MILLENNIUM Microsystem Analyzer

MILLENNIUM

Microsystem Analyzer
Users Manual

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MICROSYSTEM ANALYZER

USERS MANUAL

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MicroSystem Analyzer

PREFACE

The MicroSystem Analyzer Users Manual provides operational procedures in a tutorial format for both equipment and software.

As the use of the MicroSystem Analyzer is expected to entail all technical skill-levels, the descriptions within this publication are confined, in most cases, to only those instructions necessary for operation of the MicroSystem Analyzer.

The material this publication is subject to change without notice.

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- Diagnostic Programming for Microprocessor-based Systems
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- uSA/uSE 6800/6802 Emulators Users Manual
- uSA/uSE 8080 Emulator Users Manual
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Chapter 1

INTRODUCTION

1.1 PRODUCT DESCRIPTION

The **Millennium** MicroSystem Analyzer (uSA) is a portable, stand-alone test instrument for developing and testing microprocessor-based systems. Typical applications for the uSA include product development, production testing, depot repair and field maintenance. Through the use of plug-in emulator boards, the uSA can test many different types of microprocessor-based systems.

The uSA contains internal circuitry that employs In-Circuit Emulation, Signature Analysis, and Time Domain Analysis on the Unit Under Test (UUT). All three of these test techniques are discussed in more detail later in this manual.

The uSA is housed in a compact carrying case that also provides storage space for the instrument's power cord and the signals cables that connect to the UUT.

1.2 SPECIFICATIONS

1.2.1 Power

1.2.1.1 Standard

120 VAC, -10%, +5%,
48 Hz to 66 Hz, 120 watts max.

1.2.1.2 Optional

100 VAC, 220 VAC or 240 VAC -10%, + 5%,
48 Hz to 66 Hz, 120 watts Max.

1.2.2 Physical

Width	19.0 in	(48.3 cm)
Height	10.5 in	(26.7 cm)
Depth	8.75 in	(22.2 cm)
Weight	21 lbs.	(9.5 Kg)

1.2.3 Environmental

Operating temperature	0°C to 50°C	(32°F to 122°F)
Storage temperature	-40°C to 75°C	(-40°F to 167°F)
Humidity	95% RH 15°C to 40°C	(59°F to 104°F)

1.3 PHYSICAL DESCRIPTION

1.3.1 Keyboard

The keyboard (see figure 1-1), located in the hinged lid of the uSA, contains:

1 RESTART KEY

2 PROCESS CONTROL-DIAGNOSTIC SELECT KEYS

3 FAULT DETECTION CONTROL KEYS

4 DISPLAY SELECT KEYS

5 DATA ENTRY PAD

6 SUBFUNCTION CONTROL KEYS

7 SPECIAL CONTROL KEYS

8 REMOTE LINK KEYS

9 TWO PROM SOCKETS

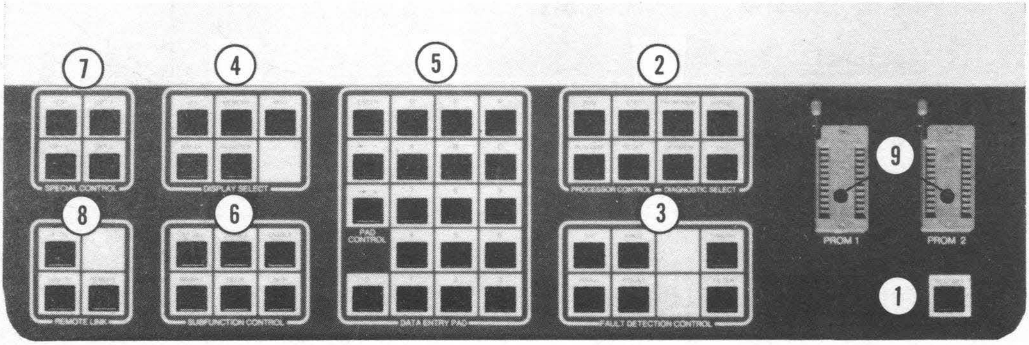


Figure 1-1. uSA Keyboard

See chapter 4 for a detailed description of the uSA keyboard.

1.3.2 **Front Panel**

The upper front panel (see figure 1-2) contains:

1 20-CHARACTER ALPHANUMERIC DISPLAY

2 DISPLAY FIELD INTERPRETER

3 10 LED STATUS INDICATORS

4 STORAGE COMPARTMENT

5 MONITOR TEST POINTS

6 CONTROL POD AND DATA PROBE CONNECTORS

7 REMOTE LINK CONNECTOR

8 ON/OFF PUSH BUTTON

9 AC POWER FUSE

10 AC POWER CORD

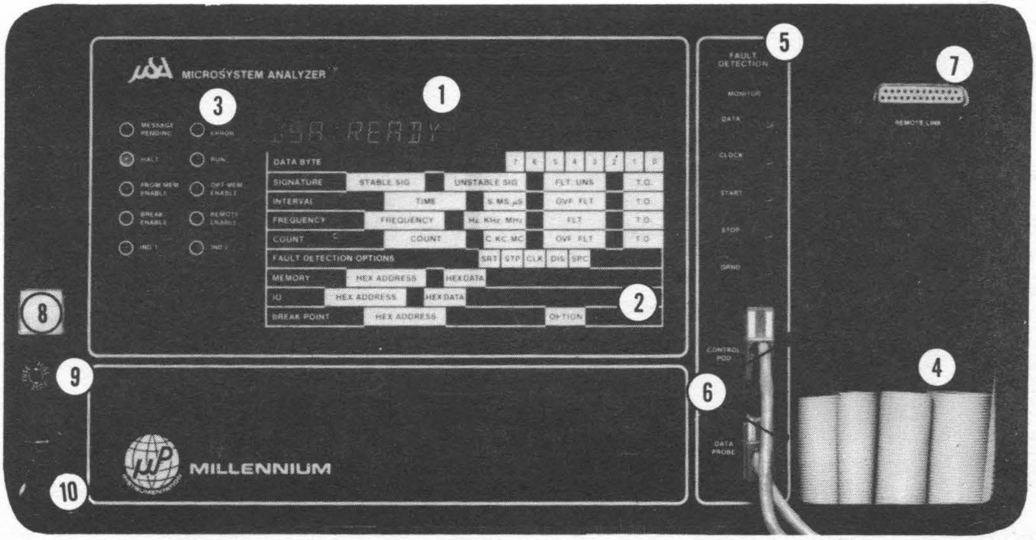


Figure 1-2. uSA Front Panel

1.3.2.1 Alphanumeric Display

The uSA provides twenty large, green 16-segment fluorescent characters that can be easily read and understood.

1.3.2.2 Display Field Interpreter

This visual aid identifies fields in the alphanumeric display. Each line of the display field interpreter is labeled with a mode of operation followed by the appropriate field label to interpret the displayed data in a clear format.

1.3.2.3 LED Status Indicators

The ten LED used to indicate the status of the microprocessor are:

LED Indicator	Description
MESSAGE PENDING	Display Message Pending
INPUT ERROR	Input Error
HALT	Microprocessor Halt
RUN	Microprocessor Running
PROM MEM ENABLE	PROM Memory Enabled
OPT MEM ENABLE	Optional Memory Enabled
BREAK ENABLE	Breakpoint Enabled
REMOTE ENABLE	Remote Enabled
IND 1	Used by Comm Option to Indicate Local Mode
IND 2	Not Used

1.3.2.4 Storage Compartment

Used to store the Emulator cables, the Emulator Pod, and the Signature Analysis Control Pod.

1.3.2.5 Monitor Test Points

Five test points provide convenient triggering of additional instruments such as an oscilloscope. These test points are:

Test Point	Description
DATA	Buffered Data Probe
CLOCK	Buffered Clock Probe
START	Buffered Address Comparison
STOP	Buffered Address Comparison
GRND	Ground

1.3.2.6 Control Pod and Data Probe Connectors

Connectors for the Signature Analysis/Time Domain Analysis Control Pod and Data Probe.

1.3.2.7 **Remote Link Connector**

The optional Remote Link connector allows a master uSA to control a remote slave unit and download diagnostic programs via an RS232 telephone link. The uSA also can communicate with either a large computer, or with a development system. Data communications is block oriented, with transmission rates ranging from 110 to 9600 baud. For details on the communications option, see the uSA Communications Option Users Manual.

1.3.2.8 **On/Off Push Button**

The AC power on/off switch for the uSA.

1.3.3 **Signature Analysis Probe**

The Signature Analysis and Time Domain Analysis probe is shown in figure 1-3. The test lead shown attached is a ground.

Figure 1-3. Signature Analysis and Time Domain Analysis Probe

1.3.4 **Control Pod**

The Control Pod for signature analysis is shown in figure 1-4. The attached test leads are:

Test Lead	Description
START	Brown lead labeled START
STOP	Small black lead labeled STOP
CLOCK	Small Red lead labeled CLK
GROUND	Large black lead

Figure 1-4. Control Pod

1.4 CONVENTIONS

1.4.1 Interpreting the Display

The data shown on the alphanumberic display is broken into fields consisting of one or more characters. More than one type of field can be displayed at the same time. Table 1-1 defines the field types.

Table 1-1. Display Field Intepretation

FIELD TYPE	MANUAL NOTATION	DISPLAY
Alphanumeric	a	All
Sign (+ or -)	s	+ or -
Binary	b	0 or 1
Decimal	d	0-9
Hexadecimal	x, y, z	0-9 and A-F

In this manual, the above notation is used to indicate the format of input display fields. For example, memory address fields are denoted by xxxx to indicate hexadecimal digits.

1.4.2 Keyboard Terminology

In the course of describing the uSA, this document will use the terminology shown in table 1-2 to refer to several of the keys on the Data Entry Keypad.

Table 1-2. Keypad Terminology

TERMINOLOGY	MEANING
Hexadecimal Keypad	0 through F, -->, <--, ENTER
Decimal Keypad	0 through 9, -->, <--, ENTER
Binary Keypad	0 or 1, -->, <--, ENTER
Sign Keypad	+, -, ENTER

1.4.3 Keystroke Representation

A key being pressed is indicated by underlining the name of the key. For example,

MEM

indicates the memory key was pressed.

1.4.4 Hexadecimal Representation

Hexadecimal data and addresses are represented in this manual as one to four hexadecimal digits (0-9 and A-F) followed by an "H". For example,

01FH

indicates the hexadecimal number 1F.

Chapter 10

FUNCTIONAL TESTING

10.1 IN-CIRCUIT EMULATION FOR LABORATORY DEVELOPMENT APPLICATIONS

1. Turn off the UUT and the uSA and remove the microprocessor from the UUT.

2. Plug the In-Circuit Emulator 40-pin probe into the microprocessor socket in the UUT.

CAUTION

Insure that pin 1 on the socket is aligned with pin 1 on the probe.

3. Turn on the UUT and the uSA.

4. Press the RESTART key. Choices are:

    a. To examine and/or modify any of the microprocessor registers or memory locations, use the REGISTER or MEMORY key. See Emulator Supplement for details.

    b. To execute a program in the UUT, set the program counter to the proper address using the REGISTER key, then press the RUN, RUN/DISP or STEP key.

    c. To set one hardware breakpoint, use the BREAK key.

    d. To read or modify an I/O port in the UUT, use the I/O key.

    e. To set the memory in the UUT to a defined value, use the FILL key.

    f. To execute a diagnostic PROM, insert the PROM(s) into the front panel socket(s), press the PROM/MEM key. If all subtests are to be executed, press the RUN key. If a particular subtest is to be run, press the SUBSEL key and choose the subtest, then press the RUN key.

10.2 EXECUTING A DIAGNOSTIC PROM

1. Turn off the UUT and the uSA and remove the microprocessor from the UUT.

2. Plug the in-circuit emulator 40-pin probe into the microprocessor socket in the UUT.

CAUTION

Insure that pin 1 on the socket is aligned with pin 1 on the probe.

3. Insert the PROM(s) into the socket(s), turn on the UUT and the uSA, and press the RESTART key. The uSA displays:

```
uSA READY xxxx
```

xxxx indicates the emulator installed.

4. Press the PROM/MEM key. The uSA displays an initial message such as:

```
UUT TEST
```

5. Press the RUN key if all subtests are to be executed.

6. Or, if a particular subtest is to be executed, select the subtest with the SUBSEL key, then press the RUN key.

11.2.1 Using Signature Analysis with a Diagnostic PROM

1. Turn off the UUT and the uSA and remove the microprocessor from the UUT.

2. Plug the In-Circuit Emulator 40-pin probe into the microprocessor socket in the UUT. Make sure pin 1 on the connector is aligned with pin 1 on the socket.

3. Plug the control pod and the data probe into the uSA.

4. Connect the control pod clock probe (red probe) to the appropriate signal in the UUT for the signature analysis clock. Connect the control pod ground to a convenient ground in the UUT.

5. If an external start and/or stop pulse is used, connect the control pod start and/or stop probe(s) to the appropriate signals in the UUT.

6. Insert the diagnostic PROM(s) into the socket (s) on the front panel.

7. Turn on the UUT and uSA.

8. Press the RESTART key. The uSA displays:

```
uSA READY xxxx
```

xxxx indicates the emulator installed.

9. Press the PROM/MEM key. The uSA displays:

```
Initial Message
```

10. Select the proper subtest using the SUBSEL key.

11. Press the SIG key. The options will be automatically be set up.

12. Press the RUN key. Signatures may now be taken in the UUT by using the Data Probe.

13. To restart go to step 8.

11.2.2 **Taking Signatures on Data Lines**

The following example shows how to use Signature Analysis with a test program t take signatures on data lines.

1. Turn off the UUT and the uSA and remove the microprocessor from th UUT.
2. Plug the in-circuit emulator, 40-pin probe into the microprocessor socket in the UUT. Make sure pin 1 on the connector is aligned wi pin 1 on the socket.
3. Plug the control pod and the data probe into the uSA.
4. Connect the control pod clock probe (red) to the Write ($\overline{WR}$) signal in the UUT for the signature analysis clock. Connect the signatur control pod ground to a convenient ground in the UUT.
5. Turn on the UUT and uSA.
6. Enter the following program into memory at any valid RAM address:

```
Address Data      Opcode        Comments

 xx00  3E00       MVI A,0    ;ZERO REGISTER "A"
 xx02  3220xx     STA 020    ;STORE DATA AT ADDRESS 0020H
 xx05  3C         INR A      ;INCREMENT THE A REGISTER BY 1
 xx06  C202xx     JNZ 002    ;JUMP IF "A" REGISTER IS NOT TO 0002H
 xx09  C300xx     JMP 00     ;JUMP TO ADDRESS 0000H
```

xx00 is any RAM location in the user's system.

The above program can be used with an 8080, Z80A, or 8085 emulator

Keys Pushed	uSA Display	Comments
RESTART	uSA READY xxxx	xxxx is the microprocessor type.
REGISTER	PN=xxxx PL=yyyy I=zz	Set PN=xx00, where xx is the RAM address.
SIG	SIG = 0000	Enable signature analysis.
OPTSEL	SIG OPTS = 00010	Look at options.
4	SIG OPTS=40010	Choose START ON address.
4	SIG OPTS=44010	Choose STOP ON address.
2, ENTER	SIG OPTS=44210	Choose SIGNATURE CLOCK.
INCR	RESTRT=0000 TIME=127	Restart address = 0000. Time out is maximum.
xx, ENTER	RESTRT=xx00 TIME=127	Choose restart address = xx00.
ENTER	RESTRT=xx00 TIME=127	
INCR	COMP START ADDR=0000	Start address = 0000.
xx02, ENTER	COMP START ADDR=XX02	Choose starting address on STORE DATA = xx02.
INCR	COMP STOP ADDR=0000	Stop address = 0000.
xx09 ENTER	COMP STOP ADDR=XX09	Choose stop address on UNCONDITIONAL JUMP.

7. To take signatures push the following keys:

Keys Pushed	uSA Display	Comments
INCR	SIG OPTS = 44210	Back to signature options.
SIG	SIG = 0000	
RUN	SIG = 0000 0000FLT	Ready to take signatures. FLT means data probe is not touching any node.
Put data probe on +5V	SIG = DD9A	This is the signature for +5 volts for this test.
Put data probe on D0	SIG = 96EC	
Put data probe on D1	SIG = 725B	
Put data probe on D2	SIG = E5ED	
Put data probe on D3	SIG = 5BE0	
Put data probe on D4	SIG = 7E25	
Put data probe on D5	SIG = 85EA	
Put data probe on D6	SIG = 77C7	
Put data probe on D7	SIG = 6EBE	

An example of a small program to take signatures on the data bus is shown in figure 11-3.

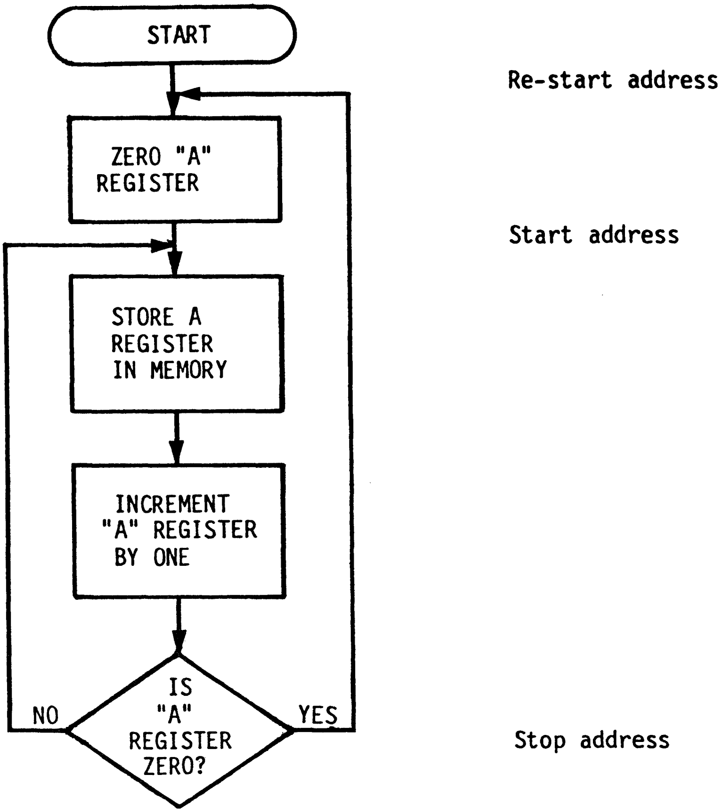


Figure 11-3. Signature Sample Program.

11.3.3 Using Frequency Analysis in a Stand-Alone Operation

1. With the power off, connect the data probe to the uSA.
2. Turn on the uSA.
3. Press the RESTART key.
4. Press the FREQ key.
5. Frequency measurements may now be taken using the data probe. Frequencies are autoranging from 1 Hz to 40M Hz.
6. To restart go to step 3.

11.3.4 Using Pulse Width and/or Interval Measurements in a Stand-Alone Operation

1. With the power off, connect the data probe to the uSA.
2. Turn on the uSA.
3. Press the RESTART key.
4. Press the INTRVL key.
5. Interval measurements may now be taken in the UUT by using the data probe. To measure the width of a positive pulse, press the INTRVL key and then press the OPTSEL key.

```
INTVL OPTS=32810
```

6. Now measure the width of the pulse using the data probe. Pulse width is 10 nanosec to 1 sec.
7. To restart go to Step 3.

11.4 SIGNATURE ANALYSIS MEASUREMENTS

The SIG key allows a signature measurement to be taken with the data probe. When the SIG key is pressed, the OPTSEL subfunction key is enabled. If the options for signature measurement are valid, the following message is displayed.

```
SIG = 0000
```

This message indicates that signature analysis measurements are being taken.

If the options for signature analysis are invalid, it is equivalent to pressing the OPTSEL key; and the curser will be positioned at the first invalid digit.

11.4.1 Signature Options

The OPTSEL key is used to enter or modify the options and parameters necessary to define a signature measurement.

The following subfunctions are enabled:

HEX PAD
INCR
DECIMAL PAD

The operator selects the signature measurement by pressing the SIG key and then the OPTSEL key. The following is displayed:

```
SIG OPTS = dxyzb
```

d = Start Criteria
x = Stop Criteria
y = Clock/Data Criteria
z = Display Criteria
b = Special Criteria

The operator specifies the criteria by digits which have preassigned meanings. The digits and their meanings are described in the following sections.

11.4.2 **Start Criteria**

The uSA can start a signature measurement on any of these conditions:

START DIGIT	CONDITION
0	Using external start probe, negative going edge
1	Using external start probe, positive going edge
2	Using external data probe, negative going edge
3	Using external data probe, positive going edge
4	Address compare
5	Address compare and external start probe, negative going edge
6	Address compare and external start probe, positive going edge
7	Address compare and external data probe, negative going edge
8	Address compare and external data probe, positive going edge
9	Start immediately

The address comparison is triggered when the specified address is referenced.

When the address comparison is used in conjunction with an external signal, both conditions must be met before the signature window is opened.

Note that the address comparison can only be used when the uSA is performing in-circuit emulation.

11.4.3 **Stop Criteria**

The uSA can stop a signature measurement on any of the following conditions:

STOP DIGIT	CONDITION
0	External stop probe, negative going edge
1	External stop probe, positive going edge
2	External data probe, negative going edge
3	External data probe, positive going edge
4	Address compare
5	Address compare and external stop probe, negative going edge
6	Address compare and external stop probe, positive going edge
7	Address compare and external data probe, negative going edge
8	Address compare and external data probe, positive going edge
9	Count
A	Count and external stop probe, negative going edge
B	Count and external stop probe, positive going edge
C	Count and address compare
D	Count and address compare and external stop probe, negative going edge
E	Count and address compare and external stop probe, positive going edge

The address comparison can only be used when the uSA is performing in-circuit emulation. It is triggered when the specified address is referenced. When the address comparison is used with an external stop signal, both conditions must be met before the measurement is terminated.

When the count is used as the signature terminator, the shift register will be clocked the number of times specified by the count. The maximum count is 65,535.

When the stop on count and address comparison is used, both conditions must be met before the signature is terminated.

When the stop on count and an external condition is used, both conditions must be met before the signature is terminated.

When count, address comparison and external condition is used, all three conditions must be met before the signature is terminated.

11.4.4 **Clock/Data Criteria**

The Clock/Data Criteria is a collection of information which specifies the:

CLOCK SOURCE
SYNCHRONIZATION OF THE CLOCK WITH THE START AND STOP SIGNAL
DATA SOURCE
SIGNATURE CLOCKING

The signature measurement requires all of the above information. The CLOCK SOURCE can be:

CLOCK PROBE
OPREQ

OPREQ is a signal that signifies that a bus transaction is taking place and will be different for each microprocessor. See the microprocessor emulator supplement for details of the OPREQ signal.

To avoid those conditions where the external start or stop signal is not stable on a given clock edge, the start and stop signals are synchronized with either the positive going (+) or negative going (-) edge of the clock.

The data source is always the data probe.

The signature is taken with either the positive going (+) or the negative going (-) edge of the clock.

The following defines the Clock/Data Digit:

CLOCK/DATA DIGITS	CLOCK SOURCE	EXTERNAL START/STOP SYNC. WITH CLOCK	DATA SOURCE	SIGNATURE CLOCK
0	Clock Probe	+	Data Probe	+
1	Clock Probe	+	Data Probe	-
2	Clock Probe	-	Data Probe	+
3	Clock Probe	-	Data Probe	-
4	OPREQ	+	Data Probe	+
5	OPREQ	+	Data Probe	-
6	OPREQ	-	Data Probe	+
7	OPREQ	-	Data Probe	-

11.4.6 **Display Criteria**

For signature analysis, two readings are taken and if they are the same, the signature is displayed. If a wait is desired between displays, the display digit specifies the wait.

The following defines the Display Criteria Digit:

DISPLAY DIGITS	MEANING
0	Not valid
1	No wait
2	Wait 100 msec. between displays
3	Wait 200 msec. between displays
4	Wait 300 msec. between displays
5	Wait 400 msec. between displays
6	Wait 500 msec. between displays
7	Wait 700 msec. between displays
8	Wait 1 sec. between displays
9	Wait 2 sec. between displays
A	Wait 5 sec. between displays

11.4.7 Special Criteria

The Special Criteria digit indicates how memory is to be mapped. If it is zero, all memory except the test diagnostic memory is mapped to the UUT. If it is a one, all memory is mapped to the uSA and all control, address, and data signals are passed to the UUT. When mapped to the uSA, all memory signals from the UUT are disregarded. This allows fault analysis on the UUT memory and the bus structure. See the microprocessor emulator supplement for further details.

After the operator has entered the Start, Stop, Clock/Data, Display, Special digits, and pressed the ENTER key, the lines of the OPTSEL display can be reviewed and modified by pressing the INCR key. The next display is:

```
RESTRT=xxxx TIME=ddd
```

RESTRT is the address where the test restarts after each measurement. Before the RESTART address is executed, two additional signature clock pulses must be generated. The TIME value is measured in 100 millisecond increments and represents the maximum time that a measurement can take for completion with the current subtest. TIME may range from 100 msec to 12.7 sec. If the measurement is not completed in the specified time, a Time Out condition (TO) occurs. A change in this value affects all measurements taken with the current subtest.

If the Comparator Start Address is enabled by the option selected with the Start Digit, and the INCR key is pressed again, the system will display

```
COMP START ADDR=xxxx
```

If the Comparator Stop Address is enabled, and the INCR key is pressed again, the system will display

```
COMP STOP ADDR=xxxx
```

and the address can be modified with the HEX PAD. NOTE: One more instruction will be executed.

If the Stop on Count has been enabled, the next time the INCR key is pressed,

```
STOP COUNT=ddddd
```

is displayed. The Stop on Count can modify it using the decimal pad. The range for the stop count is 1 to 65,535.

After all of the options have been specified the SIG key is pressed to take a signature.

11.4.8 **Signature Display**

The following display appears on the front panel and consists of:

```
SIG=xxxx yyyy bbb cc
```

```
xxxx = STABLE SIGNATURE,
yyyy = UNSTABLE SIGNATURE,
bbb  = STATUS = blank (stable signature),
                "UNS" (unstable signature),
                "INC" (incomplete signature),
                "FLT" (floating signature),
cc   = blank or "TO"  (time out)
```

When consecutive signatures are the same, the signature is stable.

When the present signature is not the same as the previous signature, the signature is unstable. STATUS indicates what is wrong with the present signature.

STATUS is used to display the status of the measurements. If it is blank, no error condition exists.

To prevent an infinite measurement, a time limit is imposed and the measurment must be taken during that period. If it is not, a time out condition occurs and the system displays the Time Out indicator (TO) and sounds a beep. If no valid data (0 or 1) is detected, during the measurement window, the data source is said to be floating, the FLT indicator is displayed and the beep is sounded. If the diagnostic program starts a signature measurment and signals the end of subtest, or the end of a test, before the measurement is complete, the system will display INC in the status field as well as the Time Out indicator (TO) and sound the beep. If the present signature is not the same as the previous signature, the signature is said to be unstable, UNS is displayed and the beep is sounded.

11.5 FREQUENCY MEASUREMENT

The FREQ key allows the operator to take frequency measurements using the data probe. All measurements are autoranging. When the FREQ key is pushed, the OPTSEL subfunction key in enabled. If the options for frequency are valid, the uSA displays

```
FREQ = 0000  HZ FLT
```

to indicate the frequency at which time domain analysis is active. Frequency measurements may now be taken using the data probe.

If the options for the frequency measurements are invalid, this is equivalent to pushing the OPTSEL key, and the cursor will be positioned at the first invalid digit.

11.5.1 Frequency Options

The OPTSEL key is used to enter or modify the options and parameters necessary to define a Frequency Measurement.

The following subfunctions are enabled:

HEX PAD
INCR
DECIMAL PAD

The operator selects the frequency measurement by pressing the FREQ key and then the OPTSEL key. The following will be displayed:

```
FREQ OPTS = dxyzb
```

d = Start criteria
x = Stop criteria
y = Clock/data criteria
z = Display criteria
b = Special criteria

The operator specifies the criteria by digits which have preassigned meanings. The digits and their meanings are described in the following sections.

11.5.2 **Start Criteria**

The uSA can start a frequency measurement on any of these conditions:

START DIGIT	CONDITION
0	External start probe, negative going edge
1	External start probe, positive going edge
2	External data probe, negative going edge
3	External data probe, positive going edge
4	Address compare
5	Address compare and external start probe, negative going edge
6	Address compare and external start probe, positive going edge
7	Address compare and external data probe, negative going edge
8	Address compare and external data probe, positive going edge
9	Start immediately

The address comparison is triggered when the specified address is referenced.

When the address comparison is used in conjunction with an external signal, both conditions must be met before the frequency measurement will be started.

The address comparison can only be used when the uSA is performing in-circuit emulation.

11.5.4 **Stop Criteria**

The Stop Criteria is to stop on count; the digit is 9. The uSA will vary the clock to satisfy the signal being sampled.

11.5.5 **Clock/Data Criteria**

The Clock/Data Criteria is a collection of information which specifies the:

CLOCK SOURCE
SYNCHRONIZATION OF CLOCK WITH THE START AND STOP SIGNAL
DATA SOURCE
SIGNATURE CLOCKING

For the frequency measurement, the data source is the data probe and the Clock/Data digit is 8. This selects the data probe as the data source and uses an internal clock.

11.5.6 **Display Criteria**

When the measurement window is very short and the values are changing slightly, the low order digits in a display tend to flutter. In the uSA, there are two ways to solve this problem.

For frequency measurements, the uSA can take ten measurements, average them and display the average. Or, the operator can specify the wait time between samples from 100 millisceconds to 5 seconds.

The following defines the display digit:

DISPLAY DIGIT	MEANING
0	Average of 10 samples
1	No Average. No wait
2	Wait 100 msec between displays
3	Wait 200 msec between displays
4	Wait 300 msec between displays
5	Wait 400 msec between displays
6	Wait 500 msec between displays
7	Wait 700 msec between displays
8	Wait 1 sec between displays
9	Wait 2 sec between displays
A	Wait 5 sec between displays

11.5.7 **Special Criteria**

The Special Criteria digit indicates how memory is to be mapped. If it is zero, all memory except the test diagnostic memory is mapped to the UUT. If it is a one, all memory is mapped to the uSA; however, all control, address and data signals are passed to the UUT. While mapped to the uSA, all memory signals from the UUT are disregarded. This allows fault analysis on the UUT memory and BUS structure. See the microprocessor emulator supplement for further details.

Once the operator has entered the Start, Stop, Clock/Data Display, and Special digits and pressed the ENTER key, the operator can review and modify successive lines of the OPTSEL display by pressing the INCR key. The next display is:

```
RESTRT=xxxx TIME=ddd
```

RESTRT is the address where the test restarts after each measurement. The TIME value is measured in 100 millisecond increments and represents the maximum time that a measurement can take for completion with the current subtest. TIME may range from 100 msec to 12.7 sec. If the measurement is not completed in the specified time, a Time Out condition (TO) occurs. A change in this value affects all measurements taken with the current subtest.

To take a frequency measurement the signal should be uniform and must exist for the duration of the measurement. Below is a table of frequencies and duration times, so that time must be greater than the duration time:

FREQUENCY	DURATION TIME
Above 10 MHz	100 usec
Above 1 MHz	1 msec
Above 100 KHz	10 msec
Above 10 KHz	100 msec
Below 10 KHz	1 sec

If the Comparator Start Address is enabled by the option selected with the Start Digit, and the INCR key is pressed again, the system will display

```
COMP START ADDR=xxxx
```

and the address can be modified with the hex pad.

After all of the options to take a frequency measurement have been specified, press the FREQ key.

11.5.8 **Frequency Display**

The following display appears on the front panel and consists of: FREQ = Time Range Units Status Timeout

```
FREQ=dddd aHZ bbb cc
```

dddd = FREQUENCY (dddd with decimal point)
a = RANGE (blank, K or M)
HZ = UNITS (HERTZ)
bbb = STATUS (FLT, INC, or blank)
"INC" (incomplete measurement),
"FLT" (floating meaturement),
cc = blank or "TO" for timeout

The RANGE and UNITS combine to display the frequency in terms of HERTZ, KILOHERTZ, or MEGAHERTZ and is autoranging from 40 MHz to HERTZ.

STATUS is used to display the status of the measurement. If it is blank, no error condition exists.

In order to prevent an infinite measurement, a time limit is imposed and the measurement must be taken during that period. If it is not, a time out condition occurs, the system displays the Time Out indicator (TO) and sounds a beep. If no valid data (0 or 1) is detected, during the measurement window, the data source is said to be floating, the FLT indicator is displayed and the beep is sounded. If the diagnostic program starts a frequency measurement and signals end of subtest or end of test before the measurement is complete, the system will display INC in the status field, as well as the Time Out indicator (TO) and sound the beep.

11.6 COUNT MEASUREMENT

The COUNT key allows the uSA to count pulses or transitions. When the COUNT key is pressed this enables the OPTSEL subfunction key. If the options for the count measurement are valid the following will be displayed:

```
COUNT = 0000
```

This indicates that the uSA is now ready to count transitions or pulses.

If the options for COUNT are invalid, this is equivalent to pressing the OPTSEL key, and the cursor will be positioned at the first invalid digit.

11.6.1 Count Options

The OPTSEL key is used to enter or modify the options and parameters necessary to define a COUNT measurement.

The following subfunctions are enabled:

HEX PAD
INCR
DECIMAL PAD

The operator selects the count measurement by pressing the COUNT key and then the OPTSEL key. The following will be displayed:

```
COUNT OPTS = dxyzb
```

d = Start Criteria
x = Stop Criteria
y = Clock/Data Criteria
z = Display Criteria
b = Special Criteria

The operator specifies the criteria by digits which have preassigned meanings. The digits and their meaning are described in the following sections.

11.6.2 **Start Criteria**

The uSA can start a count measurement on any of these conditions.

START DIGIT	CONDITION
0	Using external start probe, negative going edge
1	Using external start probe, positive going edge
2	Using external data probe, negative going edge
3	Using external data probe, positive going edge
4	Address compare
5	Address compare and external start probe, negative going edge
6	Address compare and external start probe, positive going edge
7	Address compare and external data probe, negative going edge
8	Address compare and external data probe, positive going edge

The address comparison is triggered when the specified address is accessed.

When the address comparison is used in conjuction with an external signal, both conditions must be met before counts will be taken.

The address comparison can only be used when the uSA is performing in-circuit emulation.

11.6.3 **Stop Criteria**

The uSA can stop a signature measurement on any of the following conditions:

STOP DIGIT	CONDITION
0	External stop probe, negative going edge
1	External stop probe, positive going edge
2	External data probe, negative going edge
3	External data probe, positive going edge
4	Address compare
5	Address compare and external stop probe, negative going edge
6	Address compare and external stop probe, positive going edge
7	Address compare and external data probe, negative going edge
8	Address compare and external data probe, positive going edge

The address comparison is triggered when the specified address is referenced.

When the address comparison is used with an external stop signal, both conditions must be met before the count is terminated.

The address comparison can only be used when the uSA is performing in-circuit emulation.

11.6.4 Clock/Data Criteria

The Clock/Data Criteria is a collection of information which specifies the:

CLOCK SOURCE
SYNCHRONIZATION OF THE CLOCK WITH THE START AND STOP SIGNAL
DATA SOURCE
SIGNATURE CLOCKING

Measurements of either Pulse Counts or Transition Counts can be taken depending upon the value selected for the Clock/Data Digit. The transition counts can only be taken from the data probe, but pulse counts can be taken from the data probe or OPREQ. OPREQ is a signal that signifies that a bus transaction is taking place and will be different for each processor. See the particular microprocessor emulator supplement manual for details of the OPREQ signal.

The uSA can count the following conditions:

DIGIT	CONDITIONS
8	COUNT PULSES, SOURCE IS THE DATA PROBE
9	COUNT OPREQ SIGNALS
A	COUNT TRANSITIONS, SOURCE IS THE DATA PROBE

11.6.5 Display Criteria

When the measurement window is very short and the values are changing slightly, the low order digits in a display tend to flutter. In the uSA, there are two ways to solve this problem.

For count measurements, the uSA can take ten measurements, average them and display the average; or, the operator can specify a wait time between samples from 100 milliseconds to 5 seconds.

The following defines the Display Digit:

DISPLAY DIGITS	MEANING
0	Average of 10 samples
1	No Average. No wait
2	Wait 100 msec between samples
3	Wait 200 msec between samples
4	Wait 300 msec between samples
5	Wait 400 msec between samples
6	Wait 500 msec between samples
7	Wait 700 msec between samples
8	Wait 1 sec between samples
9	Wait 2 sec between samples
A	Wait 5 sec between samples

11.6.6 Special Criteria

The Special Criteria digit indicates how memory is to be mapped. If it is zero, all memory except the test diagnostic memory is mapped to the UUT. If it is a one, all memory is mapped to the uSA. However, all control, address, and data signals are passed to the UUT. While mapped to the uSA, all memory signals from the UUT are disregarded. This allows fault analysis on the UUT memory and BUS structure. See the microprocessor emulator supplement for further details.

Once the operator has entered the Start, Stop, Clock/Data, Display, and Special digits and pressed the ENTER key, the operator can review and modify successive lines of the OPTSEL display by pressing the INCR key. The next display is:

```
RESTRT=xxxx TIME=ddd
```

RESTRT is the address where the test restarts after each measurement. The TIME value is measured in 100 millisecond increments and represents the maximum time that a measurement can take for completion with the current subtest. TIME may range from 100 msec to 12.7 sec. If the measurement is not completed in the specified time, a Time Out condition (TO) occurs. A change in this value affects all measurements taken with the current subtest.

If the Comparator Start Address is enabled by the option selected with the Start Digit, and the INCR key is pressed again, the system will display

```
COMP START ADDR=xxxx
```

and the address can be modified with the hex pad.

After all of the options have been specified to take a count measurement the COUNT key is pressed.

11.6.7 Count Display

The following display appears on the front panel and consists of:

```
COUNT = xxxx bbb cc

xxxx = the count
bbb  = STATUS = blank (good measurement),
                "INC" (incomplete measurement),
                "OVF" (overflow),
cc   = blank or "TO"  (time out)
```

STATUS is used to display the status of the measurement. If it is blank, no error condition exists.

In order to prevent an infinite measurement, a time limit is imposed and the measurment must be taken during that period. If it is not, a time out condition occurs and the system displays the Time Out indicator (TO) and sounds a beep. If no valid data (0 or 1) is detected during the measurement window, the data source is said to be floating, the FLT indicator is displayed and the beep is sounded. If the diagnostic program starts a count measurement and signals end of subtest or end of test before the measurement is complete, the system will display INC in the status field as well as the Time Out indicator (TO) and sound the beep. The Overflow indicator (OVF) indicates that the measurement was too large for the counter and overflowed it.

11.7 INTERVAL MEASUREMENT

The INTRVL key allows interval or pulse width measurements to be taken. All measurements are autoranging. When the INTRVL key is pushed, this enables the OPTSEL subfunction key. If the options for interval measurement are valid, the following will be displayed:

```
INTVL = 0000 S
```

This indicates that the interval time domain analysis is active and measurements may now be taken.

If the options for interval are invalid, this is equivalent to pressing the OPTSEL key, and the cursor will be positioned at the first invalid digit.

11.7.1 Interval Options

The OPTSEL key is used to enter or modify the options and parameters necessary to define an interval measurement.

The following subfunctions are enabled:

HEX PAD
INCR
DECIMAL PAD

The operator selects the interval measurement by pressing the INTRVL key and then the OPTSEL key. The following will be displayed:

```
INTVL OPTS = dxyzb
```

d = Start Criteria
x = Stop Criteria
y = Clock/Data Criteria
z = Display Criteria
b = Special Criteria

The operator specifies the criteria by digits which have preassigned meanings. The digits and their meanings are described in the following sections.

11.7.2 **Start Criteria**

The uSA can start an interval measurement on any of these conditions.

START DIGIT	CONDITION
0	Using external start probe, negative going edge
1	Using external start probe, positive going edge
2	Using external data probe, negative going edge
3	Using external data probe, positive going edge
4	Address compare
5	Address compare and external start probe, negative going edge
6	Address compare and external start probe, positive going edge
7	Address compare and external data probe negative going edge
8	Address compare and external data probe, positive going edge

The address comparison is triggered when the specified address is referenced.

When the address comparison is used in conjuction with an external signal, both conditions must be met before the internal measurement is started.

The address comparison can only be used when the uSA is performing in-circuit emulation.

11.7.3 **Stop Criteria**

The uSA can stop the interval measurement on any of the following conditions:

STOP DIGIT	CONDITION
0	External stop probe, negative going edge
1	External stop probe, positive going edge
2	External data probe, negative going edge
3	External data probe, positive going edge
4	Address compare
5	Address compare and external stop probe, negative going edge
6	Address compare and external stop probe, positive going edge
7	Address compare and external data probe, negative going edge
8	Address compare and external data probe, positive going edge

The address comparison is triggered when the specified address is referenced.

When the address comparison is used with an external stop signal, both conditions must be met before the measurement is terminated.

The address comparison can only be used when the uSA is performing in-circuit emulation.

11.7.4 **Clock/Data Criteria**

The Clock/Data Criteria is a collection of information which specifies the:

CLOCK SOURCE
SYNCHRONIZATION OF CLOCK WITH THE START AND STOP SIGNAL
DATA SOURCE
SIGNATURE CLOCKING

For interval measurement, the data source is specified by the start and stop digit. The Clock/Data Criteria Digit is 8, which selects an internal clock.

11.7.5 **Display Criteria**

When the measurement window is very short and the values are changing slightly, the low-order digits in a display tend to flutter. In the uSA there are two ways to solve this problem.

For interval measurements, the uSA can take ten measurements, average them and display the average; or, the operator can specify a wait time between samples from 100 milliseconds to 5 seconds.

The following defines the Display Digit:

DISPLAY DIGITS	MEANING
0	Average of 10 samples
1	No Average. No wait
2	Wait 100 msec between samples
3	Wait 200 msec between samples
4	Wait 300 msec between samples
5	Wait 400 msec between samples
6	Wait 500 msec between samples
7	Wait 700 msec between samples
8	Wait 1 sec between samples
9	Wait 2 sec between samples
A	Wait 5 sec between samples

11.7.6 Special Criteria

The Special Criteria Digit indicates how memory is to be mapped. If it is zero, all memory except the test diagnostic memory is mapped to the UUT. If it is a one, all memory is mapped to the uSA. However, all control, address, and data signals are passed to the UUT. While mapped to the uSA, all memory signals from the UUT are disregarded. This allows fault analysis on the UUT memory and BUS structure. See the microprocessor emulator supplement for further details.

Once the operator has entered the Start, Stop, Clock/Data, Display, and Special digits and pressed the ENTER key, the operator can review and modify successive lines of the OPTSEL display by pressing the INCR key. The next display is:

```
RESTRT=xxxx TIME=ddd
```

RESTRT is the address where the test restarts after each measurement. The TIME value is measured in 100 millisecond increments and represents the maximum time that a measurement can take for completion with the current subtest. TIME may range from 100 msec to 12.7 sec. If the measurement is not completed in the specified time, a Time Out condition (TO) occurs. A change in this value affects all measurements taken with the current subtest.

If the Comparator Start Address is enabled by the option selected with the start Digit, and the INCR key is pressed again, the system will display

```
COMP START ADDR=xxxx
```

and the address can be modified with the hex pad.

If the Comparator Stop Address is enabled, and the INCR key is pressed again, the system will display:

```
COMP STOP ADDR=xxxx
```

and the address can be modified with the Hex pad. NOTE: One more instruction will be executed.

After all the options have been specified to take an interval measurement, the INTRVL key is pushed again.

11.7.7 Interval Display

The following display appears on the front panel and consists of: INTRVL = Time Range Units Status Timeout

```
INTVL=dddd aS bbb cc
```

dddd = TIME (with a decimal point)
a = RANGE = blank
= m (milli)
= u (micro)
= n (nano)
S = SECONDS

bbb = STATUS = blank (good measurement)
= OVF (overflow)
= FLT (floating)
= INC (Incomplete measurement)
cc = TIMEOUT = TO (timeout)
= blank

The RANGE and UNITS combine to display the time intervals in terms of seconds, millisecond, microseconds or nanoseconds, and is autoranging from 10 nanoseconds to 12.7 seconds.

STATUS is used to display the status of the measurement. If it is blank, no error condition exists.

In order to prevent an infinite measurement, a time limit is imposed and the measurement must be taken during that period. If it is not, a time out condition occurs and the system displays the Time Out indicator (TO) and sounds a beep. If no valid data (0 or 1) is detected during the measurement window, the data source is said to be floating, the FLT indicator is displayed and the beep is sounded. If the diagnostic program starts an interval measurement and signals end of subtest or end of test, before the measurement is complete, the system will display INC in the status field as well as the Time Out indicator (TO) and sound the beep. The Overflow indicator (OVF) indicates that the measurement was too large for the counter and overflowed it.

Chapter 11

FAULT DETECTION

11.1 INTRODUCTION

This section explains how to employ the test techniques of signature analysis and time domain analysis.

Figure 11-1 shows the additional uSA accessories supplied with each uSA. The control pod and the data probe plug into jacks provided on the upper panel of the uSA. One end of the control pod has a set of four leads wired to a removable connector. If one or more of these leads become damaged or broken, merely unplug the connector of the damaged lead set and plug in a replacement lead set.

Figure 11-1. uSA with Additional Accessories

11.2 CONNECTION OF uSA TO UUT, AND TESTING OPERATION

Figure 11-2 is a diagram of one type of connection for signature analysis and time domain analysis. The user has the choice of operating the uSA with or without PROMs. The user can also leave the emulator pod disconnected. This type of hook-up is referred to as "stand-alone operation."

Figure 11-2. uSA Connected for Signature Analysis

Chapter 12

DIAGNOSTIC PROGRAMMING EXAMPLE

12.1 INTRODUCTION

This section explains how to write the various subtests in the body of the PROM program.

A typical system containing components common to most microprocessor-based products has been selected to illustrate a general approach to the task of program preparation. For diagnostic purposes, the system is partitioned into sections and a subtest is written to test each section. Flowcharts are included for each subtest to denote the minimal amount of new software required. Most of the test routines can easily be adapted from software already developed for the unit under test.

The subtests are written to provide both functional go/no-go testing and fault isolation down to the node level. Fault isolation is acomplished by using signature analysis. It is important to note that signature analysis testing requires no additional programming. The go/no-go functional test software can be used as a stimulus for the unit under test. The control information for clocking, starting and stopping the signature analyzer is all that must be added to the functional software.

12.2 DESCRIPTION OF THE UNIT UNDER TEST (UUT)

Figure 12-1 is a block diagram of a typical microprocessor-based Unit Under Test (UUT). The components on the left comprise an 80/10 microcomputer subassembly that includes an 8080A microprocessor, PROM and RAM, a serial data communication interface, and a set of parallel I/O ports. On the right is a user-designed assembly comprising a Digital-to-Analog converter, an Analog-to-Digital converter, hexadecimal LED displays, and a set of switches.

12.3 TEST CONNECTIONS

Figure 12-2 shows test connections between the uSA and the UUT. A wrap-back technique is employed to return system generated output signals as system input signals. Jumpers accomplish this at the serial data interface and at the ports of the D-to-A and A-to-D converters. The 8080A microprocessor has been removed from the UUT so that the emulation pod can be inserted in its place. The diagnostic PROM is plugged into the uSA and, if signature analysis is to be implemented, the data probe and the control pod are also connected.

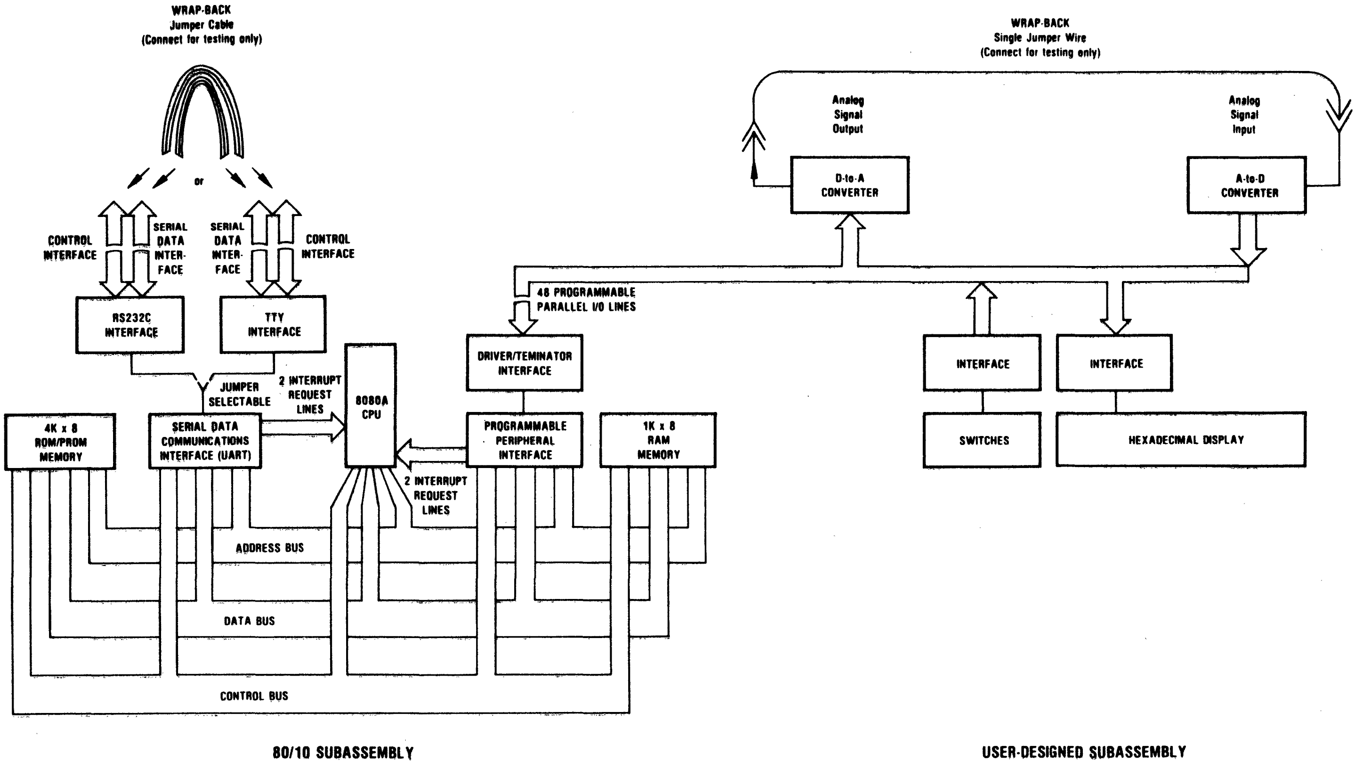


Figure 12-1. Typical Unit Under Test (UUT)

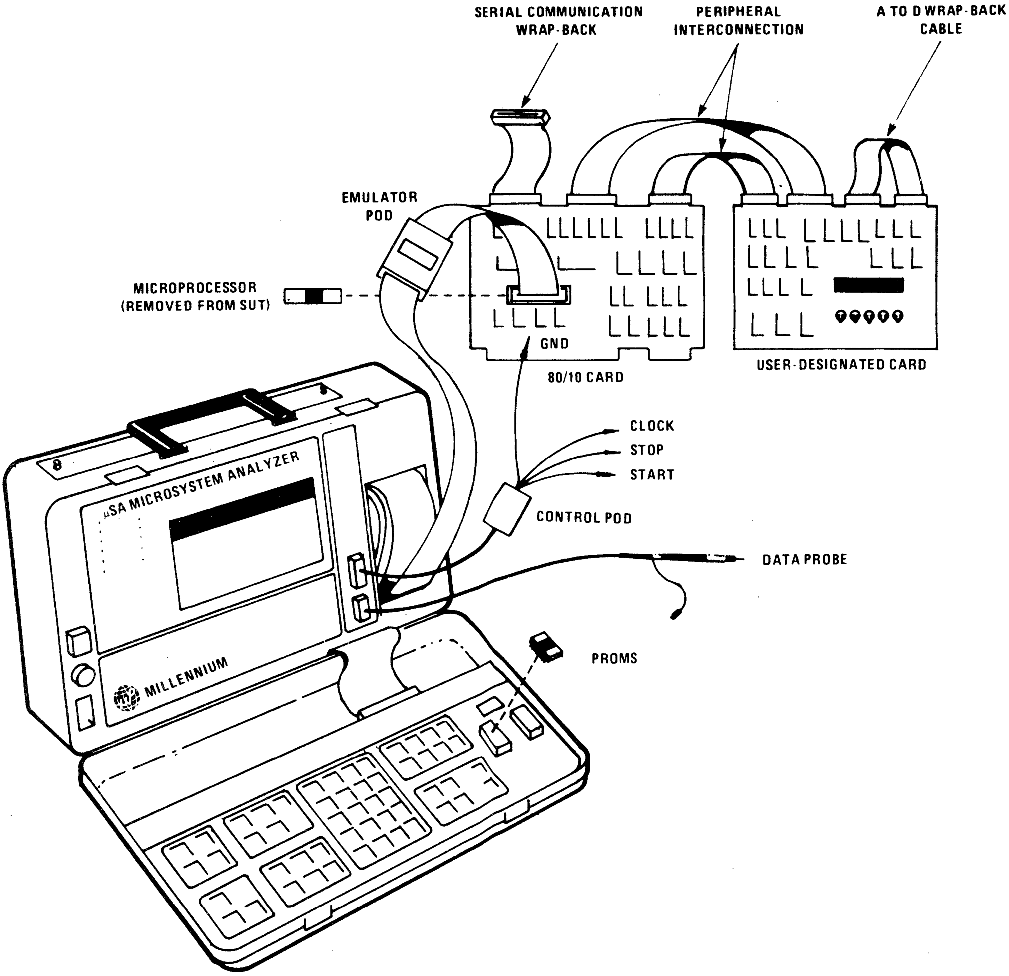


Figure 12-2. Test Hook-up

12.4 PARTITIONING OF THE UNIT UNDER TEST

The first step in program preparation is to decide how to partition a system into small subsections so that they can be functionally tested, one at a time.

12.4.1 ROM/PROM Test

PROMS are tested first. To check if a PROM or ROM is programmed correctly, simply read its contents. The first diagnostic program subtest executes a read operation from all PROM locations, and adds the contents from each PROM byte to yield a checksum. This checksum is then compared with a known good checksum to determine if it is correct.

In addition to testing the PROM or ROM, this subtest also verifies the correct operation of the data bus, address bus, and address decoding.

12.4.2 RAM Test

A fast way to test RAM is to first write zeros into all memory locations and then read them back to determine if any bits are stuck "high." Next, ones are written to all locations and then read back to determine if any bits are stuck "low." In addition to checking the RAM, this subtest also checks control signals and additional address decoding. (If the user prefers, he can program random data patterns or galloping test patterns.)

12.4.3 Serial Data Interface Test

The serial data interface can be checked using the jumper cable for a wrap-back path. The data transmitted by the microprocessor via the serial data interface is immediately fed back as received data. The subtest then confirms that this data matches the data transmitted.

12.4.4 **I/O Ports Test**

To test the driver/terminator interface (I/O ports) that form the link between the 80/10 subassembly interface and the components on the user-designed subassembly, install a single-wire jumper to connect the analog signal output back to the analog signal input. This allows the D-to-A and A-to-D conversions to be checked by a single subtest. This wrap-back method enables a subtest to cause the 80/10 subassembly to send digital data to the A-to-D converter, producing the corresponding digital data. Again, the subtest simply compares this received data with the data originally transmitted to the D-to-A converter.

12.4.5 **Display and Switch Tests**

To check the displays and switches, a subtest sends data that causes the hexadecimal characters to be displayed, one at a time, in a prescribed sequence. The operator observes the display to confirm that each character is correct.

Once display operation has been checked, a final subtest causes the 80/10 to sense switch settings and send data to the display corresponding to the switch setting actually sensed. During this subtest the operator can manually change switch settings and confirm that the codes change appropriately, according to the test procedure.

Subtests are now fully defined for the sections of the UUT.

In a production application, functional go/no-go testing is adequate because boards or systems failing any subtest can be so marked and replaced. The uSA, with the signature analysis option, isolates faults at the node level.

The next step in the programming task is the preparation of routines and subroutines for subtests just outlined.

12.5 SUBTEST FORMAT

The test descriptions that follow have three sections in common:

INITIALIZATION AND DISPLAY OF SUBTEST NAME
BODY OF THE SUBTEST
FAULT LOCATION CONTROL (optional)

The body of the tests described in the following sections can also generate the signal stimuli required for taking signatures. This is accomplished by adding some new data to the subtest header in the control information portion of the program.

The restart address is noted on each subtest flow diagram at the beginning of the setup sequence. By locating the restart address, the user makes sure that all registers are initialized and will be in a known state whenever a signature is taken. The start of the signature window will be a point that occurs at the beginning of the loop. When the end of the signature window occurs, a jump to the restart address is forced by the uSA.

In most cases, useful signatures are obtained by applying the data probe to the data bus lines, bus control lines, and the address decode lines. The correct signatures obtained from a known good system can be noted directly on the system's logic diagram. In order to identify defective nodes, signatures sensed are compared with the known values until an invalid signature is found.

12.5.1 ROM/PROM Checksum Subtest

The flowchart shown in figure 12-3 outlines the checksum test. This dedicated software is simple to write and accurate code can be prepared quickly.

After initialization, the next sequence of steps in the flowchart is a loop for computing the checksum. First the H and L registers that were saved are fetched and the data pointed to by them is added to the A register. The H and L registers are incremented by 1 and then saved. The B and C registers (which contains the twos complement of the last address of the PROM) are added to the H and L registers and the H and L registers are checked for zero. If zero, the loop is complete and the A register contains a checksum of the PROM. If not zero, the program repeats until the H and L registers become zero.

The next sequence of steps compares the checksum contained in the A register with the correct value stored as a constant in the diagnostic program. If the checksum is correct, then the data read out of the PROM is correct. If it is incorrect, the uSA displays an error message (PROM TEST ERROR). The diagnostic program can be programmed to cause this error message to remain on the display for a predetermined time interval, thereby allowing the operator to decide whether to press a key on the uSA, halt the test, or allow the uSA to proceed automatically to the next subtest. The uSA automatically produces a brief audio tone each time it begins a new subtest.

12.5.2 **Write/Read RAM Subtest**

Figure 12-4 is the flowchart of the RAM subtest. The first step after initialization of this subtest is the "Write to RAM" routine. The contents of the A register are stored in the RAM location pointed to by the H and L registers. If the memory pointer is incremented, the contents of these registers are stored, and then the B and C registers are added to the H and L registers to determine if all data has been written into the RAM. This is true if the contents of the H and L registers are zero. If they are not zero, the program jumps back to the beginning of this loop and keeps storing data to the RAM until the contents of the H and L registers are zero. This completes the "Write to RAM" routine.

The next sequence again initializes the registers. The data now resident in the RAM is read to determine if any bits are stuck "high" (logic ones). ORing the data read from the RAM with the A register detects any bits stuck high, since all bits have been written as "low" (logic zeros) and should, therefore, read as low. Again the H and L registers are incremented by 1, the contents are saved, the B and C registers are added to the H and L registers, and the H and L registers are checked for zero. If the H and L registers are not zero, the program returns to the beginning of this loop and continues until the H and L registers are zero. The value in the A register, which is the "ORed value" stored throughout RAM, is saved so that it can be checked at a later time.

Next, as shown in figure 12-4, all ones are written into RAM, in order to check if any bits are stuck "low." To do this, execute the initialize routine, and set the A register to all ones. The next sequence writes this value into all RAM memory locations.

Again the registers are initialized and the H and L registers are restored. Then the contents of the A register are ANDed with the RAM. This checks for any bits stuck low, since all bits stored in the RAM locations should be high. Then the H and L registers are incremented, and the program continues to read the data until the H and L registers are zero. This data is saved, and the A register is complemented (with a result of all zeros, provided that there have been no RAM errors).

The A register is then ORed with the "ORed value" that had been saved, and the results are checked for zero. If zero, this indicates that the RAM checked correctly and the subtest is ended. If not zero, this means that the test failed, and an error message (RAM TEST ERROR) is displayed on the uSA. The operator can decide whether to halt testing or continue on to the next subtest.

12.5.3 **Serial I/O Interface Subtest**

Figure 12-5 shows a flowchart for a serial I/O interface subtest. The three blocks labeled "Initialize Communication Port," "Send Character Routine," and "Received Character Routine," are routines that can be taken directly from the user's existing system software. This flowchart applies to a test circuit in which an external jumper cable wraps the transmitted serial data, as shown in figure 12-1.

After initialization, the program executes the user's software for initializing the serial I/O interface port. The next step, as shown in the flowchart, loads a character into the A register. The program executes the user's software to transmit data out of the port. A delay ensures that time is allowed for the data to be transmitted via the jumper cable and received. Then the user's software is used to receive the data at the I/O port.

The program returns with the received value in the A register. Now the program compares the character received with the character sent. If the two are the same, the test is successful. Otherwise, an error has occurred and the uSA displays an error message (SERIAL I/O ERROR). Again, the test operator can either halt testing or go on to the next subtest.

The same subtest can be used to generate stimulus signals for signature or for transition counting. Control information could be included in the subtest header to specify how to take a frequency or time interval measurement. Such tests are useful to determine if the transmit clock and receive clock signals are running at the proper baud rates.

12.5.4 **Parallel I/O Port D-to-A, A-to-D Subtest**

With an external jumper wrapping the digital-to-analog converter output back into the analog-to-digital converter input, as shown in figures 12-1 and 12-2, the subtest checks the 80/10 parallel I/O ports as well as the D-to-A and A-to-D circuits on the user-designated assembly. As with the serial I/O subtest, existing user software can be adapted directly. Figure 12-6 is a flowchart for this subtest. The blocks labeled "Initialize Parallel Ports," "Send Data to D/A Converter," and "Read A/D Converter" represent the existing user software.

After initialization, the user software routine is executed to initialize the parallel port. Then the number of values to be sent are put in the B register. The "Send Data" routine is executed to send data to the D-to-A converter. Once the delay has lapsed, the user's software routine is used to read the A-to-D port and the binary value read is returned to the A register. The value is saved and the B register is decremented. If it is not zero, the loop is repeated and a new value is sent. When the B register is zero, the B register is again set to the number of values sent. The saved value is compared with the value originally sent to the D-to-A converter. (As an option, masking can be added to the A-to-D value to ensure that the conversion accuracy is within a specified tolerance range.) The B register is decremented and if it is not zero, the subtest is successful. Normally, three different values are sent through the converter loop representing minimum, mid-range, and maximum values. The purpose is to ensure correct converter operation over a specified analog voltage range.

If the comparison was unsuccessful, an error message (D/A AND A/D ERROR) is displayed. The operator can choose to halt or to go on to the next subtest. In the case of a halt, the upper wire can be disconnected so that the other test equipment can be employed to measure the analog D-to-A output, or to apply a known analog voltage to the A-to-D input. Other subtests could be added to the diagnostic program to display values measured by the A-to-D converter on the uSA display.

12.5.5 **Parallel I/O Port and the Display Subtest**

In this subtest the operator interacts with the diagnostic program. As the subtest excercises the hexadecimal displays, the operator observes that the correct characters appear. The two blocks labeled "Initialize Parallel Port" and "Send to Display," shown in figure 12-7, represent routines which can be supplied by the user's existing system software.

After initialization, the H and L registers are set to the address of the first set of values in the display table, and the B register is used to count the number of displays in the table. This completes the setup.

A value is read from the display table and is sent to the display. A delay is programmed providing the operator a chance to view the display. Then the H and L registers are incremented to the next value in the table, the count is decremented, and then the count is checked for zero. If it is not zero, the loop is repeated, reading a new value and displaying it. The subtest ends once the count reaches zero. No error messages are required since the operator can detect any errors from the display himself.

12.5.6 **Parallel I/O Port and Switches Subtest**

Once the display has been checked for correct operation, it can be used for the Switch Subtest to denote values that represent switch positions. The subtest ends once the program senses that the operator has manually placed each switch in the predetermined final position. The three blocks labeled "Initialize Parallel Port," "Read Switches" and "Send to Display" in figure 12-8, represent routines that exist in the user's software.

The subroutine to initialize the parallel I/O port is executed and then the switch positions are read. The binary value of the switch positions is converted to a code that can be displayed. The diagnostic program compares the value against a defined value. If the values are not equal, the loop is repeated. The subtest ends once the values are equal, indicating that the switches are in their "final" position. The last step on the flowchart is an instruction to the uSA to display a final message (ALL TESTS ENDED).

Monitoring signatures on the read switch routine is not advised because moving a switch during a signature window would change the signature on the data bus. Other signatures, however, such as on the address bus and at the device-select logic can be taken. However, the data bus signature itself varies depending upon the switch positions. If the operator is instructed to set the switches to known positions and then these signatures are recorded for two, three, or more settings, signature analysis can be employed.

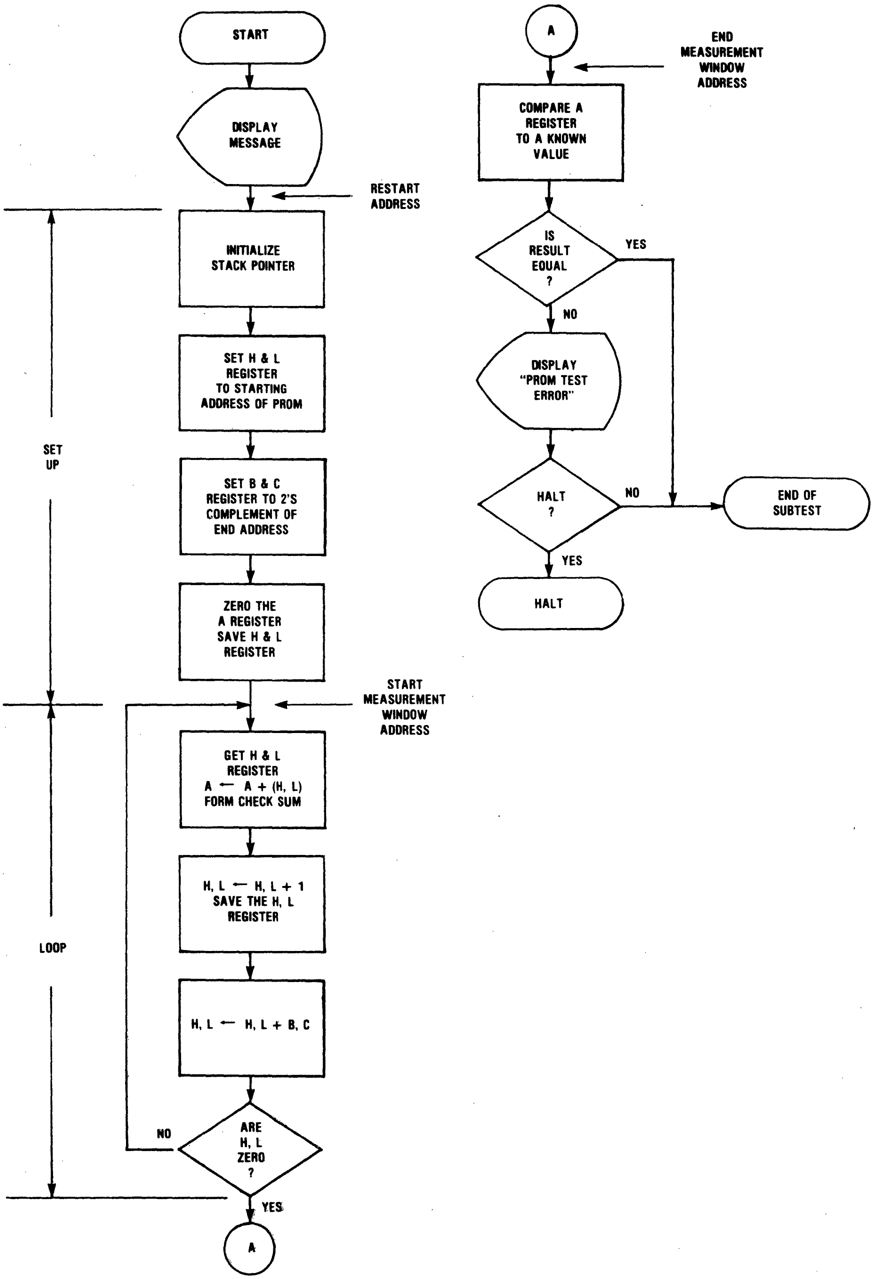


Figure 12-3. Checksum Test

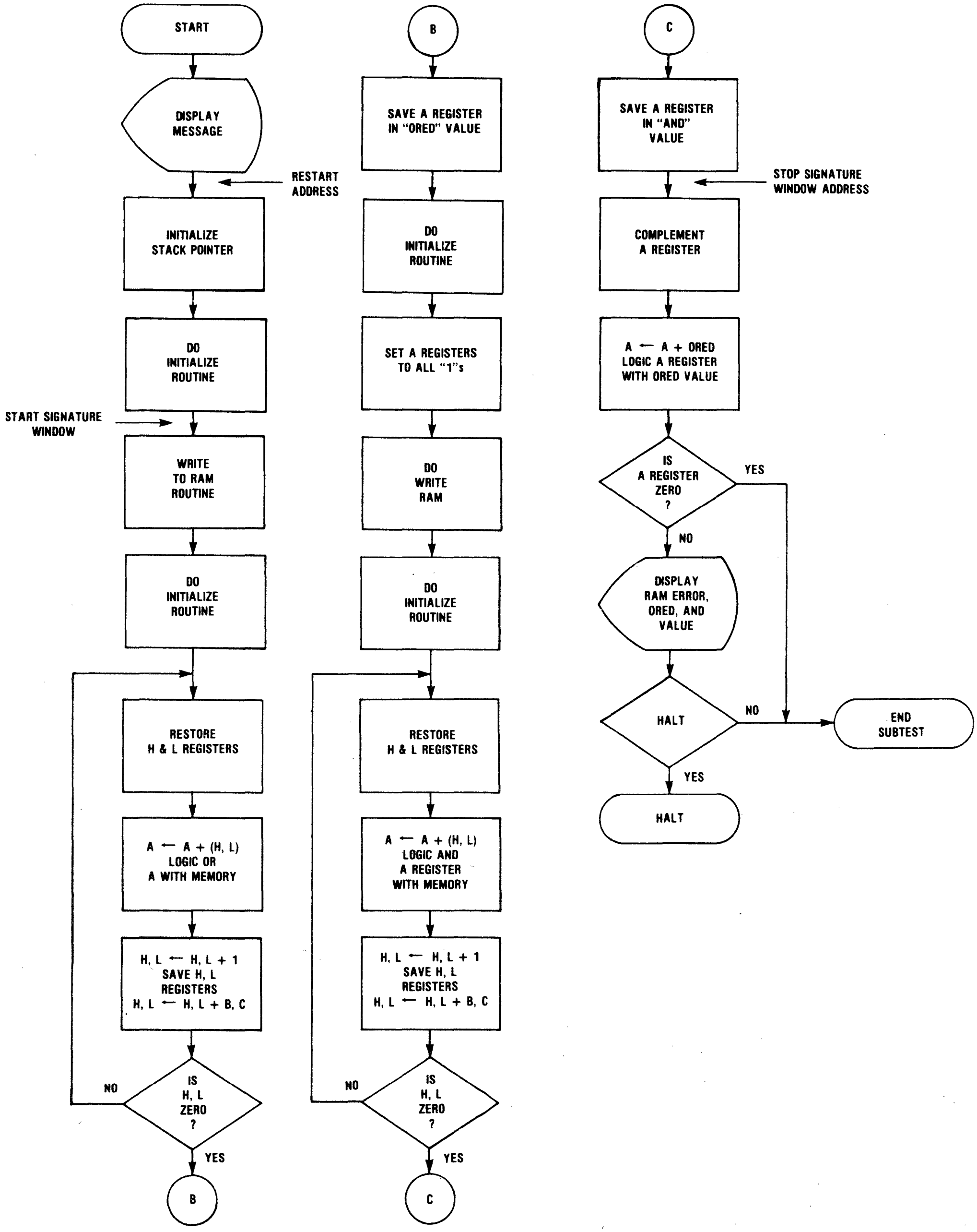


Figure 12-4. RAM Subtest

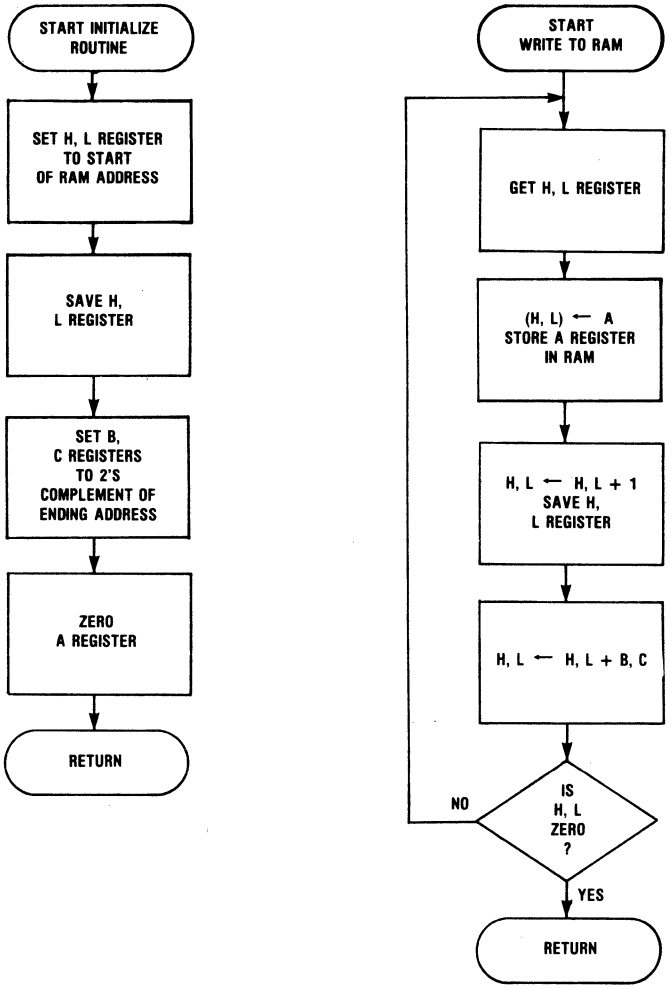


Figure 12-5. RAM Subtest (Continued)

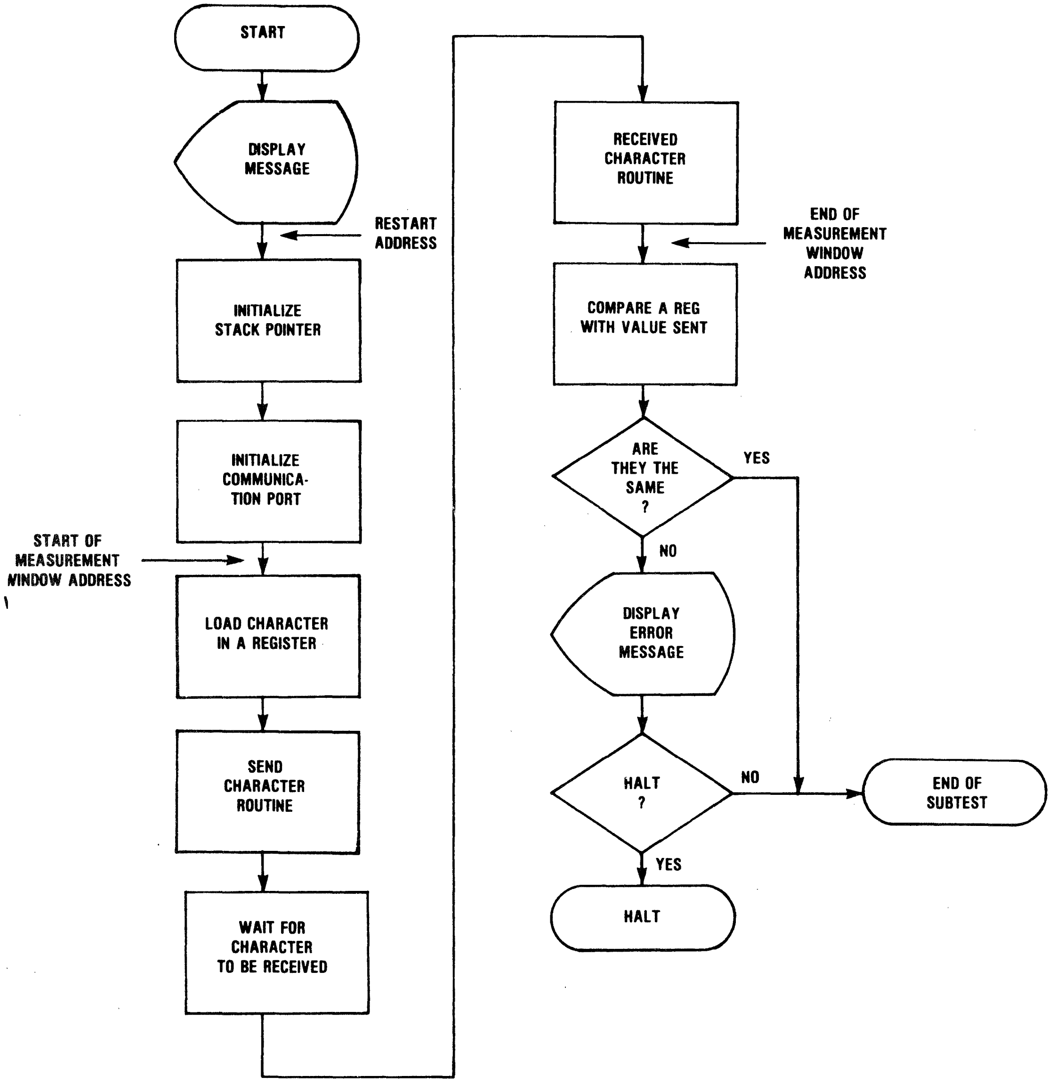


Figure 12-6. Serial I/O Subtest

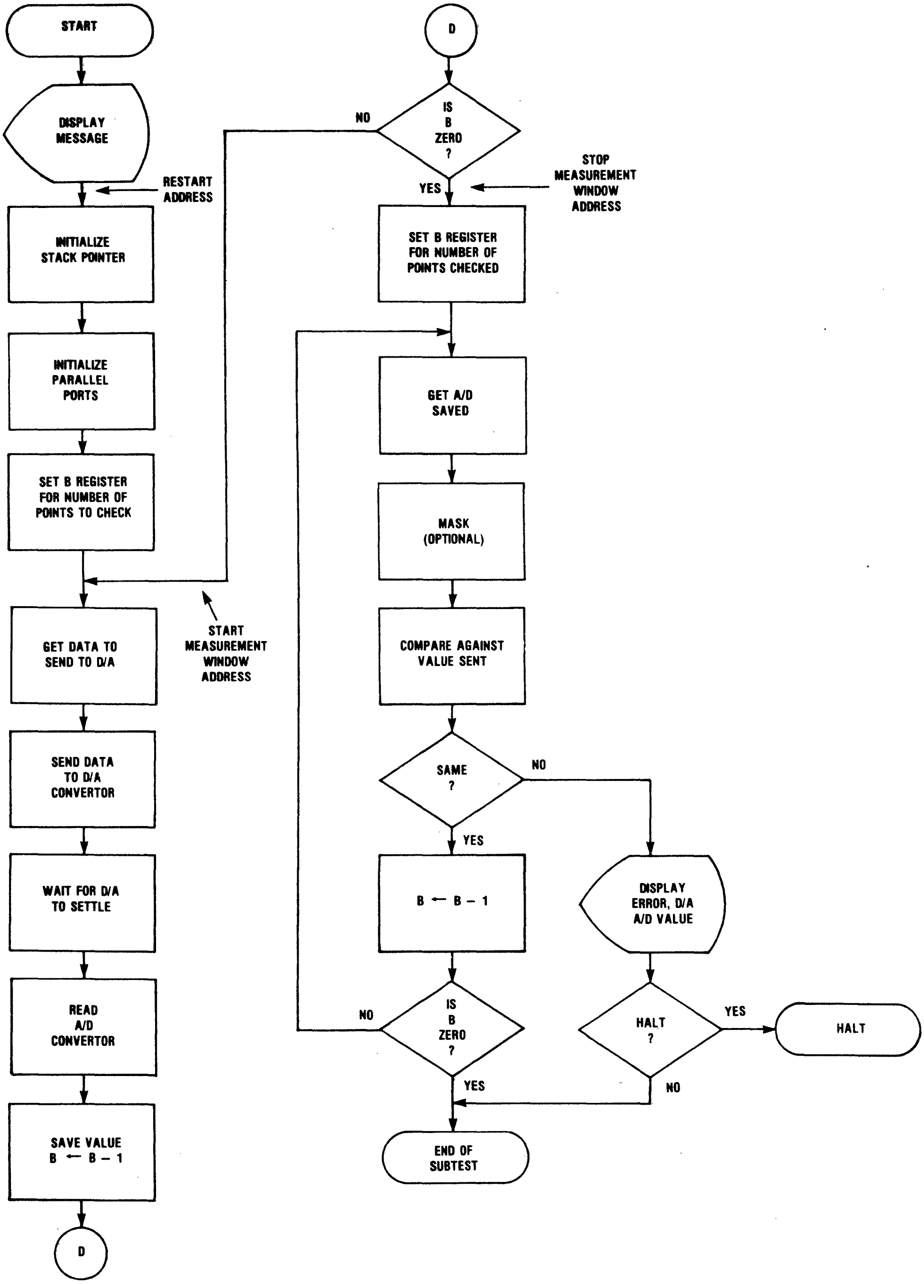


Figure 12-7. D-to-A and A-to-D Subtest

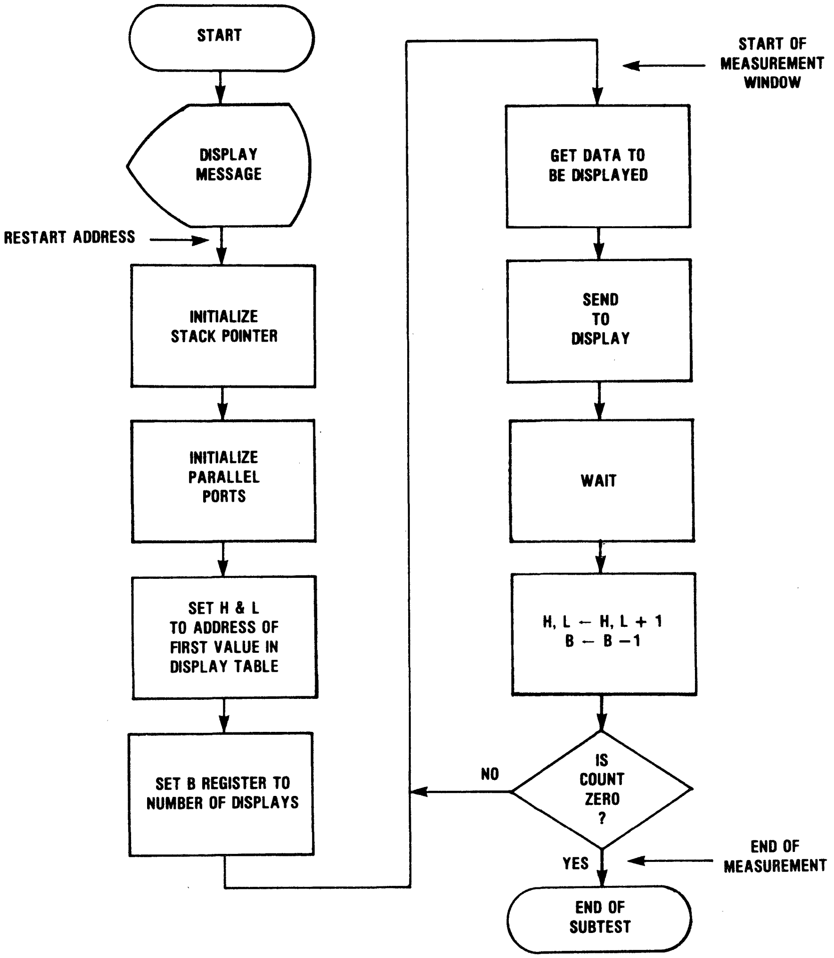


Figure 12-8. Display Subtest

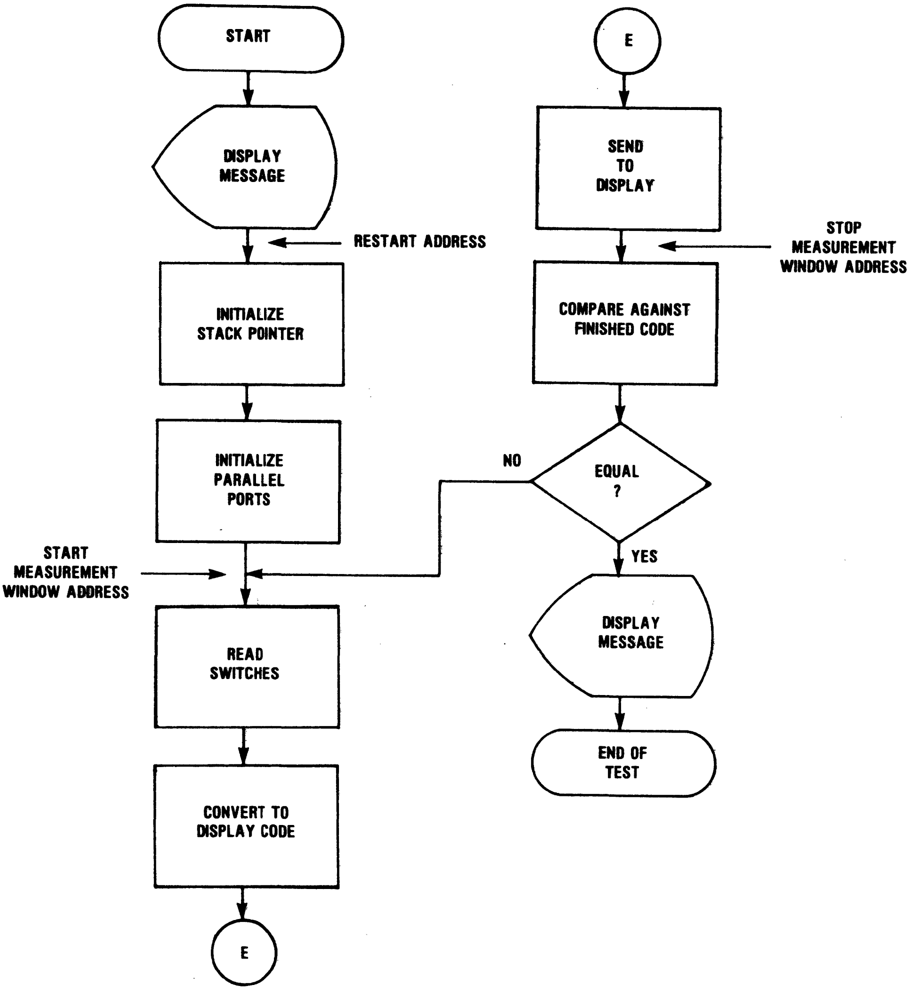


Figure 12-9. Switch Subtest

Chapter 2

INSTALLATION

2.1 UNPACKING, INSPECTION, AND SERVICE

Inspect the instrument and accessories for physical damage. If damage is evident do not operate the instrument. Notify the carrier and **Millennium Systems** at once. **Millennium** will arrange for repair or replacement without waiting for settlement of the claim against the carrier.

If the instrument is to be returned to **Millennium**, attach a tag showing owner, address, part number and a description of the failure mode. The original shipping carton and packing material should be reused with the Returned Material Authorization (RMA) number prominently displayed on the carton. An RMA number can be obtained by calling Customer Service.

Unless notified to the contrary, any claims for operations assistance and/or service will be provided by **Millennium Systems, Inc.**, from its plant in Cupertino, California. Should assistance be required, call the Customer Service Manager at:

National	(800) 538-9320/9321
California	(800) 662-9231

2.2 EQUIPMENT

The following standard equipment is included with each uSA:

ONE SIGNATURE ANALYSIS CONTROL POD ASSEMBLY
ONE SIGNATURE ANALYSIS DATA PROBE
ONE 34-CONNECTOR EMULATOR CABLE
ONE 50-CONNECTOR EMULATOR CABLE
ONE POWER CORD

The following accessories are included with each uSA:

ONE EMULATOR BOARD (installed inside instrument)
ONE EMULATOR POD WITH EMULATOR PROBE AND 40-PIN AUGAT HEADER
DOCUMENTATION PACKAGE

2.3 POWER REQUIREMENTS

The standard uSA will operate from a line supply of 120v AC (+5%, -10%) at 48 to 66 Hz, 120 watts maximum. The 3-wire power cable outlet grounds the instrument. To preserve this safety feature when operating from an outlet without a ground connection, use an appropriate adapter and connect the ground lead to an external ground.

2.4 CIRCUIT PROTECTION

The fuse is located on the front panel above the power cord. Table 2-1 gives the value and types of fuses required for various input voltages.

Table 2-1. Fuse Requirements

INPUT VOLTAGE	FUSE
100/120 VAC	3A, 3AG
220/240 VAC	2A, 3AG

2.5 USER PRECAUTIONS

The following precautions should be observed before using the uSA:

1. Before applying power to the instrument, check the model number/voltage label located to the left and above the keyboard (see figure 2-1). Insure that the AC line output coincides with the power requirements of the instrument.

2. Before inserting a PROM into one of the sockets on the front panel, insure that the instrument will accept that PROM. The instrument will accept either 2708 PROMs or 2716 PROMs but not both.

3. When connecting or disconnecting the in-circuit emulator, power must be off in both the UUT and the uSA. Otherwise, the units could be damaged. Also be sure that pin 1 of the emulator connector is aligned with pin 1 of the device socket.

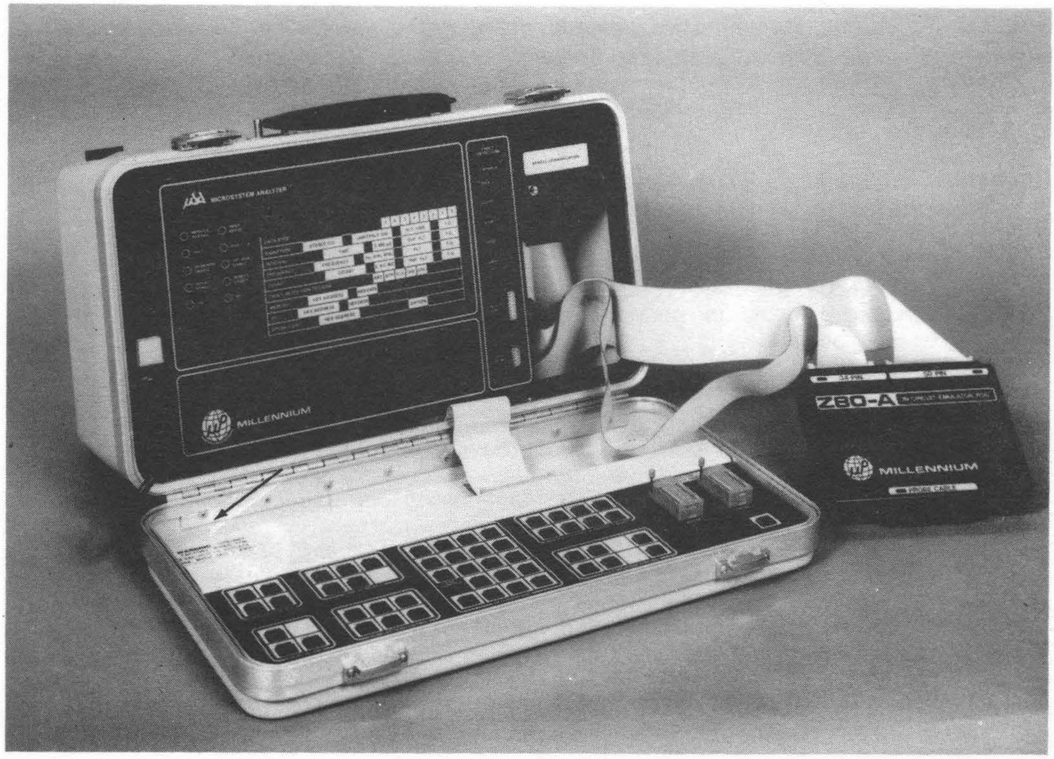


Figure 2-1. Locating the Model Number

2.6 CHANGING THE EMULATOR BOARD

Before any kind of system testing can be performed, an emulator board must be installed inside the uSA. For instruments supplied with only one type of emulator, the board is installed at the factory. Only one emulator board can be installed at a time. Therefore, for instruments supplied with more then one emulator, it will be necessary to change boards if the instrument is to be used to test a system having a different type of microprocessor. For example, if an 8080A emulator board is in the instrument, then, to test a system having a 6800-type microprocessor, the 8080A board must be removed and a 6800 emulator board must be installed.

Each type of emulator board has an associated emulator pod that works only for that type of emulator. For example, a 6800 emulator pod will not work with an 8080 emulator board and it may damage the board. So, be certain that you have installed the correct emulator pod.

Use the following step-by-step procedure and refer to figure 2-2 when changing over from one microprocessor type to another.

1. Turn the uSA off.

2. Using both hands, grasp both cover release knobs and pull straight up. Then completely remove the hatch cover and set to the side.

3. Using both hands, grasp the release tabs on each side of the emulator board and pull up on the tabs so that the board is raised up out of its socket. (The emulator board is identified by the name of the microprocessor at the top of the board).

4. Reach inside the opening and locate the ribbon cable connector(s) plugged into the top edge of the emulator board. Unplug the cables by simultaneously pulling up on both sides of the connector(s).

5. Remove the emulator board from the instrument and store it away.

6. Insert the new emulator board into the instrument and push down simultaneously with both hands to make sure that the board is fully seated. Be careful not to damage the ribbon cable connector(s) while seating the board. (Refer to the individual emulator manuals for installation illustrations relative to specific emulator boards.)

7. Plug the ribbon cable connector(s) onto the mating portion along the top of the emulator board. Be sure that the red edge of the cables is toward the left side of the uSA as you face the instrument.

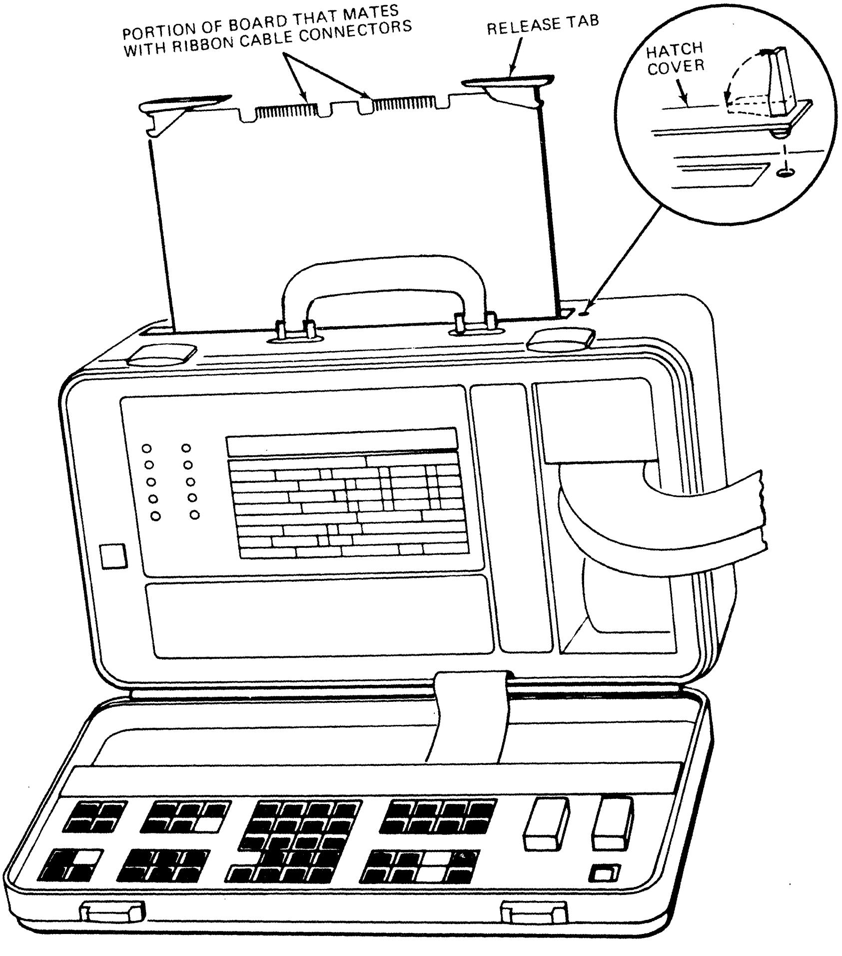
8. Replace the hatch cover. CAUTION: Heat build-up due to improper air flow will result if the hatch cover is not replaced.

9. Unplug the old emulator pod from the instrument's emulator connector, and plug in the new emulator pod (which must correspond to the emulator board that is now inside the instrument). See the individual emulator supplements for details.

10. Turn the uSA on.

WARNING

Installing the wrong pod may damage the emulator board.



NOTE: COMPONENT SIDE OF BOARD IS FACING HANDLE ON TOP OF uSA CASE.

Figure 2-2. Removal of Emulator Board

Chapter 3

TEST TECHNIQUES

3.1 INTRODUCTION

The MicroSystem Analyzer (uSA) uses in-circuit emulation, signature analysis, and time domain analysis to test microprocessor-based boards and systems. In-circuit emulation allows the uSA to perform functional go/no-go tests on the Unit Under Test (UUT) by using the microprocessor socket as a common test point. In-circuit emulation is also used to generate external stimuli for component-level fault isolation in the UUT. Signature analysis allows the uSA to use a detection and comparison technique to isolate faults to the node level in the UUT. Time domain analysis allows the uSA to perform pulse width, time interval and frequency measurements, and to count pulses and signal transitions.

3.2 IN-CIRCUIT EMULATION

In-circuit emulation is the basic mechanism by which the uSA interfaces to the UUT. Using this technique, the microprocessor chip is removed from the unit to be tested and is replaced by a 40-pin test probe cabled to the uSA. The uSA then provides all required signals to the external system just as if the microprocessor were resident. The only requirement is that the external system provide a processor clock. Figure 3-1 shows a diagram of the typical test connection for in-circuit emulation.

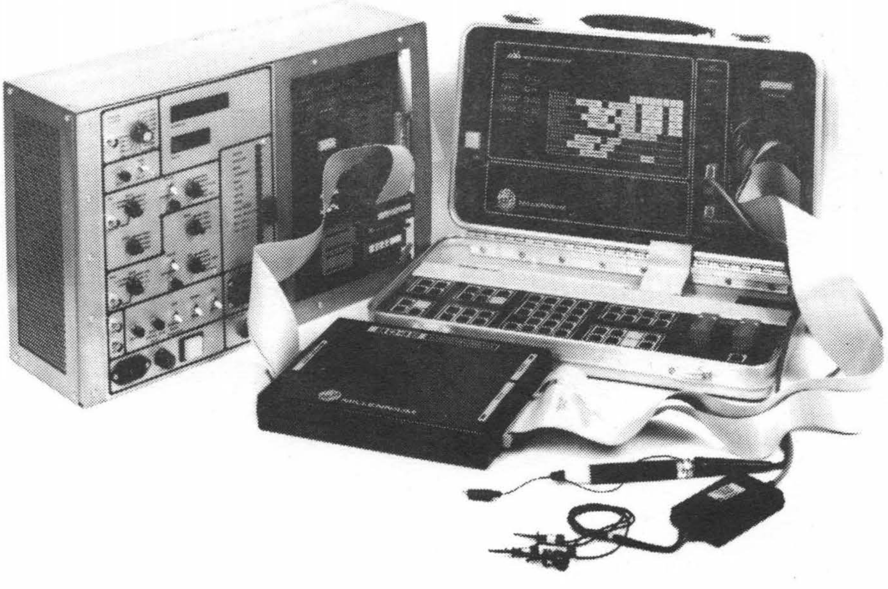


Figure 3-1. uSA Connected to a Unit Under Test (UUT)

A microprocessor in the uSA, an exact copy of the UUT microprocessor, replaces the UUT microprocessor for the purposes of emulation. The uSA then operates the UUT, using the programs and memory of either the UUT or the uSA. The uSA has the additional capability of setting a hardware breakpoint, stepping through program instructions, examining, displaying and alternating CPU registers, memory and I/O values. In this way, in-circuit emulation allows the user to monitor and control a microprocessor-based product and detect faulty hardware and software logic.

Test programs exercise all UUT functions by providing externally generated stimuli. Fault diagnostics are used to identify functional defects. In-circuit emulation is additionally useful in the production line, where procedures can be standardized and semiskilled personnel are available to take the results of the functional tests and perform component fault-isolation procedures.

3.3 SIGNATURE ANALYSIS

Signature analysis is a technique that locates component level faults by probing test nodes. As implemented on the uSA, signature analysis detects bit streams either generated by the UUT or injected from the uSA by the in-circuit emulator. It then compresses the bit streams and displays hexadecimal representations of their values. Each time the emulator cycles through its test program, identical bit streams are generated and the same hexadecimal values appear at each node. Locating faults is then just a matter of comparing the hexadecimal values obtained from a UUT against known good values.

The system, when exercised with a repeatable stimulus pattern, will produce a predictable and unique serial stream of digital data at each node. Because each stream may be thousands of bits long, it is compressed to make it recognizable to the operator.

Data stream compression is done with polynomial code-generation technology, a technology widely used in digital error-detection and correction. It is based on the use of serial shift registers with linear feedback, where the feedback causes the contents of the shift register to be a function of both prior and current data (refer to Figure 3-2). The signature bits are displayed as four hexadecimal characters. The compression logic ensures that the probability of two different bit streams yielding the same signature is exceedingly small (less than 0.002%).

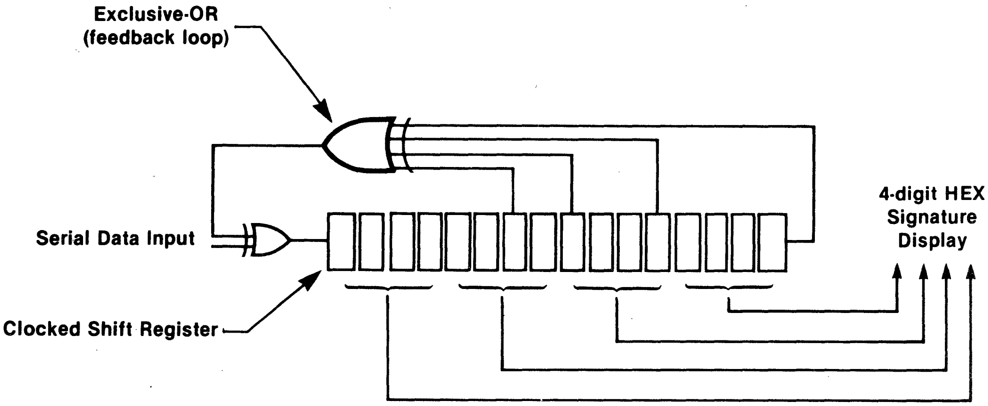


Figure 3-2. Signature Analysis Compression Register

A fundamental requirement of network stimulation is that it forces state changes at each node of the digital system. This can be done either with firmware built into the product or with external stimuli. A more practical approach, the method implemented by the uSA, is external network stimulation using in-circuit emulation. External stimulation lowers product cost and complexity by eliminating the need for built-in, stimulus-generating firmware. It requires only that the processor clock of the unit under test be operable.

3.4 THE SYNERGY OF IN-CIRCUIT EMULATION AND SIGNATURE ANALYSIS

The uSA eliminates inherent limitations of either in-circuit emulation or signature analysis by combining the two techniques. The uSA is the first test system that employs both techniques.

Simply stated, the uSA uses in-circuit emulation to provide the stimulus to the UUT, and signature analysis to examine the response of the UUT. Signature analysis provides the best and most cost-effective solution to fault isolation. When used alone, it requires that the system designer build stimulus-generating firmware into each product to generate the bit streams necessary for analysis. This adds to the cost and development time of new microprocessor-based products, and denies use with earlier product designs.

In-circuit emulation can operate without built-in test points, and requires only that a clock in the UUT be functional. While useful for functional testing, in-circuit emulation, when used alone, is incapable of nodal or component level fault isolation. Hence it is of limited use in field service and repair.

By combining both techniques in the uSA, a low-cost system is achieved that has the ability to emulate the UUT for functional testing, and to perform component fault isolation.

For signature analysis, the uSA uses in-circuit emulation to generate bit streams. Because these bit streams come from a source external to the UUT, testing can proceed even with an inoperable UUT.

When used in combination, in-circuit emulation and signature analysis enable the uSA to isolate faults more quickly. Test personnel need not be familiar with the detailed operation of the UUT or the uSA. The uSA uses in-circuit emulation to localize the error at the board or system level, then switches to signature analysis to achieve more precise fault isolation.

3.5 TIME DOMAIN ANALYSIS

Time domain analysis consists of pulse width, time interval and frequency measurement. Pulse and transition counting is also provided. These are all auxiliary techniques provided by the uSA to complement in-circuit emulation and signature analysis.

Time domain analysis is useful when the "kernel" of the UUT is inoperable. The kernal is the parts of the UUT that must be operational for testing to proceed. For the uSA, the kernel is the system clock. Through use of time domain analysis, the uSA is able to diagnose even a faulty system clock. Time domain analysis is also useful when events occur asynchronously. In such cases, time domain analysis may be the only technique that can provide useful troubleshooting data.

Frequency measurement is useful for clock and other repetitive event measurement. It can be used in production testing of setups such as oscillators and multivibrators.

All measurements are autoranging and displayed in the appropriate units.

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All measurements are auto-ranging and displayed in the appropriate units.

Chapter 4

KEYBOARD

4.1 INTRODUCTION

The keys of the uSA are divided into two catergories, major function keys and subfunction keys. Major function keys are used to select a particular operation, and subfunction keys are used to modify or to select options for that operation. Each major function has its own set of valid subfunctions. Any other subfunction key will be ignored when that function is in effect. The current function may be aborted by pressing another major function key.

The major function keys are:

RESTART
SPECIAL CONTROL
PROCESSOR CONTROL-DIAGNOSTIC SELECT
DISPLAY SELECT
FAULT DETECTION CONTROL
REMOTE LINK

The subfunction keys are:

SUBFUNCTION CONTROL
DATA ENTRY PAD

The major function keys and the subfunction keys are explained in detail in the remainder of this chapter.

4.2 RESTART KEY

This key resets the uSA to an initialized power-on state and tests the Master RAM, Emulator ROM, and System ROM. All front panel indicators are extinguished, all active functions are reset, and the following message is displayed to indicate the uSA is ready to accept commands:

```
uSA READY xxxx
```

Where: xxxx is the emulator type.

If there is an error on startup, the following message is displayed:

MESSAGE	DESCRIPTION
uSA CONDITION 01	Master RAM failure.
uSA CONDITION 02	Emulator ROM failure.
uSA CONDITION 03	Master ROM failure.
uSA CONDITION 04	Emulator not responding.
uSA CONDITION 05	Signature ROM failure.
uSA CONDITION 06	Shadow RAM failure.

After checking all connections, if the error is not apparent, then you should call customer service at the toll-free hot-line numbers listed below:

National	(800) 538-9320/9321
California	(800) 662-9231

4.3 PROCESSOR CONTROL

The Processor Control keys listed and described below control the operation of the UUT:

RUN
RUN/DISP
STEP
RESET
FILL

4.3.1 RUN Key

This key starts execution at the address contained in the program counter status register PN. The PN can be changed using the REGISTER key. When the RUN key is pressed, the Run LED status indicator is illuminated.

4.3.2 RUN/DISP Key

In addition to the functions of the RUN key, the RUN/DISP key causes the selected Memory, Register, or I/O displays to be updated ten times per second when they are selected.

4.3.3 STEP Key

This key enables the operator to single-step program execution. Each time the step key is pressed, one instruction is executed. If any of the Memory, Register, or I/O displays are active, they are updated after each instruction is executed. This key is also used to stop execution when RUN or RUN/DISP is active.

4.3.4 RESET Key

This key forces a hardware Reset signal to the emulator microprocessor. The signal occurs once each time the key is pressed. This key does not effect the UUT.

4.3.5 **FILL Key**

The FILL key stores a specified byte of data to a given range of RAM addresses in the UUT. All data is verified as the fill process occurs. Any byte that does not verify produces the following error display and terminates the fill process:

```
FILL ERR xxxx=yy
```

xxxx = Address where the error occurred.
yy = Data that was read after the write.

After pressing the FILL key, the uSA displays

```
FILL xxxx xxxx xx
```

and prompts for the beginning address. When the ENTER key has been pressed the system prompts for the ending address

```
FILL xxxx xxxx xx
```

After the ending address has been specified the ENTER key is pressed and the system prompts for the data

```
FILL xxxx xxxx xx
```

When the operator terminates this field, the system fills the memory with the specified byte from starting to ending address and then displays

```
FILL COMPLETE
```

if there are no errors. If the ending address is smaller than the starting address, the fill process will "wrap-around" memory.

4.4 DIAGNOSTIC SELECT KEYS

Diagnostic Select keys listed and described below are used to map a PROM into the UUT memory and to select subtests from the PROM:

PROM/MEM
SUBSEL
OPT/MEM KEY

4.4.1 PROM/MEM Key

This key maps diagnostic PROMs located on the keyboard into the UUT memory space. The PROM Memory Enable LED status indicator is illuminated and the initial message is displayed. The subtest is initialized to the first subtest. When the PROM/MEM key is pressed the operator sees

```
initialize message
```

and the subfunction INCR is enabled. The message that is displayed is the diagnostic initialization message as defined by the Diagnostic PROM Header. If the Message Pending LED status indicator is on, the INCR key is used to view multi-line messages. After the PROM/MEM key is pressed, the REGISTER key can be used to find the PROM origin, since the Program-Counter Last (PL) contains the starting address of the PROM overlay.

4.4.2 SUBSEL Key

The SUBSEL key selects one of 99 possible subtests as defined in the Diagnostic Header (see section 6.1). Selecting Subsel=00 causes all the diagnostic subtests to be executed. Selecting subroutine "n" causes only the designated subtest to execute. If the subtest number selected does not exist in the program, an input error will occur. This will cause the Input Error LED status indicator to light and will cause an audio error alert to be sounded.

When the SUBSEL key is pressed the operator sees

```
SUBSELECT=dd
```

dd = Subtest number in decimal.

and the subfunction Decimal keypad is enabled. After the decimal number is entered, press the ENTER key to terminate the input mode.

4.4.3 OPT/MEM Key

The OPT/MEM key is used by the Communication Option. See the Communication Option manual for details.

4.5 DISPLAY SELECT KEYS

The Display Select keys listed and described below control which of the following functions will be displayed:

- I/O
- BREAK
- MEMORY
- REGISTER
- MSG

4.5.1 I/O Key

The I/O key allows the operator to read from or write to I/O devices in the UUT. Data can be in hexadecimal or binary notation. The displays which are seen vary according to the microprocessor. (See emulator supplements for details.)

4.5.2 BREAK Key

The BREAK key allows the operator to select the address, options and provide parameters for the hardware breakpoint. Options are provided so that the system will break on:

- READ ACCESS
- WRITE ACCESS
- READ OR WRITE ACCESS
- PASS COUNT

Pass count represents the number of times a location is referenced before a break occurs.

The operator can select what action shall be taken when a breakpoint is encountered. The options are to pause the processor or to jump to a specific address.

When the operator presses the BREAK key, the system displays the current break address and options:

```
BRKA=xxxx OPT=y
```

xxxx = Address where the break occurred.
y = The options in hexadecimal format

The system enables these subfunctions:

- INCR
- HEXADECIMAL KEYPAD
- BINARY KEYPAD
- ENABLE
- DISABLE

The BINARY key will cause the options to be displayed in binary format:

BITS	FUNCTION
0	0 = Pause uP, 1 = Jump to Address
1	1 = Pass Count Enable
2	1 = Break On Read Access at the specified address
3	1 = Break On Write Access at the specified address

The default value is OPT = C (or in binary 1100) that breaks on write or read access and pauses the processor.

After all the fields have been edited, the existence of other displays depends upon options which were selected. If the PASS COUNT was selected, pressing the INCR key displays:

```
PASS COUNT = dddd
```

dddd = number of times the specified memory location is accessed before a break occurs. Range is 1 through 9999.

If the JUMP option was chosen, the INCR key is used to display

```
JUMP ADDR = xxxx
```

xxxx = The address the system will jump to when the breakpoint occurs.

After the breakpoint options and addresses are entered using the BREAK key, the ENABLE key is used to activate the breakpoint. ENABLE must be pressed after the BREAK setup and before another major function key is pressed.

When a breakpoint is enabled, the Break Enable LED status indicator is illuminated. When the UUT program is executing and a breakpoint is encountered, the uSA displays:

```
BREAK POINT = xxxx
```

xxxx = The address of the instruction causing the breakpoint.

A breakpoint is cleared by pressing the BREAK key and then pressing the DISABLE key.

4.5.4 MEMORY Key

This key is used to display or modify the contents of memory in hexadecimal or binary format. The UUT memory is always displayed or modified unless the address selected falls inside the boundaries of the PROM and the PROM/MEM function is activated; in this case, the diagnostic PROM memory is displayed. When this key is pressed, the auto-edit mode is entered and if the emulator is running the processor is paused and

```
MEM xxxx
```

is displayed, and the hexadecimal keypad subjection is enabled.

After the ENTER key has been pressed, the contents of the specified address are displayed

```
MEM xxxx=yy
```

xxxx = The address displayed.
yy = The contents of that address.

and these subfunctions are enabled:

HEXADECIMAL KEYPAD
BINARY KEYPAD
INCR
DECR

The hexadecimal keypad allows the operator to change the contents of memory; when a key is pressed, the USA displays:

```
MEM xxxx=yy
```

When not editing data, the INCR key increments the memory location by one, and the contents of that location are displayed. The DECR key decrements the memory location by one and displays that location's contents.

If the operator attempts to modify ROM or there is an error in modifying memory an error message is displayed

```
MEM xxxx=yy  ERR
```

yy = The data that was read from the memory address after attempting to modify it.

4.5.5 **REGISTER Key**

This key allows the operator to display or modify the UUT microprocessor's internal registers. Each specific microprocessor has its own register notations and its own displays. (See the supplement for the individual microprocessor emulator boards.) One or more registers are displayed when the REG key is pressed. The next set of registers (in the register list) is displayed when the INCR key is pressed. By continuing to press the INCR key, all of the registers can be displayed. Each display contains fields that can be modified. After editing the first field and pressing the ENTER key, the cursor will automatically move to the second field.

4.5.6 **MSG Key**

This key displays messages on the front panel display as requested by the diagnostic programs testing the UUT. When the display is being used the Message Pending LED indicator is illuminated up to notify the operator of any messages waiting to be displayed. Messages for display can be of a single or multi-line variety. The Message Pending LED indicator is extinguished when all message data has been displayed.

The MSG function is automatically initiated when the diagnostic memory is enabled and the RUN key is pressed.

The subfunction which is active is the INCR which will display the next line of a multi-line message.

If the MSG key is pressed, but the Message Pending LED indicator is not illuminated, then

```
NO MESSAGE
```

would be displayed.

4.6 DATA ENTRY PAD

The data entry pad is used to input and edit data, select options, and specify parameters for major functions. In addition, it can be used to input data to the diagnostic programs. The Data Entry Pad keys are listed and described below:

HEX KEYPAD
←
→+
ENTER

4.6.1 Hex Keypad

The Hex Keypad contains the hexadecimal character set 0-9 and A-F. It is used to enter data and address values. Data can be modified only in the input mode. In some cases, this mode is entered automatically as soon as a function key is pressed (auto-edit). In other cases, it is entered as soon as a valid key on the data entry pad is pressed (implicit-edit). When a message has been displayed and auto-edit has not been entered, edit mode is entered by pressing a key of the appropriate key pad. The system scans the display for the first input field, substitutes the typed character for the first character, and sets the cursor position at the next character, if any. The cursor position is identified by a blinking character followed by a period. Only the character pointed to by the cursor can be changed.

4.6.2 Arrow Keys

The cursor position is controlled by the right (+ →) and left arrow (←) keys. The arrow keys move the cursor position to the right or left. If the cursor is positioned at the right boundary of a field, the + → key will be ignored, and the cursor position will remain unchanged. Likewise, if the cursor is at the left boundary of a field, the ← key will be ignored.

4.6.3 ENTER Key

The ENTER key is used to terminate data input and enter the displayed value of the current field. If there are more input fields in the display, the cursor is positioned at the first character of the next field.

4.7 SPECIAL CONTROL KEYS

The Special Control keys are listed and described below:

OPT 1
OPT 2
OPT 3
TEST

4.7.1 OPT1 and OPT2 Keys

The OPT1 and OPT2 are used by the Communication Option. The OPT1 key transmits data in the uSA RAM or PROM out the serial RS-232 port. The OPT2 key is used to move data from user system memory to uSA RAM, move uSA RAM to uSA memory, move front panel PROM data to uSA RAM or uSA memory. See the Communication Option manual for details.

4.7.2 OPT3 Key

The OPT3 key is reserved for future use.

4.7.3 TEST Key

This key performs a self-test of the uSA. A quick check of RAM, ROM, front panel indicators, and various internal functions is made. This key also resets the uSA to an initialized power-on state.

```
uSA READY xxxx
```

xxxx indicates the emulator type.

This message indicates the tests were successful and the uSA is ready to accept commands.

If there is an error on startup, the following message is displayed:

```
uSA CONDITION xx
```

xx = The error code. See appendix C for details.

4.8 FAULT DETECTION CONTROL KEYS

The Fault Detection Control keys are listed and described in the following paragraphs:

COUNT
FILTER
FREQ
INTRVL
SIG
THRESH

4.8.1 COUNT Key

Allows the uSA to count pulses or transitions. The OPTSEL key can change the start and stop values, source of data, display condition, and other special events.

4.8.2 FILTER Key

Provides a digital filter to screen noise from the data probe. The available values are:

VALUE	FILTER
0	No filter
1	50 nsecs filter
2	100 nsecs filter
3	150 nsecs filter

4.8.3 FREQ Key

Allows operator to take frequency memasurements using the data probe. All measurements are autoranging. The OPTSEL key can change the start and stop values, display condition, and other special events.

4.8.4 INTRVL Key

Allows interval or pulse width measurements. All measurements are autoranging. The OPTSEL key can change the start and stop values, display condition, and other special events.

4.8.5 SIG Key

Allows signature measurments to be taken using the data probe. The OPTSEL key can change the start and stop values, source of clock, display condition, and other special events.

4.8.6 THRESH Key

Reserved for future use.

4.9 SUBFUNCTION CONTROL KEYS

The Subfunction Control keys are listed and described in the following paragraphs:

BINARY
DECR
DISABLE
ENABLE
INCR
OPTSEL

4.9.1 BINARY Key

Displays data byte of the current display value in an 8-bit binary mode.

4.9.2 DECR Key

Decrements the memory and I/O addresses.

4.9.3 DISABLE Key

Used with the BREAK key to disable (clear) breakpoint. See section 4.5.2, the BREAK Key for details.

4.9.4 ENABLE Key

Used with the BREAK key to enable breakpoint. See section 4.5.2, the BREAK Key for details.

4.9.5 INCR Key

Increments the memory and I/O addresses, linked displays, and register content display.

4.9.6 OPTSEL Key

Selects one of 99 subtests in front panel PROMs.

4.10 REMOTE LINK (OPTIONAL) KEYS

The Remote Link keys are listed and described in the following paragraphs:

- ATTN
- LOGON
- REMOTE

4.10.1 ATTN Key

Allows the operator to regain control of the uSA when it is interfacing with a host computer or a master uSA.

4.10.2 LOGON Key

Intepretive log-on procedure enables uSA to communicate with host computer.

4.10.3 REMOTE Key

Allows the uSA to operate as a remote slave unit controlled by a master uSA. Diagnostic programs can be downloaded via telephone link from a master uSA or a host computer.

Chapter 5

PROGRAM MEMORY

5.1 INTRODUCTION

This section describes in detail the formats of the memory used to execute diagnostic programs on a UUT.

The uSA supplies up to 4K bytes of PROM and 256 bytes of RAM (Shadow RAM) to execute the diagnostic programs that exercise the UUT. Understanding the organization, operation, and interaction of these two memory areas provides the basis for all subsequent diagnostic efforts.

The uSA executes diagnostics on the UUT from the diagnostic program resident in the PROMs plugged into the front of the uSA, or from the program in the UUT memory. Because the memory of the UUT can occupy any address location, the diagnostic program could overlay the UUT memory or it could extend it. For example, the UUT memory could extend from 0000 to 2FFF and the diagnostic PROM could begin at 2000. In this case, the diagnostic program would overlay the UUT memory. If, however, the UUT memory was from 0000 to 1FFF and the diagnostic program began at 2000, the diagnostic program would extend the program memory space.

In addition to the mapping of the diagnostic program to UUT memory, the uSA contains a 256-byte block of RAM, called "Shadow RAM", that dynamically overlays the control information of the diagnostic program in PROMs. The diagnostic program uses the Shadow RAM during execution.

Figure 5-1 illustrates how the diagnostic program can overlay UUT memory, and how the Shadow RAM overlays the diagnostic Program.

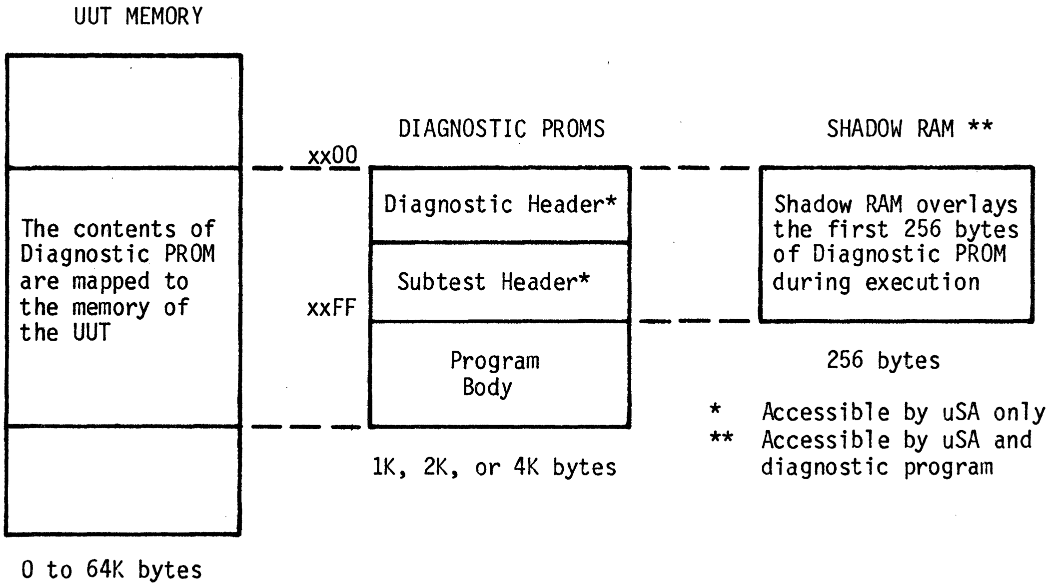


Figure 5-1. Program Memories

5.2 DIAGNOSTIC PROM

The diagnostic program in the PROM (or pair of PROMs) consists of control information and a program body as shown in figure 5-2.

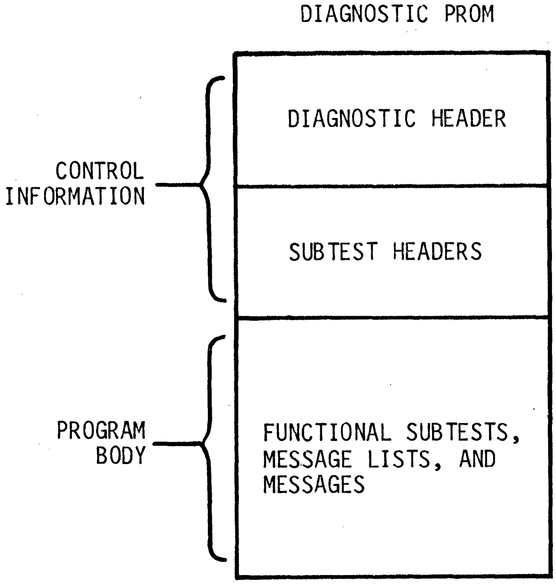


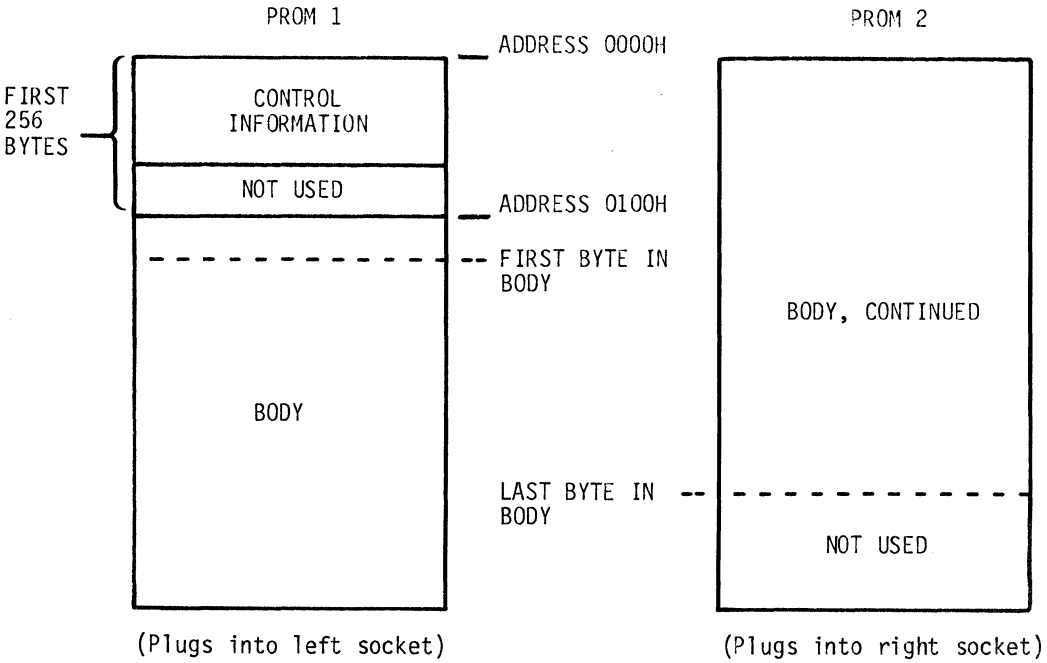
Figure 5-2. Diagnostic Program in PROMs

5.2.1 Control Information

The control information in the PROM consists of a Diagnostic Header followed by the subtest pointers and the Subtest Headers. If this information occupies less than 256 bytes, the leftover bytes can not be used because the uSA overlays the first 256 bytes of PROM 1 of the diagnostic program with Shadow RAM during program execution (see figure 5-1). The uSA provides the Shadow RAM to the users program at execution time. The uSA can switch the RAM in and out of the working memory space as required, for access to the diagnostic program control information and also to service special requests made by the diagnostic program. The information contained in the diagnostic header and subtest header areas is not accessible to the program during execution.

5.2.2 Program Body

The bytes following the first 256 bytes are reserved for the body of the program. The body consists of functional subtests, message lists and messages and usually begins at the starting location of the PROM plus 256 bytes (100H). However, if the diagnostic program requires more than 256 bytes of control information, the body starts in the next contiguous byte after the last byte of the control information. Figure 5-3 illustrates an example in which control information occupies less than 256 bytes, and figure 5-4 illustrates an example in which control information occupies more than 256 bytes.



NOTE: PROM 2 is needed only if body of program is too long to fit into PROM 1.

Figure 5-3. Program Example with Less Than 256 Bytes of Control Information

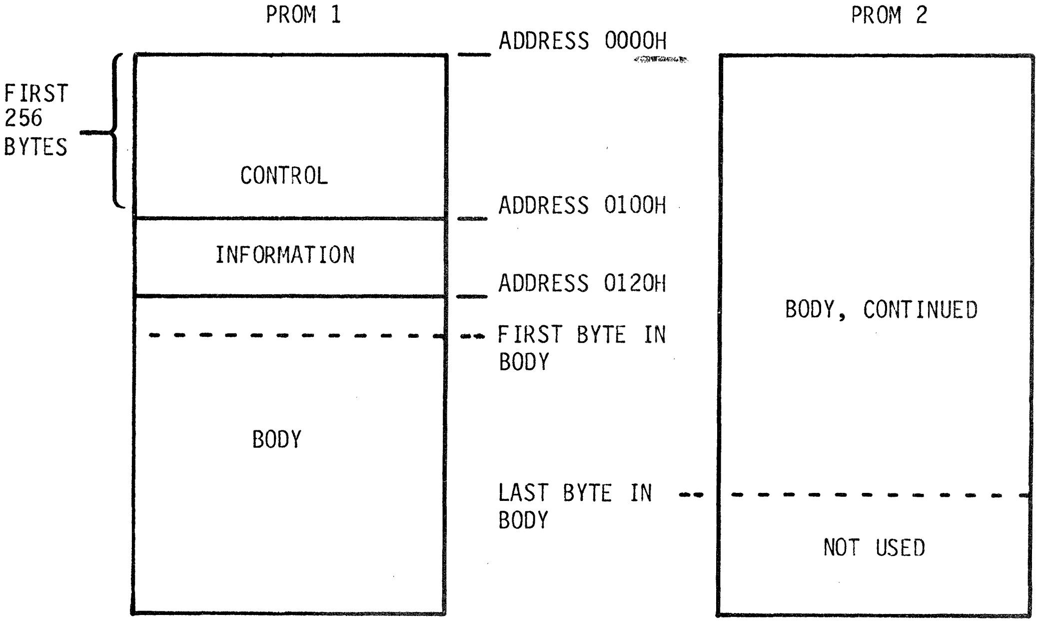


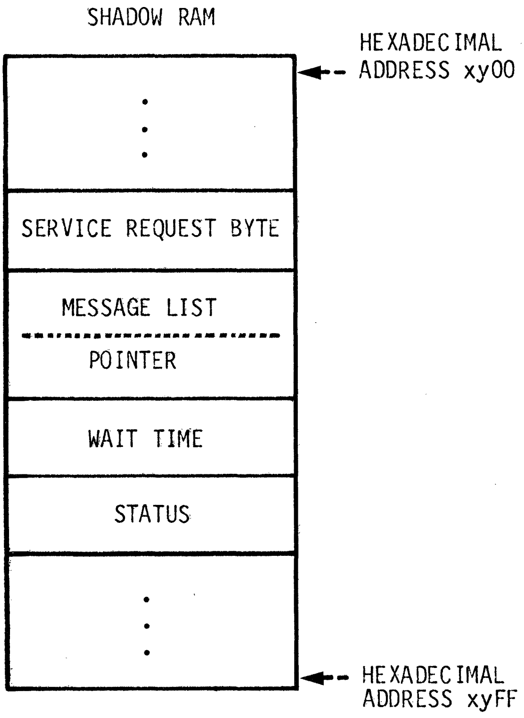
Figure 5-4. Program Example with More than 256 Bytes of Control Information

5.3 SHADOW RAM

The uSA operating system uses shadow RAM for data transfer and service requests between the uSA and the diagnostic program. Five bytes of the Shadow RAM are used for making a service request. When data is stored in the service request byte, the uSA interrupts, pauses the UUT and determines what action is to be taken.

The data stored at the Service Request byte communicates to the system: 1) when the subtest is finished, 2) when the diagnostic program is finished with all of the subtests, and 3) if there is a message to be displayed. The Service Request byte also defines what action to take after servicing the requests. The options are: 1) pause the microprocessor under test, 2) wait a period of time, or 3) continue.

If the wait option is selected, the wait time is stored in the Wait Time byte in the Shadow RAM (see figure 5-5). If the request was to display a message, then the two bytes following the service request byte point to the message list. The status byte tells the diagnostic program which, if any, fault isolation function is active. The rest of the shadow RAM is available to the programmer for data storage and stack pointer.



x = any Hex value
y = 0, 4, 8, C

Figure 5-5. Shadow RAM Format

Chapter 6

DIAGNOSTIC PROM CONTROL INFORMATION

The control information in the Diagnostic PROM consists of a Diagnostic Header followed by the Subtest Headers, as shown in figure 6-1.

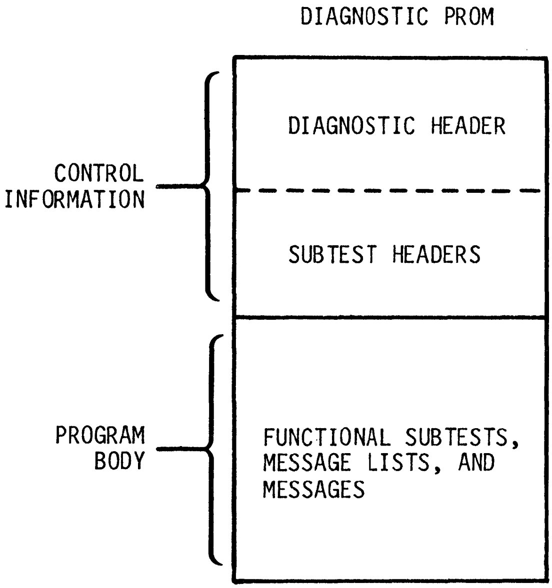


Figure 6-1. Control Information (shaded area)

6.1 DIAGNOSTIC HEADER

The Diagnostic Header contains information about the operating environment of the diagnostic program. The Diagnostic Header must start at the first address in the diagnostic PROM. Figure 6-2 shows the format of the diagnostic header block and the position of the diagnostic header block in the diagnostic program.

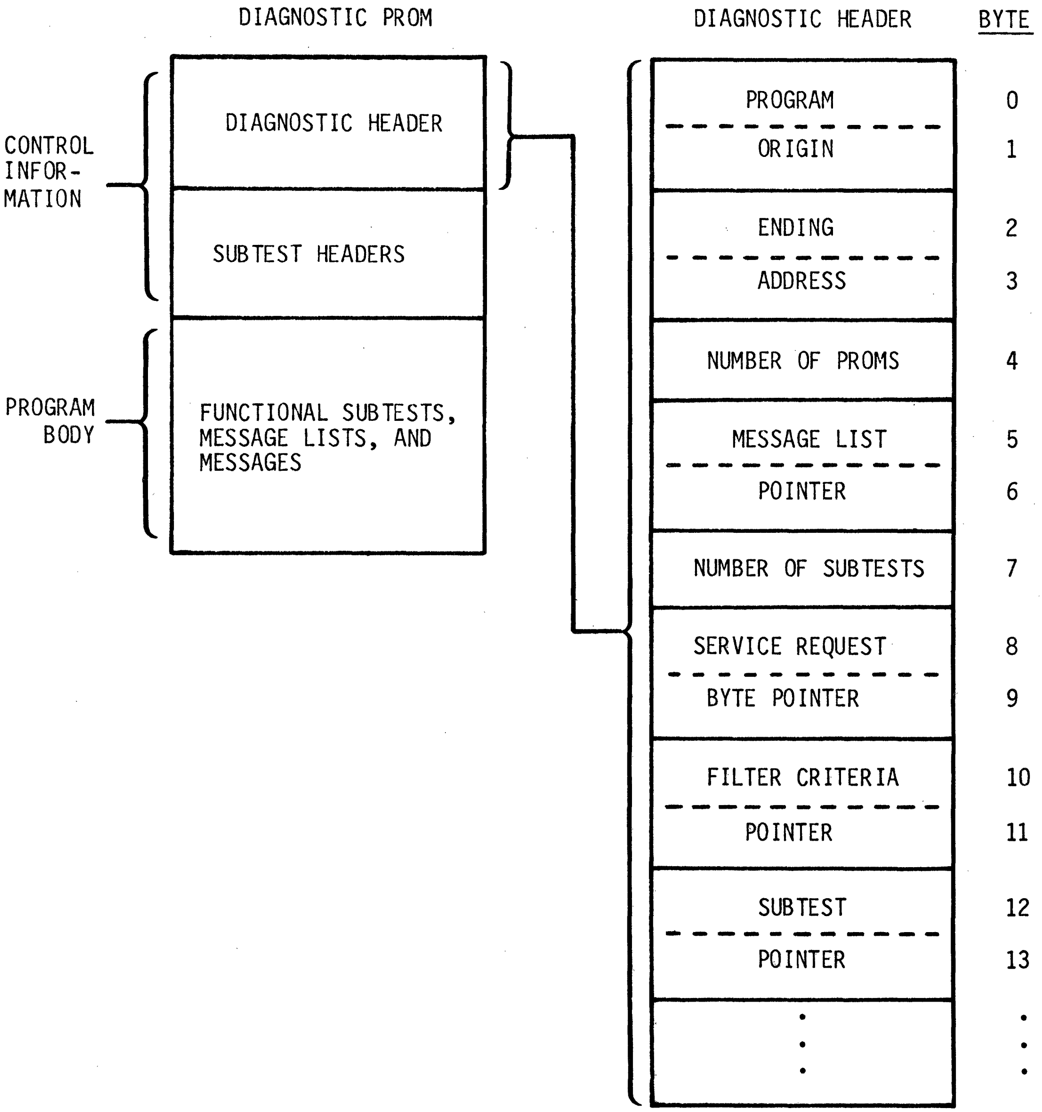


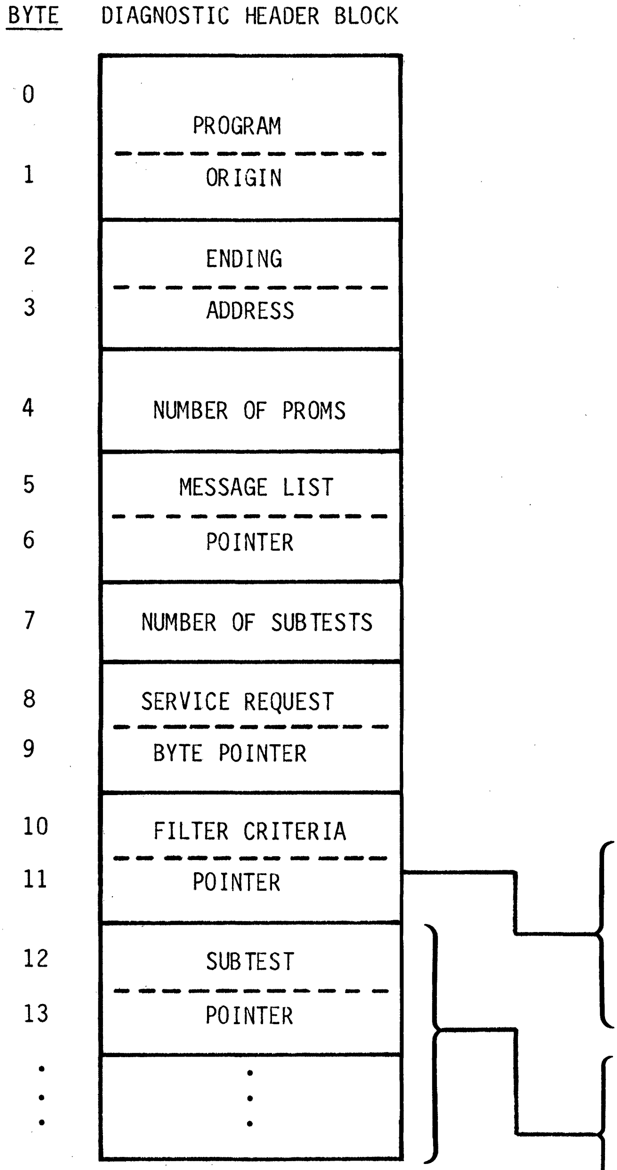
Figure 6-2. Diagnostic Header (shaded area)

A description of the bytes of the diagnostic header follows:

BYTE	DIAGNOSTIC HEADER	DESCRIPTION
0 1	PROGRAM ORIGIN	Two-byte address (high byte, low byte) used by the system to map diagnostic program into the memory space of the UUT. The program origin must fall on one of the following boundaries: Program Size — Boundary One 2708 PROM — 1K * Two 2708 PROMs — 2K * One 2716 PROM — 2K * Two 2716 PROMs — 4K *
2 3	ENDING ADDRESS	Two-byte ending address (high byte, low byte) of the diagnostic program. This address is used to calculate program size.
4	NUMBER OF PROMS	Number of PROMs plugged into the keyboard (either 1 or 2).
5 6	MESSAGE LIST POINTER	Two-byte address pointer (high byte, low byte) to the initial message list that identifies the program. The message size is restricted to 20 characters and is displayed when the PROM/MEM key is pressed. See 9.2, MESSAGE LIST.
7	NUMBER OF SUBTESTS	The number of subtests in the program. The value range is 1 through 99 (63H max).
8 9	SERVICE REQUEST BYTE POINTER	Two-byte address pointer (high byte, low byte) to the Communication Service Request byte. The address of the Service Request byte must be in the Shadow RAM. See chapter 8, SHADOW RAM.
10 11	FILTER CRITERIA POINTER	
12 13	SUBTEST POINTER	
• • •	• • •	

* Boundary 1K = x000, x400, x800, xC00
2K = x000, x800
4K = x000

Diagnostic Header description (continued).



DESCRIPTION

Two-byte address pointer (high byte, low byte) to the filter criteria. This data is optional. If no filtering is specified, the value of the address pointer must be 0. See chapter 7, DIAGNOSTIC PROM FILTER CRITERIA.

Two-byte address pointers (high byte, low byte) to subtest header blocks. A subtest pointer is required for each subtest, and a diagnostic program may have as many as 99 subtest pointers.

6.2 SUBTEST HEADER

The Subtest Header defines the control for the individual subtest. The most efficient placement of the subtest control blocks is immediately following the Diagnostic Header block, as this area is overlayed by the shadow RAM.

In addition to the information required in the subtest header, the programmer has the option of specifying criteria for any or all of the fault detection functions: SIG, FREQ, COUNT, INTRVL.

When the optional data is present and the operator presses a fault detection key, the uSA determines how to take the measurement from the information in the subtest header. Figure 6-3 shows the position of the Subtest Header Block in the diagnostic program and the format of the Subtest Header.

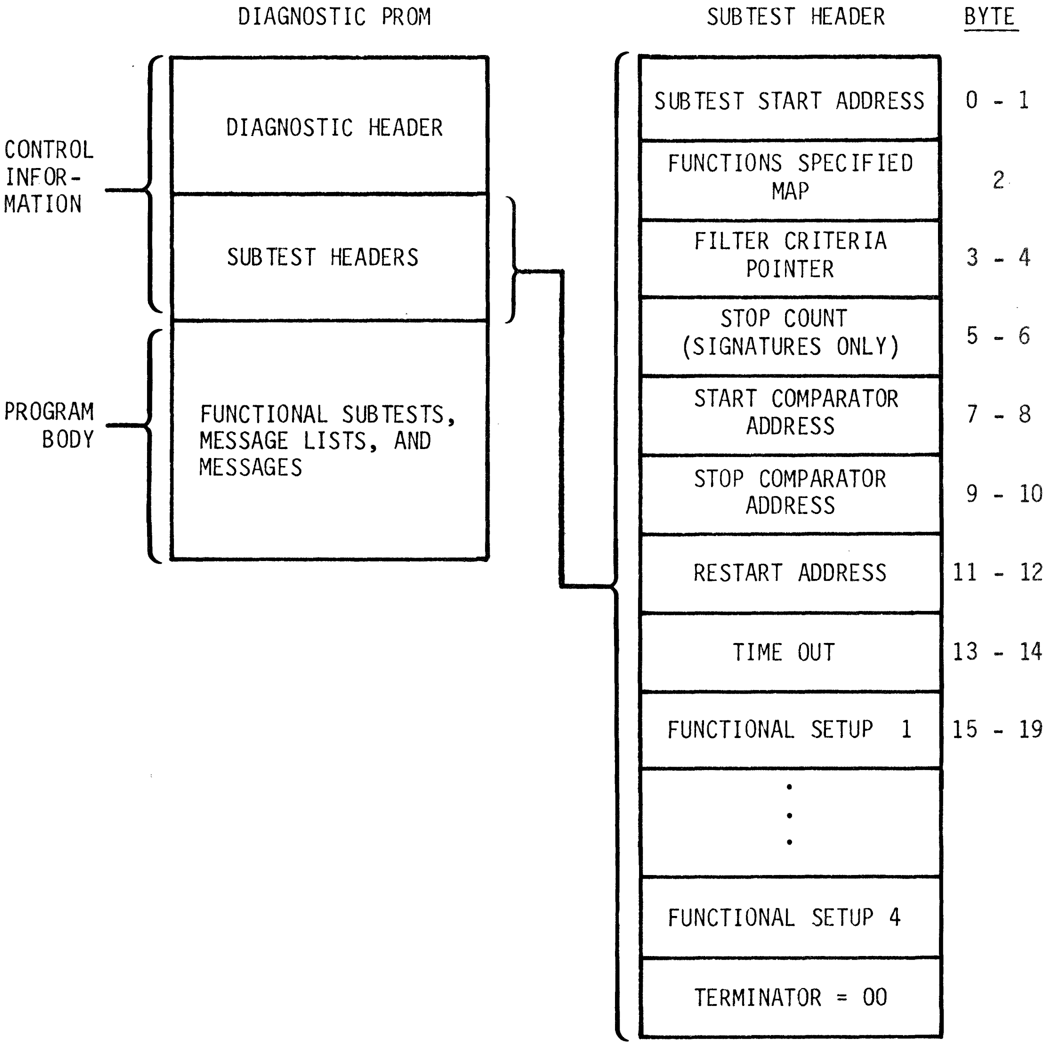


Figure 6-3. Subtest Header (shaded area)

A description of the bytes of the subtest header follows:

BYTE	SUBTEST HEADER	DESCRIPTION
0 1	SUBTEST START ADDRESS	Starting address of the subtest. (High byte, low byte.)
2	FUNCTIONS SPECIFIED MAP	Indicates if any Functional Setups are present and also specifies how memory is to be mapped. Bit 0 indicates how memory is to be mapped. If it is zero, all memory except the test diagnostic memory is mapped to the UUT. If it is a one, all memory is mapped to the uSA; however, all control, address, and data signals are passed to the UUT. While mapped to the uSA, any memory control and data signals from the UUT are disregarded. This allows fault analysis on the UUT memory and bus structure. Bit 1 is used to indicate if one or more function setup is present. This is used for fault isolation. If it is a one, setups are present. If zero, all information after byte 4 is not used and a new subtest header may be started.
3 4	FILTER CRITERIA POINTER	Two-byte address pointers (high byte, low byte) to subtest header blocks. A subtest pointer is required for each subtest, and a diagnostic program may have as many as 99 subtest pointers.
	(OPTIONAL)	
5 6	STOP COUNT (SIGNATURES ONLY)	Number of clock pulses allowed until stopping a signature sequence. Stop on count option must be selected. Stop count applies only to the SIG function. Range is from 1 to 65,535 (1-FFFFH). (High byte, low byte.)
7 8	START COMPARATOR ADDRESS	Starting address of measurement sequence. This address applies to all functions in which the start address comparator is enabled. (High byte, low byte.)
9 10	STOP COMPARATOR ADDRESS	Stopping address of measurement sequence. This address applies to all functions in which the stop address comparator is enabled. (High byte, low byte.) NOTE: One more instruction will be executed.
11 12	RESTART ADDRESS	
13 14	TIME OUT	
15 - 19	FUNCTIONAL SETUP 1	
	. . .	
	FUNCTIONAL SETUP N	
	TERMINATOR = 00	

Subtest header description (continued):

BYTE	SUBTEST HEADER	DESCRIPTION
0	SUBTEST	
1	START ADDRESS	
2	FUNCTIONS SPECIFIED MAP	
3	FILTER CRITERIA	
4	POINTER	
	(OPTIONAL)	
5	STOP COUNT	
6	(SIGNATURES ONLY)	
7	START COMPARATOR	
8	ADDRESS	
9	STOP COMPARATOR	
10	ADDRESS	
11	RESTART	Program address to restart program after measurement sequence has been completed. The uSA forces a hardware jump to this address whenever a measurement sequence has been completed. (High byte, low byte.)
12	ADDRESS	
13	TIME	Maximum time allowed to take a measurement. Byte 13 is zero and byte 14 is the time. Each hexadecimal digit represents 100 msec. The maximum value that byte 14 may have is 127(FFH) which represents 12.7 seconds.
14	OUT	
15 - 19	FUNCTIONAL SETUP 1	
	• • •	Defines the manner in which a specific measurement is to be taken. See 6.3, FUNCTIONAL SETUPS for details.
	FUNCTIONAL SETUP 4	
	TERMINATOR = 00	When all of the Functional Setups have been specified, the subtest header is terminated with a byte of zeros.

6.3 FUNCTIONAL SETUPS

Functional Setup blocks are the part of the Subtest Header that defines how specific measurements are taken. Up to four functional setups are allowed for each Subtest Header. The Functional Setup block is described in detail below:

Figure 6-4 show the position of the Functional Setup block in the subtest header and the format of the Functional Setup block.

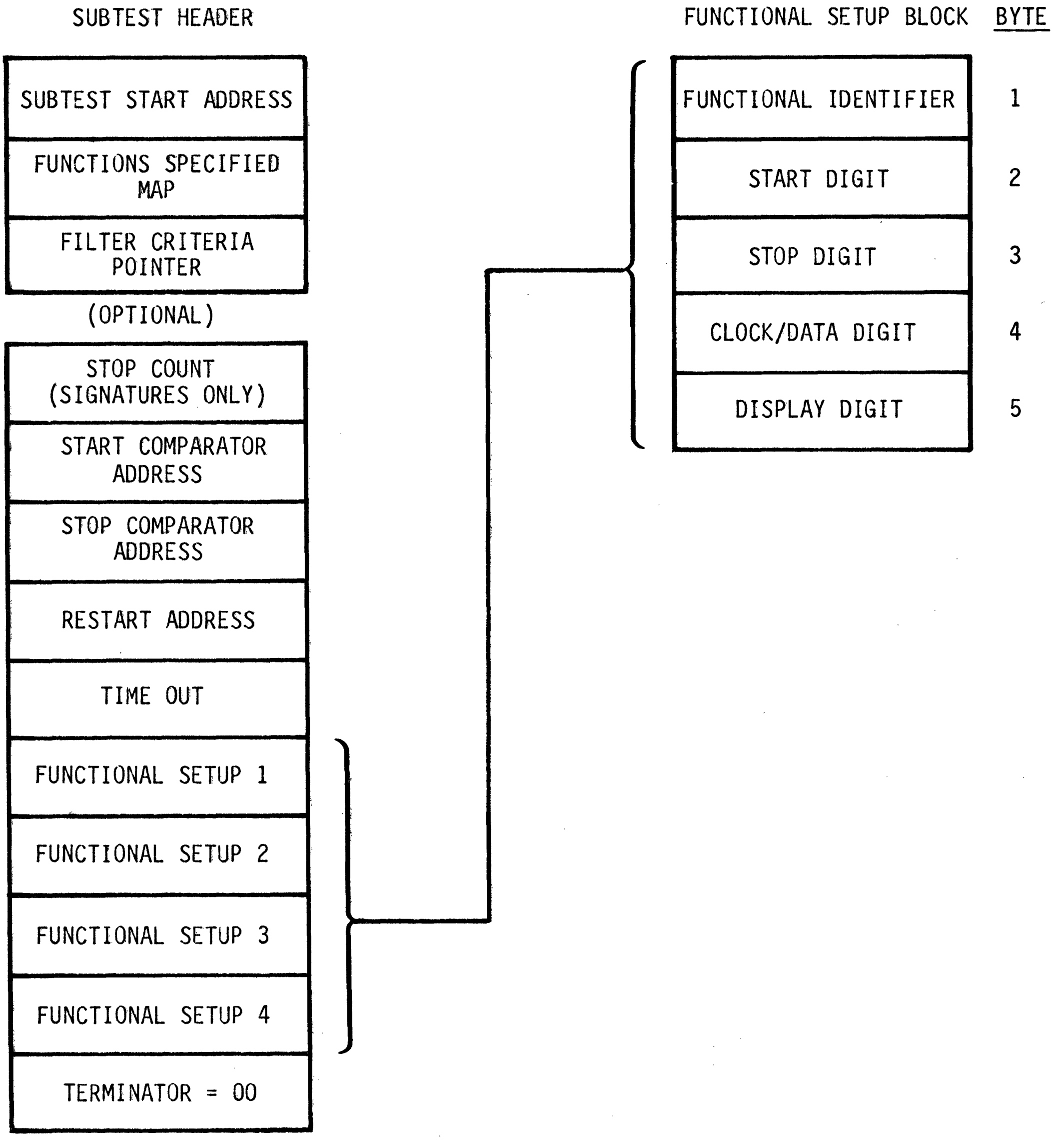


Figure 6-4. Functional Setup Block

A description of the Functional Setup Block follows:

BYTE	FUNCTIONAL SETUP BLOCK	DESCRIPTION
1	FUNCTIONAL IDENTIFIER	Defines which measurements is to be taken. FUNCTIONAL IDENTIFIER = 10H = Signature 20H = Count 40H = Interval 80H = Frequency
2	START DIGIT	
3	STOP DIGIT	
4	CLOCK/DATA DIGIT	
5	DISPLAY DIGIT	

Functional Setup Description (continued)

BYTE	FUNCTIONAL SETUP BLOCK
1	FUNCTIONAL IDENTIFIER
2	START DIGIT
3	STOP DIGIT
4	CLOCK/DATA DIGIT
5	DISPLAY DIGIT

DESCRIPTION

Depending upon the mode of operation, the uSA can start a measurement on any of the following conditions:

START DIGIT	CONDITION	SIGNATURE	FREQUENCY	COUNT	INTERVAL
0	External start probe negative going edge	X	X	X	X
1	External start probe positive going edge	X	X	X	X
2	External data probe negative going edge	X	X	X	X
3	External data probe positive going edge	X	X	X	X
4	Address compare	X	X	X	X
5	Address compare and external start probe negative going edge	X	X	X	X
6	Address compare and external start probe positive going edge	X	X	X	X
7	Address compare and external data probe negative going edge	X	X	X	X
8	Address compare and external data probe positive going edge	X	X	X	X
9	Start immediately	X	X		

The address compare is triggered when the specified address is referenced.

When the address compare is used with an external signal, both conditions must be met before the measurement is started. Either condition may occur first, the later condition starts the measurement.

The address compare can only be used when the uSA is performing emulation.

Functional Setup Description (continued)

BYTE	FUNCTIONAL SETUP BLOCK
1	FUNCTIONAL IDENTIFIER
2	START DIGIT
3	STOP DIGIT
4	CLOCK/DATA DIGIT
5	DISPLAY DIGIT

DESCRIPTION

Depending upon the mode of operations, the uSA can stop a measurement on any of the following conditions:

STOP DIGIT	CONDITION	SIGNATURE	FREQUENCY	COUNT	INTERVAL
0	External stop probe negative going edge	X		X	X
1	External stop probe positive going edge	X		X	X
2	External data probe Negative going edge	X		X	X
3	External data probe Positive going edge	X		X	X
4	Address Compare	X		X	X
5	Address compare and external stop probe negative going edge	X		X	X
6	Address compare and external stop probe positive going edge	X		X	X
7	Address compare and external data probe negative going edge	X		X	X
8	Address compare and external data probe positive going edge	X		X	X
9	Count	X	X		
A	Count and external stop probe negative going edge	X			
B	Count and external stop probe positive going edge	X			
C	Count and address compare	X			

Functional Setup Description (continued)

BYTE	FUNCTIONAL SETUP BLOCK
1	FUNCTIONAL IDENTIFIER
2	START DIGIT
3	STOP DIGIT
4	CLOCK/DATA DIGIT
5	DISPLAY DIGIT

DESCRIPTION

STOP DIGIT (continued)

STOP DIGIT	CONDITION	SIGNATURE	FREQUENCY	COUNT	INTERVAL
D	Count and address compare and external stop probe negative going edge	X			
E	Count and address compare and external stop probe positive going edge	X			

The address compare is triggered when the specified address is referenced.

When the address compare is used with an external stop signal both conditions must be met before the measurement is terminated.

When the count is used as the signature terminator, the shift register will be clocked the number of times specified by the count. The maximum count is 65,535 (FFFFH).

When the stop on count and address compare is used, both conditions must be met before the signature is terminated.

When the stop on count and an external condition are used, both conditions must be met before the signature is terminated.

When count, address comparison and external condition are used, all three conditions must be met before the signature is terminated.

Functional Setup Block definition (continued):

BYTE	FUNCTIONAL SETUP BLOCK
1	FUNCTIONAL IDENTIFIER
2	START DIGIT
3	STOP DIGIT
4	CLOCK/DATA DIGIT
5	DISPLAY DIGIT

DESCRIPTION

The Clock/Data Digit specifies the:

CLOCK SOURCE
SYNCHRONIZATION OF CLOCK WITH
EXTERNAL START AND STOP SIGNALS
DATA SOURCE
SIGNATURE CLOCKING

The Clock/Data Digit is defined below:

CLOCK/ DATA DIGIT	CLOCK SOURCE	START/ STOP SYNC	DATA SOURCE	SIG- NATURE CLOCK	SIGNATURE	FREQUENCY	COUNT	INTERVAL
0	Clock Probe	+	Data Probe	+	X			
1	Clock Probe	+	Data Probe	-	X			
2	Clock Probe	-	Data Probe	+	X			
3	Clock Probe	-	Data Probe	-	X			
4	OPREQ	+	Data Probe	+	X			
5	OPREQ	+	Data Probe	-	X			
6	OPREQ	-	Data Probe	+	X			
7	OPREQ	-	Data Probe	-	X			
8			Data Probe			X	P	X
9			OPREQ				P	
A			Data Probe (Transistions)				T	

P = Pulse Count
T = Transition Count

Functional Setup Block definition (continued):

BYTE	FUNCTIONAL SETUP BLOCK	DESCRIPTION
1	FUNCTIONAL IDENTIFIER	
2	START DIGIT	
3	STOP DIGIT	
4	CLOCK/DATA DIGIT	Signature The clock source can be the external clock probe or the OPREQ signal. OPREQ is a signal that signifies a valid bus transaction is taking place. OPREQ is different for each microprocessor. See the Emulators supplement for details of the OPREQ signal. To avoid conditions where the external start or stop signal is not stable for a given clock edge, the start and stop signals are synchronized with either the positive going (+) or negative going (-) edge of the clock. The data source is always the data probe. The signature can be taken with either the positive going (+) or the negative going (-) edge of the clock. Frequency The clock is an internal clock and the source is the data probe. The only digit that can be used is 8. Count Either Pulse Counts or Transition Counts may be chosen depending upon the value selected for the Clock/Data Digit. Transition counts can only be taken from the data probe, but pulse counts can be taken from the data probe or OPREQ. Interval The clock is an internal clock and the only digit that can be used is 8.
5	DISPLAY DIGIT	

Functional Setup Block definition (continued):

BYTE	FUNCTIONAL SETUP BLOCK
1	FUNCTIONAL IDENTIFIER
2	START DIGIT
3	STOP DIGIT
4	CLOCK/DATA DIGIT
5	DISPLAY DIGIT

DESCRIPTION

DISPLAY DIGIT

When the measurement window is very short and the values are changing slightly, the low order digits in a display tend to flutter. In the uSA, there are two ways to solve this problem.

For all measurements except Signature, the uSA can take ten measurements, average them, and display the average. Then it repeats that cycle.

The operator can specify a wait time between samples from 100 milliseconds to 5 seconds.

The following defines the Display Digit:

Display Digits	Meaning	SIGNATURE	FREQUENCY	COUNT	INTERVAL
0	Average of 10 samples		X	X	X
1	No Average. No wait	X	X	X	X
2	Wait 100 msec. between displays	X	X	X	X
3	Wait 200 msec. between displays	X	X	X	X
4	Wait 300 msec. between displays	X	X	X	X
5	Wait 400 msec. between displays	X	X	X	X
6	Wait 500 msec. between displays	X	X	X	X
7	Wait 700 msec. between displays	X	X	X	X
8	Wait 1 second between displays	X	X	X	X
9	Wait 2 seconds between displays	X	X	X	X
A	Wait 5 seconds between displays	X	X	X	X

Chapter 7

DIAGNOSTIC PROM FILTER CRITERIA

7.1 FILTER CRITERIA FORMAT

Filter criteria is used to specify the environment in which the measurement will be made. The filter is used to screen noise encountered by the probes from data. Figure 7-1 shows the position of the Filter Criteria in the diagnostic program and the format of the Filter Criteria.

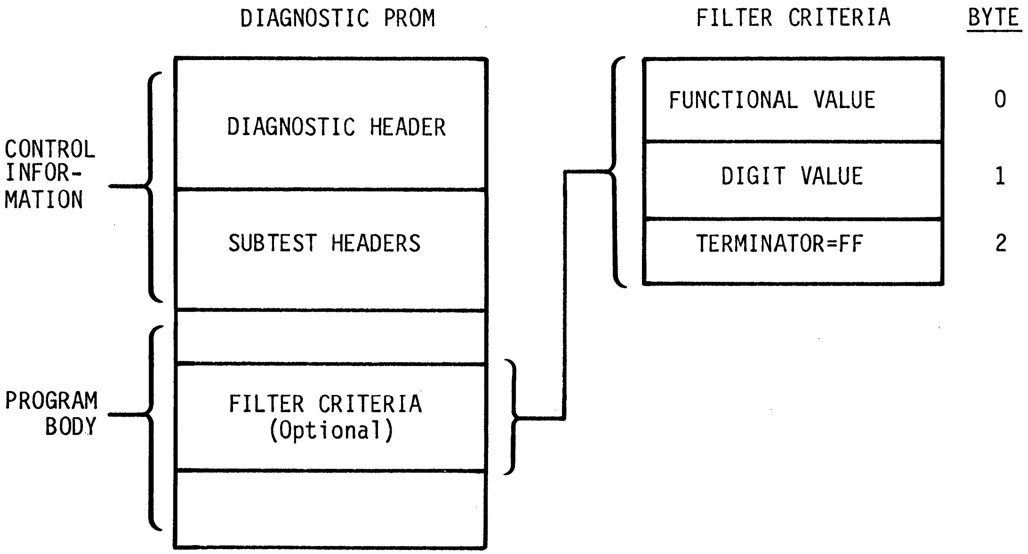


Figure 7-1. Filter Criteria (shaded area)

The filter criteria can be specified from the Diagnostic Header block as shown in figure 7-2, or from the Subtest Header block as shown in figure 7-3.

A description of the bytes of the filter criteria follows:

Filter Criteria description:

BYTE	FILTER CRITERIA	DESCRIPTION
0	FUNCTIONAL VALUE	FUNCTIONAL VALUE = 01 defines the Filter Criteria
1	DIGIT VALUE	The filters and there corresponding values are:
2	TERMINATOR	TERMINATOR = FF

VALUE	FILTER
0	No filter
1	50 nanosec filter
2	100 nanosec filter
3	150 nonosec filter

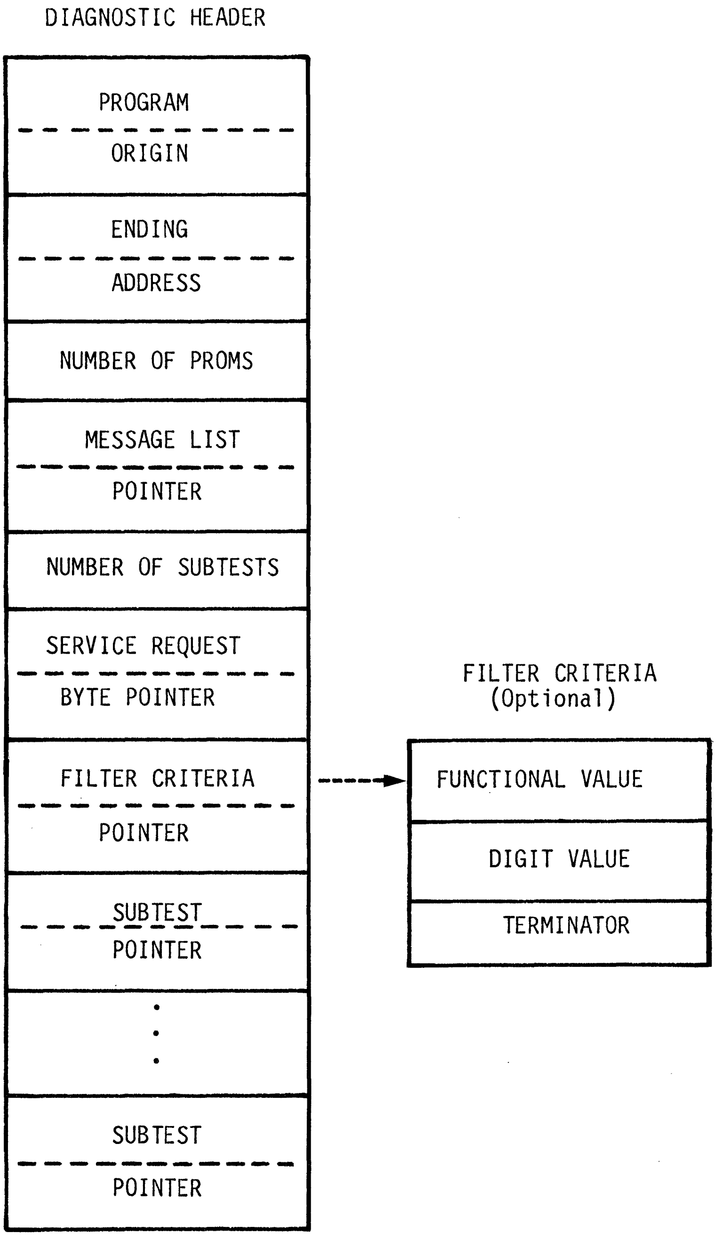


Figure 7-2. Filter Criteria Specified from Diagnostic Header Block

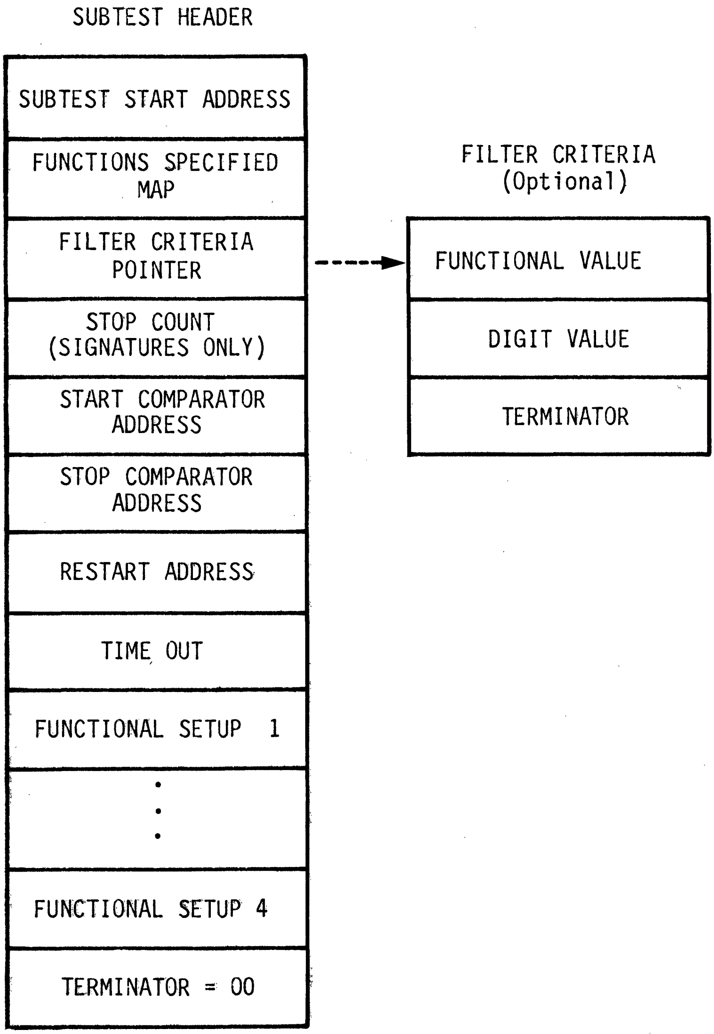


Figure 7-3. Filter Criteria Specified from Subtest Header

7.2 HIERARCHY FOR FAULT DETECTION OPTIONS

The information required by the system to execute a diagnostic program exists in the Diagnostic Header, the system default tables, and the Subtest Header. In addition, it can be input via the data entry pad. In cases such as the Filter Criteria, which can be specified in more than one place, a hierarchy must be established to set rules for the duration of any changes made by the operator.

For any subtest, the system uses the following hierarchy.

For the Filter Criteria:

MANUAL CHANGES
SUBTEST HEADER (IF SPECIFIED)
DIAGNOSTIC HEADER (IF SPECIFIED)
SYSTEM DEFAULTS (FILTER = NONE)

The Functions Specified Map digit in the Subtest Header applies only to the current subtest and is replaced when the subtest changes.

If no new functional setup is specified in the current subtest, the last defined values will be used.

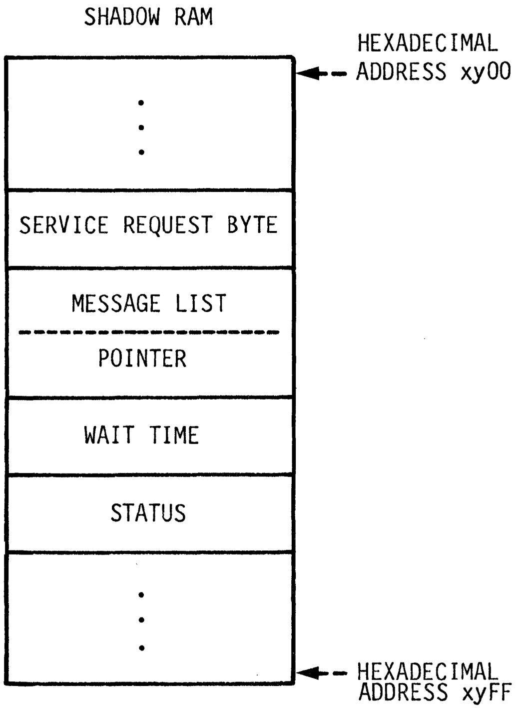
Some manual changes apply only to the current function. Changes to the Stop Count, Start Digit, Stop Digit, Clock/Data Digit, and Display Digit fall into this category. When a new function is chosen, the digits for the function are retrieved and become the current function digits.

Chapter 8

SHADOW RAM

The uSA operating system uses Shadow RAM for data transfer and service requests between the uSA and the diagnostic program. When the PROM/MEM key is pressed, the Shadow RAM is enabled and set to zero. Except for the five bytes shown below, the rest of the Shadow RAM is available to the diagnostic program for storing data and for the stack pointer.

Figure 8-1 shows the format of the Shadow RAM.

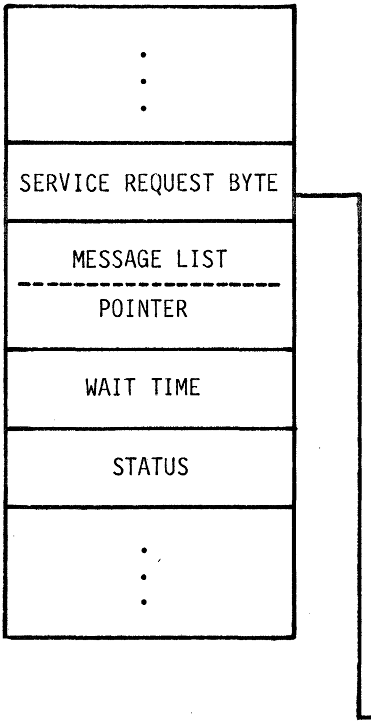


x = Any hexadecimal number.
y = 0, 4, 8, C depending upon the size of the Diagnostic PROMs.

Figure 8-1. Shadow RAM Format

Each byte of the Shadow RAM is described below:

SHADOW RAM

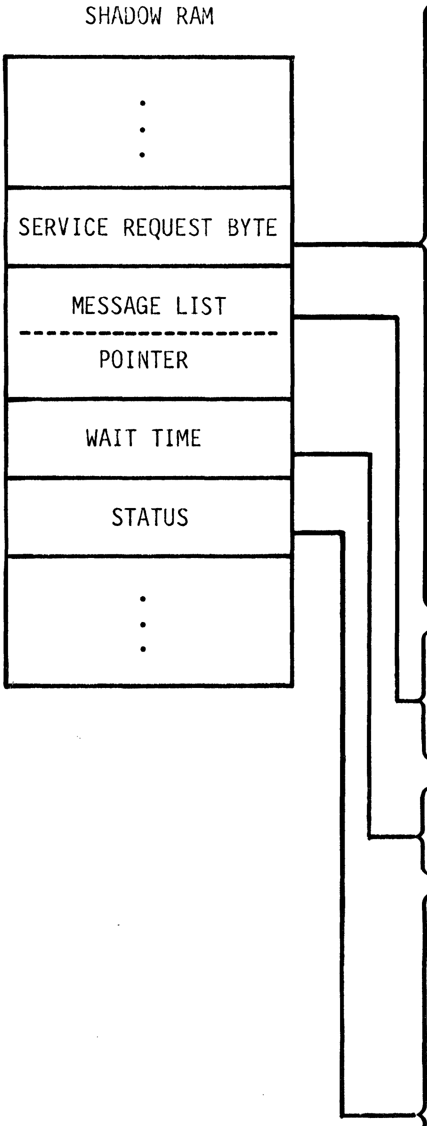


DESCRIPTION

The uSA uses service requests to provide the diagnostic program with the functions listed below. Service is requested by storing the hex value for the function in the Service Request Byte. The hex values may be ORed together for multiple requests. Storing the coded data in the Service request Byte causes the uSA to perform the request. The request types are defined below.

Hex Value	Description
01	END SUBTEST This signifies the end of the subtest. The program is not paused. One of the following actions will occur, depending on the operator selected subtest: If SUBSEL = 0 at the end of each subtest, the subtest number is incremented and the next subtest is executed until the last subtest has been run. At this point, the subtest number is set to 1 and the program continues to loop. If SUBSEL does not equal zero, the program loops on the selected subtest.
02	MESSAGE OUTPUT The Message Pending LED indicator is illuminated and the program is paused for operator inspection of the message. If input is allowed, it can be entered from the appropriate keypad at this time. See the Message List description in chapter 9 for details.
04	END TEST The program is paused and one of the following actions will occur, depending on the operator selected subtest. If SUBSEL = 0 the program will be restarted at subtest 1 when the RUN key is pushed. If SUBSEL does not equal zero, the selected subtest will be repeated when the RUN key is pushed.

Shadow RAM description (continued)



SERVICE REQUEST (continued)

Hex Value	Description
08	HALT OVERRIDE (or CONTINUE) This value, which can be ORed with any other service request, causes the uSA to perform the requested action and then to resume operation. This action can be used for diagnostic loop control and message output.
10	WAIT This value can be used by itself or ORed with the Message Output request. After displaying the message, the uSA waits a specified amount of time before resuming. The time is specified by the Wait Time Byte.

For message output to the uSA via a service request, the two bytes immediately following the Service Request Byte must contain the absolute address of the associated Message List. (High byte, low byte.)

This value specifies the amount of time to wait. Each hexadecimal digit represents approximately 100 milliseconds.

The Status Byte, the fourth byte after the Service Request Byte, is set by the uSA to indicate which fault detection measurement is currently being made. The Status Byte is updated whenever a function key is pressed.

The format of the Status Byte is:

Hex Value	Description
00	No Fault Detection Measurement
10	Signature
20	Count
40	Interval
80	Frequency

Chapter 9

DIAGNOSTIC PROM MESSAGES

9.1 INTRODUCTION

Diagnostic programs can initiate message displays and request data input from the operator. The Message List is a control block in the body of the Diagnostic PROM that is used to control and specify display data and input operations. The Message List is addressed by a pointer in the Shadow RAM, as shown in figure 9-1, or by a pointer in the Diagnostic Header. See section 6.1.

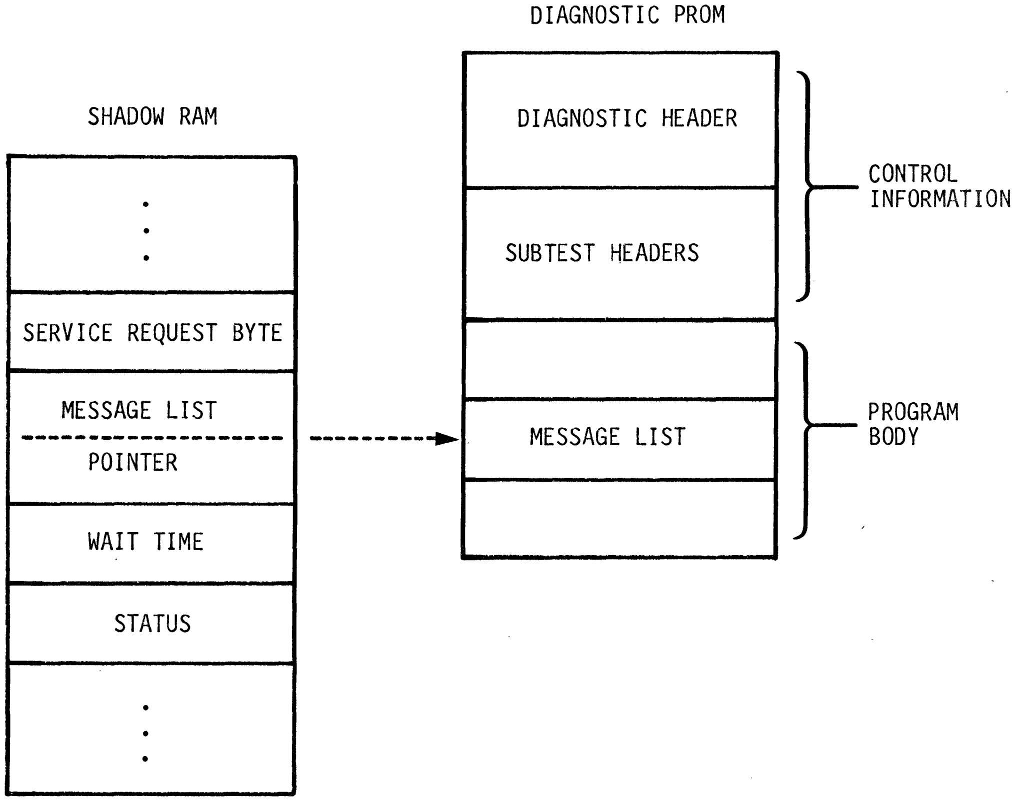


Figure 9-1. Message List (shaded area)

Messages can be from 1 to 20 characters in length. If more than 20 characters are required, messages may be linked, in which case multiple lines are displayed. The test program initiates a message output by storing a data byte in the Service Request Byte. A message can be one of two types: "Display and Pause" or "Display and Continue."

9.1.1 Display and Halt Messages

The MESSAGE PENDING LED indicator is illuminated, a beep is sounded, and the test program execution is paused. If the display is not being used to view the register, a memory or I/O message will be displayed. If the display is being used, the MSG key must be pushed to view the message. When the MSG key is pressed, the message will be displayed. Once the MSG key has been pressed, messages will be automatically displayed until a key is pressed that results in a display change. If more than one display line is associated with the message (linked message) the operator can step through the message by pressing the INCR key. To resume test execution, press the RUN key.

9.1.2 Display and Continue Messages

Similar to above except that test execution automatically resumes after the message is displayed. Note that a delay may be necessary to guarantee display stability long enough for human perception. To output a message of this type, the Service Request Byte consists of the message output bit ORed with the halt override bit or the wait bit.

To display a message, the diagnostic program will normally store the wait time, if any, in the Wait Time Byte, then store the address of the Message List in the Message List Pointer, and lastly, store the Message Output Request in the Service Request Byte.

9.2 MESSAGE LIST

A Message List consists of one or more message list entries, as shown in figure 9-2.

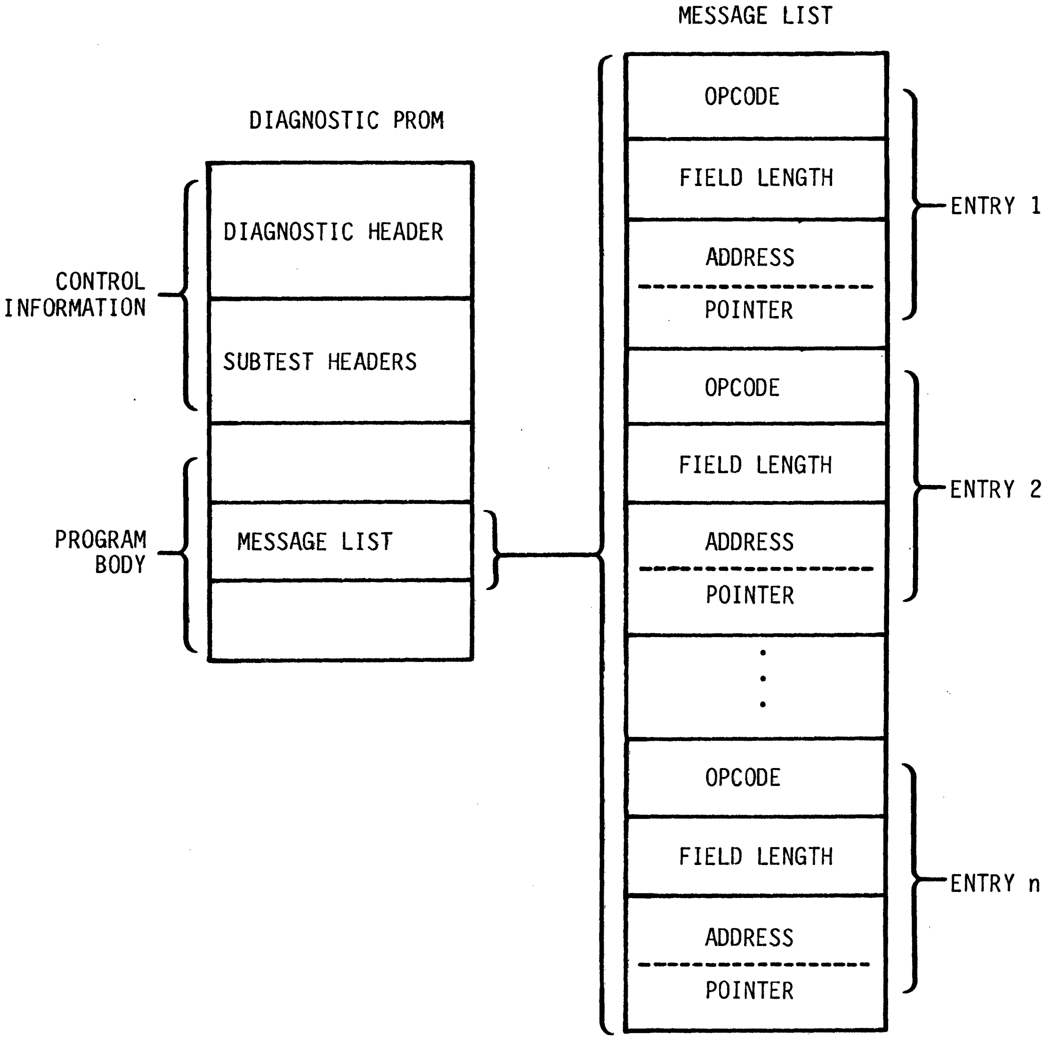
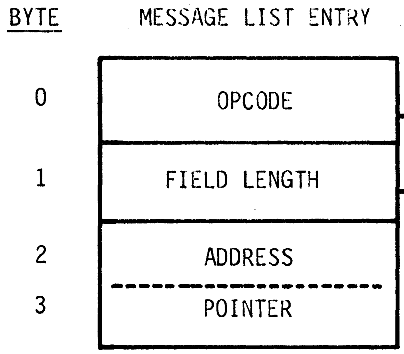


Figure 9-2. Message List (shaded area)

A description of the bytes of the Message List follows:



DESCRIPTION

Specifies the operation type and data format. The definition of the values for this byte are shown below:

HEX VALUE	MEANING
00	Output only, input not allowed.
01	Field allows operator input.
02	The data displayed or input is in <u>hexadecimal</u> format.
04	Linked message. One or more additional messages.
0A	The data displayed or input is in <u>binary</u> format.
20	The data displayed or input is in <u>decimal</u> format.
40	The data displayed or input is <u>signed</u> (+ or -).
80	Last entry of the Message List.

Any of the above may be ORed together.

Length of the field displayed. The maximum size of the field for each data type is defined below:

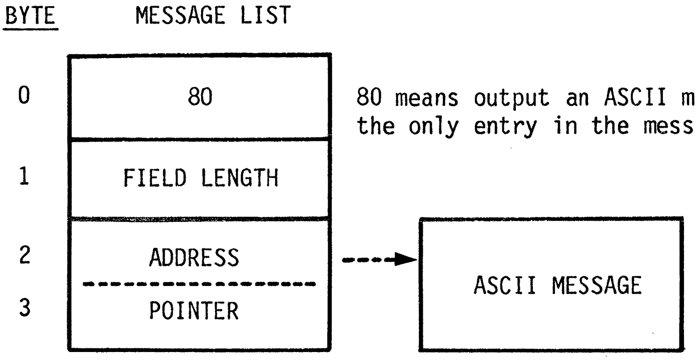
DATA TYPE	SIZE OF FIELD
ASCII	Number of characters to be displayed.
Hexa-decimal	Number of digits to be displayed.
Binary	Number of bits to be displayed.
Decimal	1 to 5 decimal digits.

(See section 9.3 also.)

Message List description (continued):

BYTE	MESSAGE LIST ENTRY	DESCRIPTION
0	OPCODE	
1	FIELD LENGTH	
2	ADDRESS	Address of the associated information. (High byte, low byte.) The types of information pointed to are: ASCII MESSAGE LINKED MESSAGE LIST DATA STORED IN SHADOW RAM
3	POINTER	

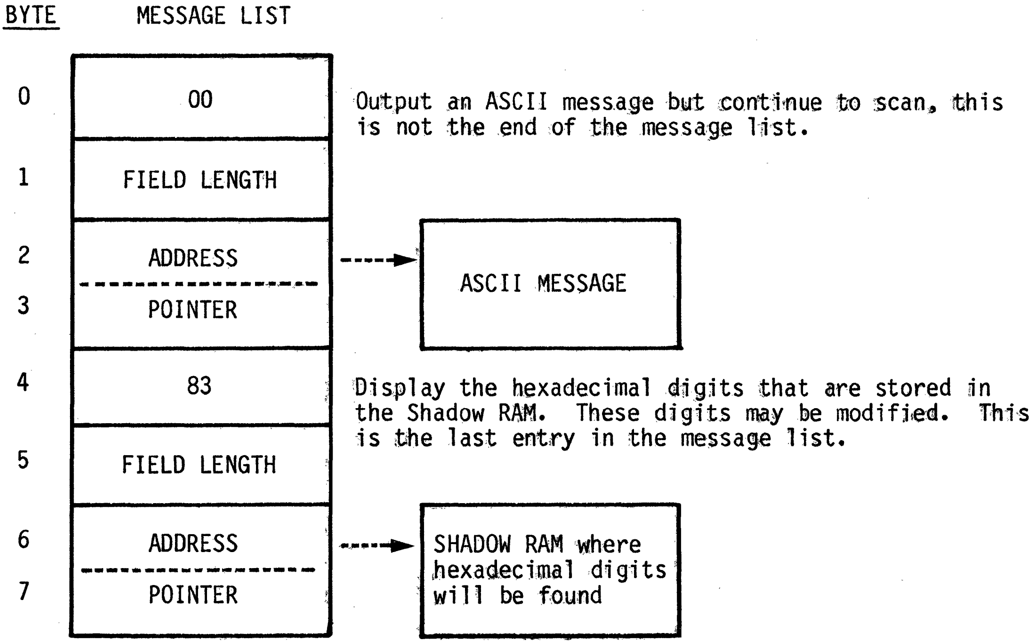
Figure 9-3 shows an example of a simple ASCII message.



80 means output an ASCII message, and that this is the only entry in the message list.

Figure 9-3. Simple ASCII Messages

Figure 9-4 shows a Message List with an ASCII message and an hexadecimal data input storage area.

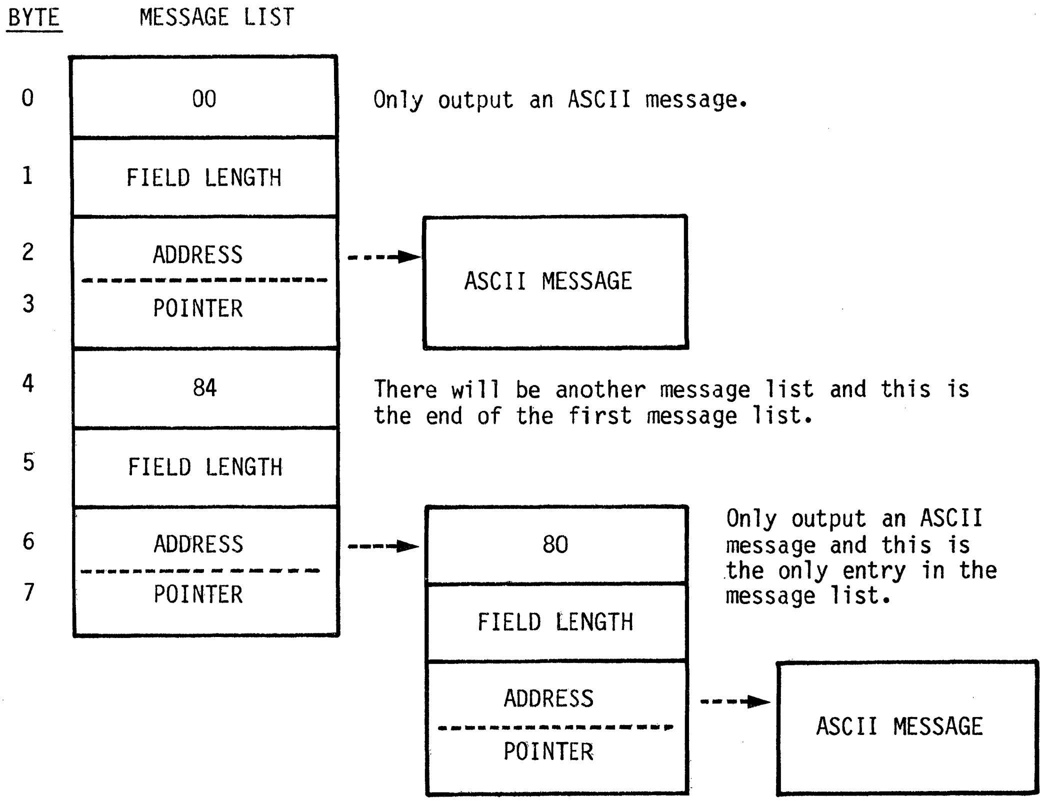


Output an ASCII message but continue to scan, this is not the end of the message list.

Display the hexadecimal digits that are stored in the Shadow RAM. These digits may be modified. This is the last entry in the message list.

Figure 9-4. ASCII Message and Hexadecimal Data

The last entry on a Message List must always be designated as last, even if the last entry is a link entry. See figure 9-5.



Only output an ASCII message.

There will be another message list and this is the end of the first message list.

Only output an ASCII message and this is the only entry in the message list.

Figure 9-5. Linked List of Two ASCII Messages

To view the second ASCII message, the operator would push the INCR key.

The last Message List of a group of linked Message Lists may also be a linked list and may point to the first (or any other) Message List. This allows the operator to continually "scroll" a number of messages. An example of this is the REGISTER display.

9.3 DATA FORMATS

The internal format of data associated with Message Lists is in either ASCII or hexadecimal format. The internal data types carried in binary are as follows:

9.3.1 Hexadecimal

Each hexadecimal character is represented internally by four bits. The number of characters allowed is limited by the display length and is specified by the Field Length entry of the Message List. The data is carried right-justified internally. In the case of an odd number of hexadecimal characters the most significant nibble (4 bits) of the internal field is set to zero by the uSA.

9.3.2 Binary

Binary is a variation of the hexadecimal format, in that, before the BINARY key is pressed, the data is input/output in hexadecimal format. The data is still right-justified hexadecimal internally. The Length Field entry of the Message List must specify the number of binary characters. The number of characters displayed for binary will be the nearest MOD 4 number. For example, if a 10-bit binary field is specified, then three hexadecimal characters will be displayed. If a hexadecimal character is entered that exceeds the specified binary field, then it is treated as an illegal input character and is not accepted.

Binary data is always displayed in the last "n" character position of the display (right-justified). Therefore, a binary field must be the last field of display.

9.3.3 Decimal

Decimal data is converted to hexadecimal when the ENTER key is pressed. Decimal data is limited to one to five characters (0 - 65,535) in length and is always stored in a two-byte field (right-justified) as an unsigned 16-bit hexadecimal number. When a decimal field is to be displayed, it is converted from hexadecimal format to decimal format. If the value exceeds the range of digits specified in the message list, "ERR" will be displayed (right-justified) and a warning beep will be sounded.

9.3.4 Signed

A signed field is stored internally as an ASCII plus (+) or minus (-).

Appendix A

ASCII CHARACTER SET

Table A-1 contains the 7-bit ASCII hexadecimal code for each character that can be viewed on the uSA front panel display.

Table A-1. ASCII Character Set in Hexadecimal Representation

7-bit Hexadecimal Number	Character	7-bit Hexadecimal Number	Character
20	SPACE	40	@
21	!	41	A
22	RIGHT DOUBLE "	42	B
23	ALL SEGMENTS ON	43	C
24	$	44	D
25	%	45	E
26	MU	46	F
27	'	47	G
28	(	48	H
29	)	49	I
2A	*	4A	J
2B	+	4B	K
2C	,	4C	L
2D	-	4D	M
2E	.	4E	N
2F	/	4F	O
30	0	50	P
31	1	51	Q
32	2	52	R
33	3	53	S
34	4	54	T
35	5	55	U
36	6	56	V
37	7	57	W
38	8	58	X
39	9	59	Y
3A	:	5A	Z
3B	;	5B	SIGMA
3C	°	5C	BACKSLASH
3D	=	5D	]
3E	LEFT DOUBLE "	5E	->
3F	?	5F	<-

Appendix B

KEY SUMMARY

KEY	DESCRIPTION	PAGE
ATTN	Suspends remote operations and returns to local mode. See the Communications Option manual for details.	4-14
BINARY	Displays data byte of the current display value in the binary mode.	4-13
BREAK	Displays and modifies the hardware breakpoint. Options are provided to select read and write, read only, or write only access to a specified memory address. Operator can establish a pass count for each breakpoint and/or jump to an address.	4-6
COUNT	Enables counting of pulses or pulse transitions. Enables OPTSEL key to establish conditions that change default START and STOP values, source of DATA, integration constant for display, and other special events.	4-12
DECR	Decrements the memory or I/O addresses.	4-13
DISABLE	Used with the BREAK key to clear breakpoint.	4-13
ENABLE	Used with the BREAK key to enable breakpoint.	4-13
ENTER	Enters display values and terminates the operation.	4-10
FILL	Allows the RAM between two addresses to be filled with a specified data byte.	4-4
FILTER	Provides digital filter to screen noise from the data probe. Filters are: None, 50, 100, and 150 nanoseconds.	4-12
FREQ	Allows frequency measurements to be taken with the data probe. Enables OPTSEL key to establish conditions that change default START and STOP values, integration constant for displayed value, and other special events.	4-12
HEX KEYPAD	Contains the hexadecimal character set 0-9 and A-F. The hex keypad is used to enter data and address values.	4-10
I/O	Writes and reads the user's microprocessor I/O ports in hexadecimal or binary mode.	4-6
INCR	Increments the memory and I/O addresses, linked displays, and register content display.	4-13
INTRVL	Allows interval or pulse width measurements. Enables OPTSEL key to establish conditions that change default START and STOP values, source of CLOCK, integration constant for displayed value, and other special events.	4-12

KEY	DESCRIPTION	PAGE
LOGON	Intepretive log-on procedure enables uSA to communicate with host computer.	4-14
MEMORY	Displays or modifies memory contents in hex or binary mode.	4-8
MSG	Displays messages placed in the emulator display area by the diagnostic program. Messages for display are indicated on the front panel via the MESSAGE PENDING indicator. Multiple line messages are displayed with the INCR key.	4-9
OPT/MEM	Enables remote communication option memory.	4-5
OPTSEL	Used with fault detection to implement start, stop, clock/data, display, and special criteria events.	4-13
OPT1	Transmits data in the uSA RAM or PROM out the RS-232 port.	4-11
OPT2	Moves data from user's memory to uSA RAM, moves uSA RAM to uSA memory, moves front panel PROMs to uSA RAM or user memory.	4-11
OPT3	Reserved for future use.	4-11
PROM/MEM	Overlays front panel PROMs into the user's memory space.	4-5
REGISTER	Displays or modifies register contents in hexadecimal or binary mode.	4-9
REMOTE	Allows the uSA to establish the communications option. See Communications Option manual for details.	4-14
RESET	Forces a hardware reset of the emulator microprocessor.	4-3
RESTART	Resets the uSA to initialized power on state and tests master RAM, emulator ROM, and system ROM.	4-2
RUN	Starts the execution of the user's microprocessor at a specified address contained in the PC register.	4-3
RUN/DISP	Runs and displays selected memory, registers, and I/0 ten times per second.	4-3
SIG	Allows signature measurements to be taken using the data probe. Enables OPTSEL key to establish conditions that change resident START and STOP values, source of CLOCK, integrated constant for display value, and other special events.	4-12
STEP	Allows single-step program execution of the user's microprocessor.	4-3
SUBSEL	Selects one of 99 subtests in front panel PROMs.	4-5
TEST	Performs a self-test of the uSA, checking RAM, ROM, front panel indicators, and internal functions.	4-11
THRESH	Reserved for future use.	4-12

Appendix C

ERROR MESSAGES

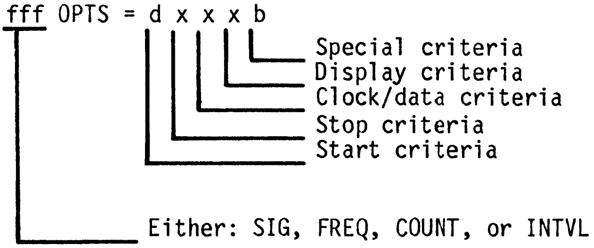
MESSAGE	DESCRIPTION
uSA CONDITION 01	Master RAM failure
uSA CONDITION 02	Emulator ROM failure
uSA CONDITION 03	Master ROM failure
uSA CONDITION 04	Emulator not responding
uSA CONDITION 05	Signature ROM failure
uSA CONDITION 06	Shadow RAM failure

Appendix D

OPERATING OPTIONS

D.1 FAULT DETECTION OPTIONS

The operator selects the signature measurement by pressing the fault detection key and then the OPTSEL key. The following is displayed:



The operator specifies the criteria by digits which have pre-assigned meanings. The digits and their meanings are described in the following sections.

D.2 START DIGIT CONDITIONS

START DIGIT	CONDITION	SIGNATURE	FREQUENCY	COUNT	INTERVAL
0	External start probe, negative going edge	X	X	X	X
1	External start probe, positive going edge	X	X	X	X
2	External data probe, negative going edge	X	X	X	X
3	External data probe, positive going edge	X	X	X	X
4	Address compare	X	X	X	X
5	Address compare and external start probe, negative going edge	X	X	X	X
6	Address compare and external start probe, positive going edge	X	X	X	X
7	Address compare and external data probe, negative going edge	X	X	X	X
8	Address compare and external data probe, positive going edge	X	X	X	X
9	Start immediately	X	X		

D.3 STOP DIGIT CONDITIONS

STOP DIGIT	CONDITION	SIGNATURE	FREQUENCY	COUNT	INTERVAL
0	Using external stop probe, negative going edge	X		X	X
1	Using external stop probe, positive going edge	X		X	X
2	Using external data probe, negative going edge	X		X	X
3	Using external data probe, positive going edge	X		X	X
4	Address compare	X		X	X
5	Address compare and external stop probe, negative going edge	X		X	X
6	Address compare and external stop probe, positive going edge	X		X	X
7	Address compare and external data probe, negative going edge	X		X	X
8	Address compare and external data probe, positive going edge	X		X	X
9	Count	X	X		
A	Count and external stop probe, negative going edge	X			
B	Count and external stop probe, positive going edge	X			
C	Count and address compare	X			
D	Count and address compare and external stop probe, negative going edge	X			
E	Count and address compare and external stop probe, positive going edge	X			

D.4 CLOCK/DATA CONDITIONS

CLOCK/ DATA DIGIT	CLOCK SOURCE	START/ STOP SYNC	DATA SOURCE	SIGNATURE CLOCK	SIGNATURE	FREQUENCY	COUNT	INTERVAL
0	Clock probe	+	Data probe	+	X			
1	Clock probe	+	Data probe	-	X			
2	Clock probe	-	Data probe	+	X			
3	Clock probe	-	Data probe	-	X			
4	OPREQ	+	Data probe	+	X			
5	OPREQ	+	Data probe	-	X			
6	OPREQ	-	Data probe	+	X			
7	OPREQ	-	Data probe	-	X			
8			Data probe			X	P	X
9			OPREQ				P	
A			Data probe (Transistions)				T	

P = Pulse Count
T = Transition Count

D.5 DISPLAY CONDITIONS

DISPLAY DIGITS	MEANING	SIGNATURE	FREQUENCY	COUNT	INTERVAL
0	Average of 10 samples		X	X	X
1	No Average. No wait	X	X	X	X
2	Wait 100 msec. between displays	X	X	X	X
3	Wait 200 msec. between displays	X	X	X	X
4	Wait 300 msec. between displays	X	X	X	X
5	Wait 400 msec. between displays	X	X	X	X
6	Wait 500 msec. between displays	X	X	X	X
7	Wait 700 msec. between displays	X	X	X	X
8	Wait 1 second between displays	X	X	X	X
9	Wait 2 seconds between displays	X	X	X	X
A	Wait 5 seconds between displays	X	X	X	X

D.6 SPECIAL CRITERIA

The special criteria digit indicates how memory is to be mapped. If zero, all memory except test diagnostic memory is mapped to the UUT. If one, all memory is mapped to the uSA and all control, address and data signals are passed to the UUT. When mapped to the uSA, memory control and data signals from the UUT are disregarded. This allows fault analysis on the UUT memory and BUS structure.

D.7 BREAKPOINT OPTIONS

BITS	FUNCTION
3	1 = Break On Write Access
2	1 = Break On Read Access
1	1 = Pass Count Enable
0	0 = Pause Microprocessor 1 = Jump to Address

The default value of OPT = C breaks on read or write access and pauses the microprocessor.

D.8 FILTER OPTIONS

VALUE	FILTER
0	No filter
1	50 nanosec filter
2	100 nanosec filter
3	150 nonosec filter

Appendix E

PARTS LIST

Table E-1. Indexed by Description

PART NUMBER	DESCRIPTION
13000033	AC Distribution PC-board Assembly
90010013-01	Comm RAM Cable
13000015-02	Comm RAM PC-board Assembly
90010014	Data Probe Cable Assembly
13000009	Data Probe PC-board Assembly
15000029	DC Power Supply
13000044	Debug PC-board Assembly
13000017-02	Display Board PC-board Assembly
15000026	Ground Clip for Data Probe
13000002-01	Keyboard PC-board Assembly
13000001	Motherboard PC-board Assembly
90010016	Pod Cable Assembly
13000004	Signature Control PC-board Assembly
13000018	Signature PC-board Assembly
90060005	Test Clips
13000027	Threshold PC-board Assembly
87000033	uSA Communications Option Users Manual
87000001	uSA User's Manual
15000099	Z80 Emulator Interface Assembly
13000098-02	Z80 Emulator PC-board Assembly
15000078	Z80 Emulator Probe Assembly
87000015	Z80 Emulator Users Manual
13000014-02	2708 Control Processor PC-board Assembly
13000014-03	2716 Control Processor PC-board Assembly
90010022	34-Connector Emulator Cable
20580460	40-Pin Augat Connector
90010007	50-Connector Emulator Cable
15000016	6800 Emulator Interface Assembly
13000005-02	6800 Emulator PC-board Assembly
87000003	6800 Emulator User's Manual
15000016	6802 Emulator Interface Assembly
13000005-02	6802 Emulator PC-board Assembly
15000106	6802 Emulator Probe Assembly
87000035	6802 Emulator User's Manual
15000179	8021 Emulator Probe Assembly
15000147	8048 Emulator Probe Assembly
13000126	8048/8021 Emulator I/F PC-board Assembly
15000148	8048/8021 Emulator Interface Assembly
13000125	8048/8021 Emulator Slave PC-board Assembly
87000024	8048/8021 Emulator User's Manual
15000018	8080 Emulator Interface Assembly
13000012-02	8080 Emulator PC-board Assembly
87000005	8080 Emulator User's Manual
15000109	8085 Emulator Interface Assembly
13000108-02	8085 Emulator PC-board Assembly
15000054	8085 Emulator Probe Assembly
87000011	8085 Emulator User's Manual

Table E-2. Parts List Indexed by Part Number

PART NUMBER	DESCRIPTION
13000001	Motherboard PC-board Assembly
13000002-01	Keyboard PC-board Assembly
13000004	Signature Control PC-board Assembly
13000005-02	6800 Emulator PC-board Assembly
13000005-02	6802 Emulator PC-board Assembly
13000009	Data Probe PC-board Assembly
13000012-02	8080 Emulator PC-board Assembly
13000014-02	2708 Control Processor PC-board Assembly
13000014-03	2716 Control Processor PC-board Assembly
13000015-02	Comm RAM PC-board Assembly
13000017-02	Display Board PC-board Assembly
13000018	Signature PC-board Assembly
13000027	Threshold PC-board Assembly
13000033	AC Distribution PC-board Assembly
13000044	Debug PC-board Assembly
13000098-02	Z80 Emulator PC-board Assembly
13000108-02	8085 Emulator PC-board Assembly
13000125	8048/8021 Emulator Slave PC-board Assembly
13000126	8048/8021 Emulator I/F PC-board Assembly
15000016	6800 Emulator Interface Assembly
15000016	6802 Emulator Interface Assembly
15000018	8080 Emulator Interface Assembly
15000026	Ground Clip for Data Probe
15000029	DC Power Supply
15000054	8085 Emulator Probe Assembly
15000078	Z80 Emulator Probe Assembly
15000099	Z80 Emulator Interface Assembly
15000106	6802 Emulator Probe Assembly
15000109	8085 Emulator Interface Assembly
15000147	8048 Emulator Probe Assembly
15000148	8048/8021 Emulator Interface Assembly
15000179	8021 Emulator Probe Assembly
20580460	40-Pin Augat Connector
87000001	uSA User's Manual
87000003	6800 Emulator User's Manual
87000005	8080 Emulator User's Manual
87000011	8085 Emulator User's Manual
87000015	Z80 Emulator Users Manual
87000024	8048/8021 Emulator User's Manual
87000033	uSA Communications Option Users Manual
87000035	6802 Emulator User's Manual
90010007	50-Connector Emulator Cable
90010013-01	Comm RAM Cable
90010014	Data Probe Cable Assembly
90010016	Pod Cable Assembly
90010022	34-Connector Emulator Cable
90060005	Test Clips

Appendix F

WARRANTY AND SERVICE PROGRAM

Millennium Systems products were designed and manufactured to strict performance standards and tested to criteria sufficient to provide the user with trouble-free service. Concurrently, our customer service policy is designed to provide our customers with prompt, effective repair services both during and after the warranty period.

F.1 WARRANTY

The Seller warrants that the products sold hereunder will at time of shipment be free from defects in material and workmanship and will conform to the Seller's specifications, or as appropriate, to the Buyer's specifications which have been accepted in writing by the Seller for a period of 120 days from date of initial shipment. Seller's obligation for any breach of this warranty shall be limited, at Seller's election, to either refunding the purchase price of the defective products or repairing or replacing the same; provided that Buyer shall have (1) given written notice of nonconformance to Seller within 120 days from date of initial shipement, and (2) obtained a Customer Return Material Authorization Number for non-conforming products, and returned such products FOB Seller's plant or authorized repair center within thirty (30) days from expiration of said 120-day period. In no event shall Seller have any obligation hereunder for defects in respect of which Seller has not received written notice within said 120-day period. The warranty shall not apply to any products that Seller determines have, by Buyer or otherwise, been subjected to operating and/or environmental conditions in excess of the maximum values established, therefore in the applicable specifications or otherwise have been subjected to mishandling, misuse or neglect, or to any repair, alteration or use which alters the physical or electrical properties of said products. Transportation charges for the return to the Buyer shall be paid by Seller within the contiguous 48 United States. If Seller determines that the products are not defective, Buyer shall pay Seller all costs of handling and transportation. The warranty outside the contiguous United States excludes all costs of shipping, customs clearance and related charges.

Seller may repair or replace returned products at their sole option. Such repair or replacement shall not extend the warranty period. Buyer's remedies are expressly limited to Seller's obligations as stated in this paragraph.

In no event will Seller be liable to Buyer or to any customer of Buyer for any incidental or consequential damages or other commercial loss of whatever nature and however occasioned.

THIS WARRANTY EXTENDS TO BUYER ONLY AND NOT TO BUYER'S CUSTOMERS OR USERS OF BUYER'S PRODUCTS AND IS IN LIEU OF ALL OTHER WARRANTIES WHETHER EXPRESS, IMPLIED, OR STATUTORY INCLUDING IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

F.2 SERVICE

Should service be required, Millennium Systems Customer Service Program is easy to use. Merely follow these steps:

1. Refer to section of Manual entitled "Trouble Shooting" and locate the various modes or symptoms. A checklist is given for possible failure modes. The checking of each symptom should enable the user to find most common faults. After finding the defect, go to step #3 or,

2. Use the (optional) automated self-diagnostic package to identify and verify the defective board or module. After finding the defect, go to step #3.

3. Call one of Millennium's hot-lines listed in the preface and ask for the Customer Service Manager who will assist you in providing spare parts and service. Be prepared to provide the Model Number, Serial Number, date of purchase and description of failure mode.

4. The Customer Service Manager will issue (if necessary) a Return Material Authorization Number which would be included on any paperwork accompanying a return. Be sure to pack the defective part securely. Include the RMA number, the name and phone number of the person requesting the repair, and ship it prepaid to Millennium Systems.

5. The Customer Service Manager will ask you for a Purchase Order Number (or certified check) for a new or equivalent to new replacement part which Millennium Systems will ship within 48 hours, freight prepaid (in contiguous 48 states).

6. If the returned part meets the conditions stated in the warranty, Millennium Systems will issue a full credit against your Purchase Order. If the warranty has expired or other warranty conditions have not been complied with, Millennium will invoice you for the difference between the spare part price less the return allowance.

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DOCUMENT REVIEW FORM

MICROSYSTEM ANALYZER
USERS MANUAL

Publication No. 87000001
April 1980
Release 2.0

Dear Customer:

Your comments concerning this document help us to produce better documentation for you.

GENERAL COMMENTS

☐ Easy to read?
☐ Well organized?
☐ Accurate?
☐ Complete?
☐ Well illustrated?
☐ Suitable for your needs?

SPECIFIC COMMENTS AND CORRECTIONS

Reference	Page

Please sent your comments to:

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19050 Pruneridge Avenue
Cupertino, Calif. 95014
ATTN: Publications

MILLENNIUM

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