in HOST, TALK, or LOAD modes, CONSOLE BREAK causes a return to NOHOST mode.
INVALID INSTRUCTION ENCOUNTERED	An invalid op code was encountered while your program was running.
INVALID STACK POINTER	The stack pointer did not have a value between 4 and 6500 (inclusive) when you started your program or when you single stepped.
NOT IN USER RAM	You attempted to alter a location that was in the protected monitor scratchpad area (locations 6500 through 7777, inclusive).
ODD ADDRESS	You attempted to access a full word in RAM on an odd address boundary. Use the BYTE mode to examine or alter locations at odd addresses.
REPEAT OF ZERO	You input a REPEAT command that had a count of zero.
TABLE FULL	You attempted to define more than 66 symbols.
UNDEFINED EXPRESSION	You attempted to use an undefined parameter, operand, or other data object when a defined expression was required. For example, you referenced an undefined symbol while in PASS2 mode.
WHAT ?	You attempted to input a line that had a syntax error in it.

INDEX