ASYNCHRONOUS SIGNATURE PROBE

OPTION 9000A-006

OPERATION MANUAL

JANUARY, 1986 2ND PRELIMINARY VERSION

John Fluke Mfg. Co., Inc. Everett, WA 98206

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Section 1
Introduction

1-1. TROUBLESHOOTING BEYOND THE KERNEL

The combination of the 9000 Series Microsystem Troubleshooter and the Asynchronous Signature Probe Option provide an ideal troubleshooting tool. The 9000 Series Troubleshooter, already popular for testing the kernel and for providing general stimulus, is an ideal tool for checking non-kernel areas when it is equipped with the Asynchronous Signature Probe Option.

With this option installed, the Troubleshooter can be used to solve difficult off-the-bus asynchronous problems with ease. The Troubleshooter is an ideal stimulus while the Asynchronous Signature Probe Option extends the troubleshooting ability of the combination into difficult areas such as dynamic RAM, video RAM, and exotic DMA systems.

The Asynchronous Signature Probe Option can be used in the immediate mode like any other signature equipment, but the real versatility of this option is its ability to be incorporated into 9000-type test programs. In this mode, the probe can be used in conjunction with the built-in test functions of the Troubleshooter. On-the-bus testing can be integrated with off-the-bus testing.

1-2. OVERVIEW OF SIGNATURE TROUBLESHOOTING

The signature method of troubleshooting can be used to isolate faulty components in a variety of troubleshooting and test environments. While the actual procedure for using signature troubleshooting varies from equipment to equipment, the basic principle applies. The equipment under test is stimulated, by means of internally stored test routines or an external piece of stimulus equipment, in such a way that repeated signal patterns appear at meaningful test nodes. The signal pattern consists of transitions that occur at specific times relative to the basic timing of the equipment. The pattern is repeated on a regular basis and with the same timing relationships. Because the signal pattern is always the same, it may be labelled with a signature.

Since it is difficult to make a note of the signature appearing at each meaningful node using logic level and timing notation, a system is used to express the signature in four-character hexadecimal notation. Under this system, the signature equipment generates the hexadecimal signature from two types of inputs. One input monitors the signals appearing at a specific test node. The other input provides certain control signals from the UUT. The signature, which is a function of the logic level transitions and their timing relationships, is displayed on the signature equipment.

When equipment troubles exist, the signature differs from the expected signature at those nodes affected by the fault. Using the signature method of troubleshooting, the operator checks the signatures at various test nodes in the defective equipment. The present signatures are compared with those taken when the equipment was operating normally. When a signature is found that differs from the normal signature, it is usually a simple matter to trace **back** through the circuit to isolate the fault.

1-3. PURPOSE OF THE EQUIPMENT

Signature troubleshooting supplements the basic functions of the Troubleshooter. This method of troubleshooting is used in situations where the test functions of the Troubleshooter alone do not provide adequate results. This situation usually exists when a fault occurs in a circuit area that operates asynchronously with respect to the processor. In this case, the troubleshooter cannot detect the fault since it is able to examine only processor-synchronous events.

Although the Troubleshooter may not have "visibility" or access into some areas of the UUT, it is usually able to stimulate all functional areas in a consistent and repetitive manner. This type of stimulus is required to take meaningful signatures. The ability of the Troubleshooter to stimulate the UUT makes it an effective tool for signature-type fault isolation methods.

The Asynchronous Signature Option 9OOOA-006 provides additional Troubleshooting capability for the 9OOOA series Troubleshooters by using signature-type fault-isolation, events counting, and test-node waveform capture. Control signals taken from the UUT and used to establish the signature allow asynchronous operation with the Troubleshooter.

The Asynchronous Signature Option takes signatures at UUT test nodes operating at clock speeds of up to 25 MHz. For counting events, the number of data transitions appearing at the probe are accumulated up to a total of 16,777,215.

A waveform display feature permits the Troubleshooter to display a representation of the data appearing at the data probe. Thw waveform feature is useful for determining the time interval between two signal transitions. The waveform displayed shows the last 640 nanoseconds of data received by the probe before the signature-gathering operation is terminated. The display shows logic high, logic low, and tri-state levels.

During troubleshooting operations, the Troubleshooter display is used to notify the operator of all test conditions and values. The basic functions of the Troubleshooter, in conjunction with a suitable Interface Pod, provide the necessary stimulus for the unit under test (UUT) during signature troubleshooting operations.

All of these features may be accessed while you are operating the Troubleshooter in the immediate mode by using the keyboard and display. All features may also be accessed by the use of test programs that pass control and test results through registers.

1-4. EQUIPMENT DESCRIPTION

1-5. General

As shown in Figure l-l , the Asynchronous Signature option consists of the Asynchronous Signature Module mounted within the Troubleshooter case, a separate Clock Module that connects to the Troubleshooter, and operating programs contained on a magnetic tape cassette. (For the Model 9020, programs are executed from within the host computer.)

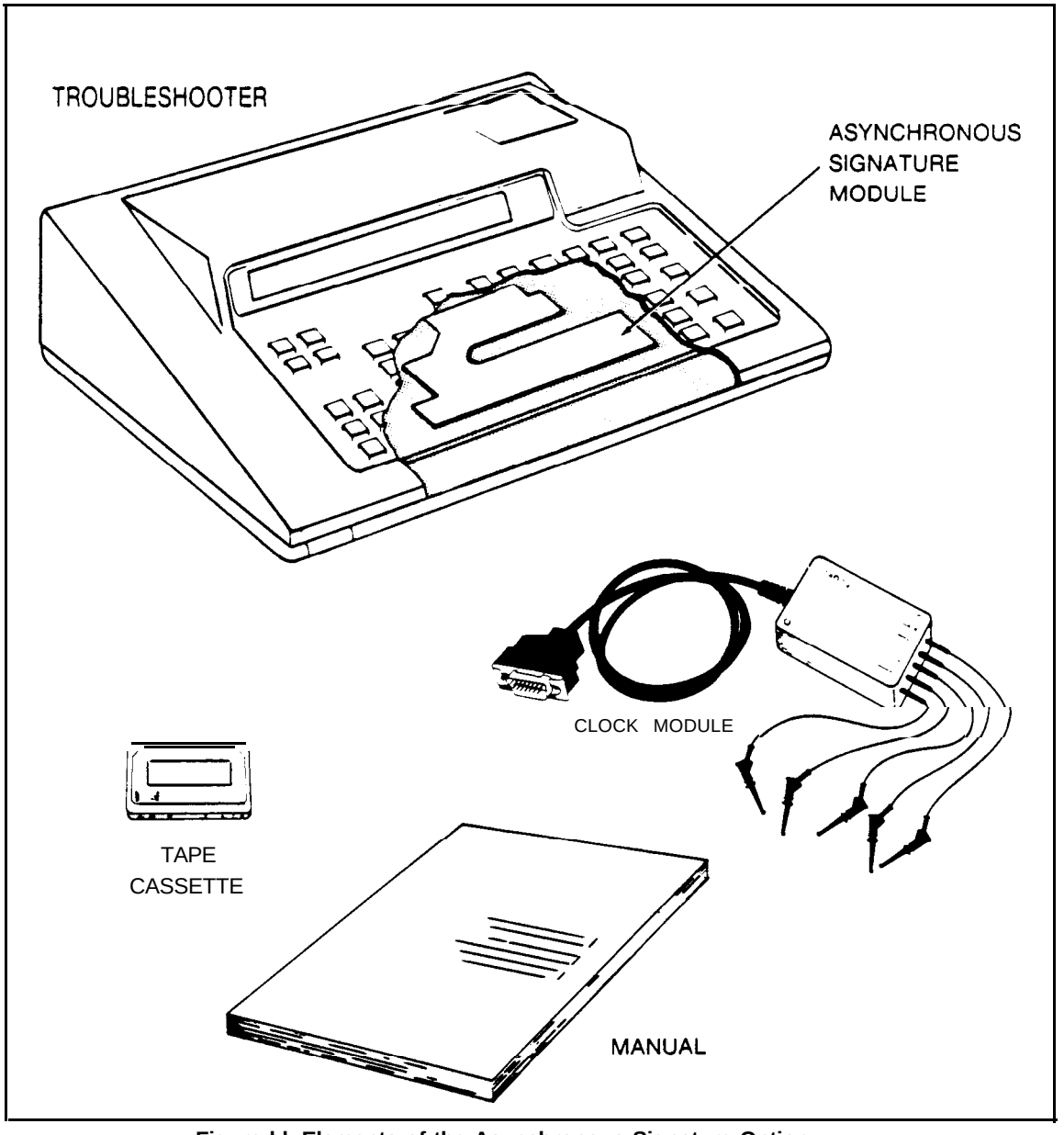

Figure l-l. Elements of the Asynchronous Signature Option

1-6. The Clock Module

The Clock Module provides interface and protection between the Troubleshooter and the UUT. Interface is required to effectively isolate the sources of the **clock,** start, stop, and enable signals located on the UUT from the input of the Troubleshooter. A fuse in the ground line provides the necessary protection. An input to the Troubleshooter from the Clock Module provides an indication of the fuse condition.

The **Clock** Module connects to the Troubleshooter with a 15-pin connector located below the front panel of the Troubleshooter. Connection to the UUT is made by up to five clip leads that protrude from the Clock Pod. A clip lead is provided for each of the control signal inputs (start, stop, clock, and enable), and one is provided for the ground connection to the UUT.

1-7. The Asynchronous Signature Module

The Asynchronous Signature Module is a printed circuit board located within the Troubleshooter. It accepts the start, stop, **clock,** and enable signals from the Clock Module, and the data stream from the Troubleshooter **data** probe. The Asynchronous Signature Module uses these inputs to generate the corresponding signature, event count, and waveform data. The module sends the calculated signature and event count over the pod bus to the Troubleshooter for display on the front panel.

In addition to the signature and events count functions, a set of registers within the module stores the latest 640 nanoseconds of the data stream gathered by the data probe. The module sends this data to the Troubleshooter for display on the front panel as a waveform.

1-8. The Cassette Tape

The Asynchronous Signature Option in the models 9005A and 9010A is operated by a series of programs contained on a magnetic tape cassette. Once the programs are loaded into the Troubleshooter RAM, operation of the Troubleshooter in the signature mode is afforded by several front panel keys. Appropriate displays provide the necessary interaction between the Troubleshooter and the operator during signature operations. Operation of the 9020A is a function of the host computer or instrument controller.

1-9. ORGANIZATION OF THIS MANUAL,

This manual documents the Asynchronous Signature Option to the 9000A series Troubleshooters. The manual provides information for the operator of the equipment (Operation), for the test engineer (Test Preparation), for the programmer (Remote Control of the 9020A), and for the service personnel (Theory of Operation and Maintenance). Operation, programming, and repair of the basic 9000A Series Troubleshooter are documented in the appropriate manual(s).

1-10. SPECIFICATIONS

Table 1-1 lists the specifications for the Asynchronous Signature Probe Option.

Table 1-1. Asynchronous Signature Probe Option Specifications

SYNCHRONIZATION AND CONTROL	
Start Event:	A selectable positive or negative edge on the Start line, or the Sync signal from the Interface Pod (when used).
Stop Event:	A selectable positive or negative edge on the Stop line, or the Sync signal from the Interface Pod (when used).
Clock Event:	A selectable positive or negative edge, or a combination of both, on the Clock line; or the Sync signal from the Interface Pod (when used).
Enable Event:	A selectable positive or negative level on the Enable line.
ELECTRICAL	
Start, Stop, Clock, and Enable lines (through Clock Module):	
Impedance:	10 pF/44 kilohms nominal
Threshold:	1.4 volts
Overvoltage:	+/-15 volts maximum Clock Module ground lead is fuse-protected
Data Channel:	Uses standard data probe supplied with 9000A mainframe
TIMING	
Start, Stop, Clock, and Enable signals: 0 to 25 MHz	
Data Signals: 0 to 12.5 MHz	
Programmable delay in data path: 0 to 36 nanoseconds	
Programmable delay increment: 3 nanoseconds	

FUNCTIONS

Nodal Signatures: 4-digit CRC-16 algorithm

Transition Counting: 24 bits (0 to 16,777,216 counts)

Waveform Capture: 32 consecutive data samples at 20-nanosecond intervals. High, low, and tristate levels. The 32 samples terminate with the stop event.

SYSTEM COMPATIBILITY

Can be installed in the Fluke 9005A, 9010A, and 9020A mainframes.

PROGRAM CONTROL

All functions of the Asynchronous Signature Probe Option can be commanded from within a 9010A or 9005A user program. All data measured by this option may be tested in the program. A test program controlling the 9020A may command all option functions and retrieve measured data.

ENVIRONMENTAL

Storage:	-40 to +80 degrees C, rh <75% non-condensing
Operating:	0 to +50 degrees C, rh <75% non-condensing
	0 to +40 degrees C, rh <95% non-condensing

Section 2
Operation

2-1. INTRODUCTION

This section provides general information to assist in the operation of the 9005A and 9010A Troubleshooters equipped with the Asynchronous Signature Module. For operation of the Model 9020A Troubleshooter equipped with the Asynchronous Signature Module, refer to Section 6, Using the 9020A.

The information contained in this section applies to the Asynchronous Signature Module in a general sense and does not pertain to a specific troubleshooting/repair situation. This is true because a particular piece of equipment being tested or repaired requires specific user-supplied test and test setup documentation. The signature type test documentation for a particular UUT is typically provided by the test engineer for the equipment. The test documentation should follow the guidelines set forth in Section 3, Test Preparation.

The information provided in this section describes:

- The Troubleshooter keys that function in the signature mode
- How to make connections to the UUT
- How to enter the signature mode
- How to verify operation of the signature mode
- How to initialize the Troubleshooter in the signature mode
- How to take signature, event count, and waveform readings

As already mentioned, the operating information contained in this section is general in nature. The documentation provided by the test engineer supports the above operations by providing initialization parameters, connection points on the UUT for the Clock Module, location of test nodes, as well as valid signatures, event counts, and waveforms. Be sure to obtain this documentation before beginning to test or troubleshoot equipment using the Troubleshooter equipped with the Asynchronous Signature Module.

2-2. TROUBLESHOOTER FRONT PANEL

When you are operating the Troubleshooter in the signature mode, the functions of several front-panel keys differ from the functions described in the Troubleshooter Operation Manual. Figure 2-1 highlights the location of the Troubleshooter keys that are operative in the signature mode of operation.

- The SETUP key allows initialization of the Troubleshooter when it is operated in the signature mode. Initialization consists of selecting control signal edges (rising or falling), the ENABLE signal level, the amount of delay compensation, and the source of the START, STOP, and CLOCK signals (UUT or interface pod).

- The READ TAPE key causes the Troubleshooter to download the contents of the supplied cassette into memory.

- The READ PROBE key causes the Troubleshooter to read the data appearing at the probe tip. As a result of the Read operation, the Troubleshooter computes and displays the signature and the events count. The troubleshooter also stores a portion of the test signal waveform for display on the front panel when you press the MORE key.

- The READ key causes the Signature Module to halt a signature/event count (Read Probe) operation and displays the resulting signature and events count. The waveform is available when you press the MORE key.

- The STOP key allows other Troubleshooter functions to be performed. To return to the signature mode, press the EXEC, 1, and ENTER keys.

- The CONT key causes the Troubleshooter to continue operation at the point where the STOP key was pressed, provided no other key is pressed.

- The EXEC key allows execution of the programs previously loaded into the Troubleshooter memory.

- The MORE key causes the Troubleshooter to scroll the display to the next "line," such as going from signature/event count to waveform display. Where several "lines" exist, such as in the setup procedure, this key allows the sequential display of each line.

- The PRIOR key causes the Troubleshooter to scroll the display to the previous "line. "

- The numeric keys may be used during initialization procedures only to enter operation parameters for the various features and control signals.

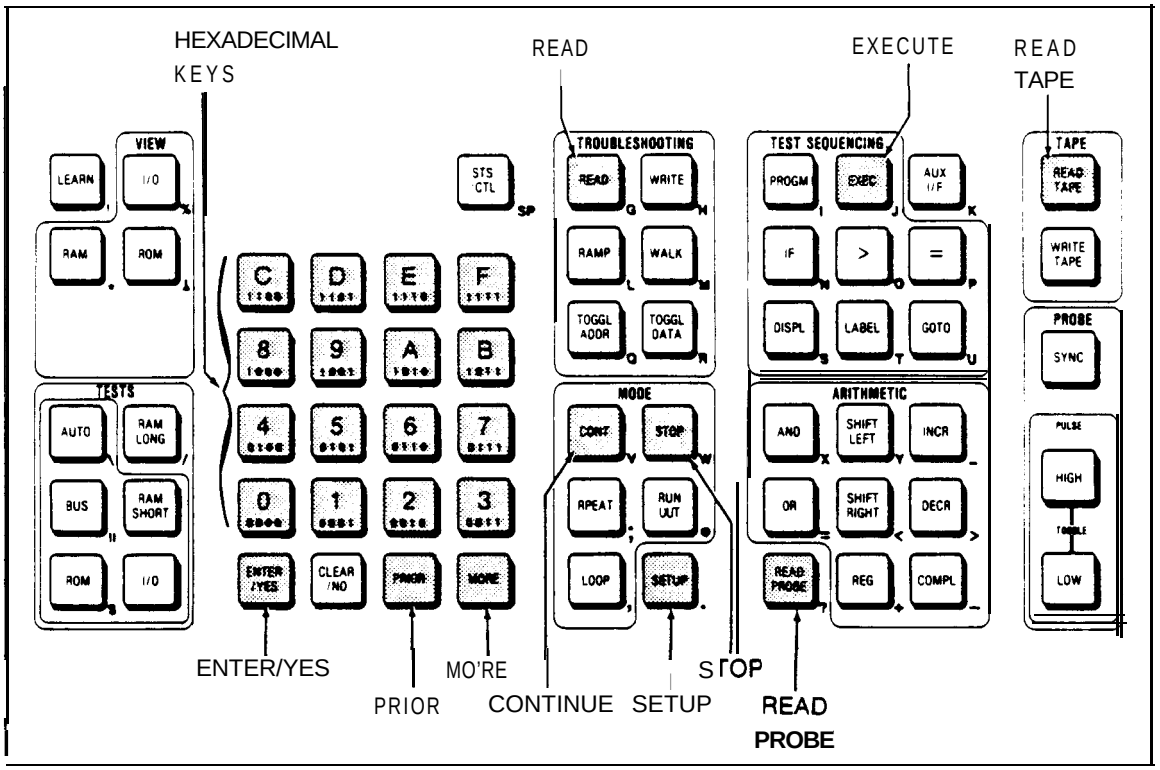

Figure 2-1. Troubleshooter Keys Used With the Signature Option

2-3. BACKING UP THE TAPE CASSETTE

Operation of the signature feature depends on several programs contained in the supplied cassette. To ensure that these programs are always available, even in the event of a problem with the cassette, it is good practice to make a back-up copy on a blank cassette before you use it the first time. To make a back-up copy of both sides of the cassette, proceed as follows:

1. Insert the master cassette into the tape drive with side A up and press the READ TAPE key on the Troubleshooter. The display reads

   READ TAPE - ARE YOU SURE?

2. Press the ENTER/YES key, and while the Troubleshooter reads and checks the contents of the cassette,the display reads

   READ TAPE WAIT

   When the Read Tape operation is complete, the display reads

   READ TAPE OK

3. Remove the cassette from the tape drive and install a blank cassette, with side A up.

4. Press the WRITE TAPE key, and the display reads

   WRITE TAPE - ARE YOU SURE?

5. Press the ENTER/YES key, and while the Troubleshooter writes the the contents of the troubleshooter memory the display reads

   WRITE TAPE WAIT

   When the Write Tape operation is complete, the display reads

   WRITE TAPE OK

6. Remove the cassette from the tape drive, turn it over and repeat steps 1 through 5 for side B.

7. Remove the cassette from the tape drive, label it, and store it in a safe place.

2-4. ENTERING THE SIGNATURE MODE

The first step in signature mode operation is to load the programs contained on the supplied cassette into the Troubleshooter's memory. To load these programs, proceed as follows:

1. Insert the cassette (with side A up) into the tape drive and press the READ TAPE key on the Troubleshooter. The display reads

   READ TAPE - ARE YOU SURE?

2. Press the ENTER/YES key, and while the Troubleshooter reads and checks the contents of the cassette the display reads

   READ TAPE WAIT

   When the Read Tape operation is complete, the display reads

   READ TAPE OK

   Remove the cassette from the tape drive.

3. Press the EXEC key, and the display reads

   EXECUTE PROGRAM (flashing cursor)

4. Enter 0 and press the ENTER/YES key. The display indicates that the Troubleshooter is ready for operation in the signature mode when it reads

   ASYNC SIGNATURE PROBE READY

2-5. INITIALIZATION (SETUP) OF THE SIGNATURE FUNCTION

2-6. Introduction

Before to operating the Troubleshooter in the signature mode, you must load the operating programs from the cassette (as described under Entering the Signature Mode), and make the following selections on the Troubleshooter:

0 Polarity of the control signals

0 Source of the control signals

0 Count limit for the CLOCK signal

0 Amount of delay compensation

0 Mode of the events counter (gated or free-running)

Since removing power causes the previous selections to be lost, these selections must be made each time the Troubleshooter is powered-up. The selection procedures presented in the following paragraphs assume that the factory-set default parameters for the initial display of each selection are made. In actual practice, the initial display is the last parameter selected since power was applied to the Troubleshooter.

In the setup procedures, the MORE and PRIOR keys are used to scroll through setup parameters. When a particular parameter is displayed, the 1 and 2 keys allow you to select the desired field for the parameter. The setup procedures that follow explain in detail the selection of each setup parameter. Once you have completed the setup procedures one time, simple use of the MORE, PRIOR, 1, and 2 keys will allow you to perform the setup operation.

2-7. Selecting the START Signal

The START signal may be a positive-going or negative-going edge, taken from the start lead of the Clock Module or the SYNC signal generated by the Interface Pod. Select the START signal for this particular UUT as follows:

1. Press the SETUP key, and the display reads

   START ON l)RISING 2)EXT START

   At this point it is possible to:

   a. Select the START signal parameters displayed above: positive-going edge and external source (UUT via the Clock Module), and then proceed to Selecting the STOP Signal. Perform step 4.

   b. Select the START signal to be (pod SYNC) from the Interface Pod. Proceed to step 2.

   c. Select a negative-going (falling edge) for the START signal. Proceed to step 3.

2. If you wish to select the SYNC signal generated by the Interface Pod as the source of the START signal, press the 2 key. The display reads

   START ON l)<edge type> 2)POD-SYNC

   To change the display back to the previous selection, press the 2 key a second time.

3. If you wish to select the falling edge of the selected START signal, press the 1 key. The display reads

   START ON l)FALLING 2)<source>

   To change the display back to the previous selection, press the 1 key a second time.

4. Press the MORE key, and proceed to Selecting the STOP Signal.

2-8. Selecting the STOP Signal

The STOP signal may be a positive-going edge or negative-going edge taken from the stop lead of the Clock Module or the sync signal generated by the Interface Pod. Select the STOP signal for this particular UUT as follows:

1. If you are selecting STOP signal parameters only, press the SETUP key and the display reads

   START ON l)<edge type> 2)<source>

   Press the MORE key and the display reads

   STOP ON l)RISING 2)EXT STOP

   At this point it is possible to:

   a. Select the STOP signal parameters displayed above (positive-going edge STOP signal external from the UUT via the Clock Module stop lead) and proceed to CLOCK signal selection. Proceed to step 4.

   b. Select the STOP signal to be from the InterFace Pod (pod SYNC). Proceed to step 2.

   c. Select a negative-going (falling edge) for the STOP signal. Proceed to step 3.

2. If you wish to select the sync signal generated by the Interface Pod, as the source of the STOP signal, press the 2 key. The display reads

   STOP ON l)<edge type> 2)POD-SYNC

   To change the display back to the previous selection, press the 2 key a second time.

3. If you wish to select the falling edge of the selected STOP signal press the 1 key. The display reads

   STOP ON l)FALLING 2)<source>

   To change the display back to the previous selection, press the 1 key a second time.

4. Press the MORE key, and proceed to Selecting the CLOCK signal.

2-9. Selecting the CLOCK Signal

The CLOCK signal may be a positive-going edge, a negative-going edge, or both. It may be taken from the clock lead of the Clock Module or the sync signal generated by the Interface Pod. Select the CLOCK signal for this particular UUT as follows:

1. If you are selecting CLOCK signal parameters only, press the SETUP key, and the display reads

   START ON l)<edge type 2)source>

   Press the MORE key until the display reads

   CLOCK ON l)RISING 2)EXT CLOCK

   At this point it is possible to:

   a. Select the CLOCK signal parameters displayed above (positive-going edge and CLOCK signal external via the Clock Pod), and proceed to ENABLE signal selection. Proceed to step 4.

   b. Select the CLOCK signal to be the pod SYNC signal from the Interface Pod. Proceed to step 2.

   c. Select a negative-going (falling) edge, or both rising and falling edges, for the CLOCK signal. Proceed to step 3.

2. If you wish to select the SYNC signal generated by the Interface Pod as the source of the CLOCK signal, press the 2 key. The display reads

   CLOCK ON l)<edge type> 2)POD-SYNC

   To change the display back to the previous selection, press the 2 key a second time.

3. If you wish to select the falling edge of the selected CLOCK signal, press the 1 key. The display reads

   CLOCK ON l)FALLING 2)<source>

   If you wish to select both edges of the selected CLOCK signal (double the clock), press the 1 key a second time, and the display reads

   CLOCK ON l)BOTH EDGE 2)<source>

   To change the display back to the previous selection, press the 1 key a third time.

4. Press the MORE key, and proceed to Selecting the ENABLE signal.

2-10. Selecting the ENABLE Signal

The ENABLE signal may be a positive or a negative level, and it is taken from the enable lead of the Clock Module, or it is selected to be enabled at all times during signature operation. Select the ENABLE signal for this particular UUT as follows:

1. If you are selecting ENABLE signal parameters only, press the SETUP key and the display reads

   START l)<edge type> .2)<source>

   Press the MORE key until the display reads

   ENABLE 1)ALWAYS

   At this point it is possible to:

   a. Select this function to be enabled regardless of the state of the ENABLE line and proceed to the clock count limit selection. Proceed to step 3.

   b. Select the ENABLE signal to be external via the Clock Module. Proceed to step 2.

2. If you wish to set the function to the external mode and high level, press the 1 key. The display reads

   ENABLE 1)ON EXT ENABLE 2)HICH

   If you wish to select a low level for the selected ENABLE signal, press the 2 key. The display reads

   ENABLE 1)ON EXT ENABLE 2)LOW

   To change the display back to the previous selection, press the 1 key a second time.

3. Press the MORE key, and proceed to Selecting the Stop Counter.

2-11. Selecting the Stop Counter

The stop count is the number of gated clock pulses that can occur before the Signature Module invokes a stop to terminate the gate time. Select the stop count as follows:

1. If you are selecting the stop count only, press the SETUP key, and the display reads

   START ON l)<edge type> 2)<source>

   Press the MORE key until the display reads

   STOPCOUNTERl)DISABLED

   At this point it is possible to:

   a. Leave the clock count function disabled, and proceed to Selection of Delay Compensation. Proceed to step 3.

   b. Enable the clock count function, and specify a number of clock edges to be counted. Proceed to step 2.

2. To enable the clock count function and specify a count limit, press the 1 key. The display reads

   CLOCK LIMIT l)ENABLED 2) = <prompt>

   Using the numeric keys, enter the desired number of clock edges in the range of 1 to 4095 (decimal) and press the ENTER key.

   The stop counter function can be disabled by pressing the 1 key a second time.

3. Press the MORE key, and proceed to Selecting the Data Delay Compensation.

2-12. Selecting the Data Delay Compensation

The amount of data delay is selected in increments of approximately 3 nanoseconds, over the range of zero to 36 nanoseconds. Select the amount of delay as follows:

1. If you are selecting data delay compensation only, press the SETUP key, and the display reads

   START ON 1)<edge type> 2)<source>

   Press the MORE key until the display reads

   DATA DELAY COMP 1)<0 or last selected value> UNITS

   At this point it is possible to:

   a. Leave the delay compensation as displayed, and proceed to Selecting Event Count Parameters. Proceed to step 3.

   b. Select a specific value of delay. Proceed to step 2.

2. Select the desired amount of the delay (each unit equals approximately 3 nanoseconds) by entering numerical number of desired (zero through 12 units).

3. Press the MORE key, and proceed to Selecting Event Count Parameters.

2-13. Selecting Event Count (Data Transition) Parameters

The event count function can be configured to operate in two basic modes: gated operation and free-running operation. When operated in the gated mode, the events counter counts data transitions appearing at the probe tip only during the gate-time (the period between the selected START and STOP signals), and the event counter is reset to zero at the beginning of each period. When the events counter is operated in the free-running mode, it counts data transitions as long as the probe is connected to the UUT and no other Troubleshooter key is pressed.

Select the event count parameters for this particular UUT as follows:

1. If you are selecting event counter parameters only, press the SETUP key, and the display reads

   START ON 1)<edge type> 2)<source>

   Press the MORE key until the display reads

   DATA TRANSITION COUNT1)GATED

At this point it is possible to:

a. Leave the event counter parameters displayed above (gated operation).

b. Select the free-running mode. Proceed to step 2.

2. If you wish to operate the events counter in the free-running mode, press the 1 key. The display reads

DATA TRANSITION COUNT1)FREE RUN

To change the display back to the previous selection, press the 1 key a second time.

2-14. VERIFYINGEQUIPMENTOPERATION

Before operating the Troubleshooter in the signature mode, you may want to verify that the signature feature is operational. This verification procedure is brief and does not attempt to check performance of the equipment against the specifications. The procedure verifies only that the signature function is operating normally.

The verification check consists of the following basic operations:

- Entering the signature mode
- Making connections to the data probe
- Setting the Troubleshooter to pulse the probe
- Initiating a Read Probe Operation
- Reading the signature and event count

Verify operation of the Signature Module as follows:

1. Connect the probe to its connector on the front underside of the Troubleshooter.
2. Connect the Clock Module cable to the Troubleshooter as shown in Figure 2-2.

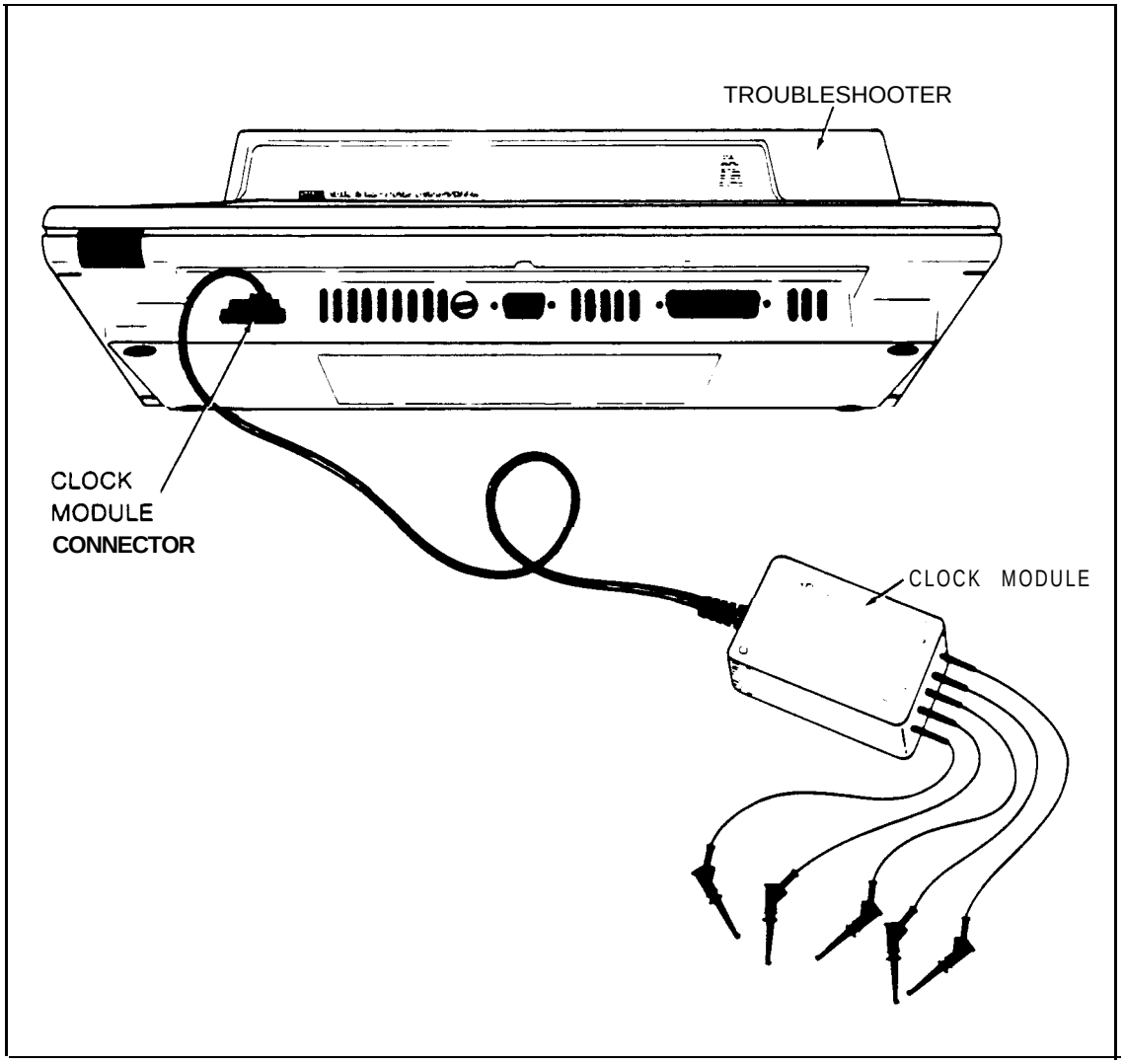

Figure 2-2. Connection of the Clock Module to the Troubleshooter

3. Connect the start and clock (green and yellow) leads of the Clock Module to the tip of the data probe.

4. Connect the stop (red), enable (blue), and ground (black) leads to the data probe ground lead.

5. Connect a 33-ohm, 1/4-watt resistor across the group of connections made in step 3 and the group of connections made in step 4. (The resistor connects so that the data probe tip is shunted to the ground lead.)

6. Switch on the Troubleshooter, and enter the signature mode as described under Entering the Signature Mode.

7. For the Model 9020A, run the example program listed in Section 6, paragraph 6-5. For the 9005A and 9010A, refer to Initialization of the Signature Function and:

   0 Set the start signal to a rising edge

   0 Sect the clock signal to a falling edge

   0 Set the stop counter to 256 (The clock limit count provides an end to the gate time in lieu of a stop signal.)

   0 Set the data transition (event) count to gated

   0 Set the enable signal to low

   0 Set the data delay to 4

8. Press the PULSE HIGH key on the Troubleshooter.

9. Press the READ PROBE key, and the display reads

   WAIT

   followed by

   SIGNATURE BB34 COUNT 256

   Any other signature or count indicates a problem with the Signature Module, the Clock Module, or the Troubleshooter.

2-15. MAKING CONNECTIONS TO THE UUT

Both the Data Probe and the Clock Module must be connected to the UUT during signature operations. Connecting the Data Probe is simply a matter of touching it to the test node; however, connecting the Clock Module to the UUT requires several temporary connections to the UUT. These connections to the UUT include clock, start, stop, ground, and enable. Refer to the labels on the Clock Module case for identification of the Clock Module control signal leads.

With reference to Figure 2-3 and the documentation provided for the UUT, connect the Clock Module leads to the start, stop, clock, and ground points on the UUT. If the enable function is to be used, connect the enable lead of the Clock Module to the UUT.

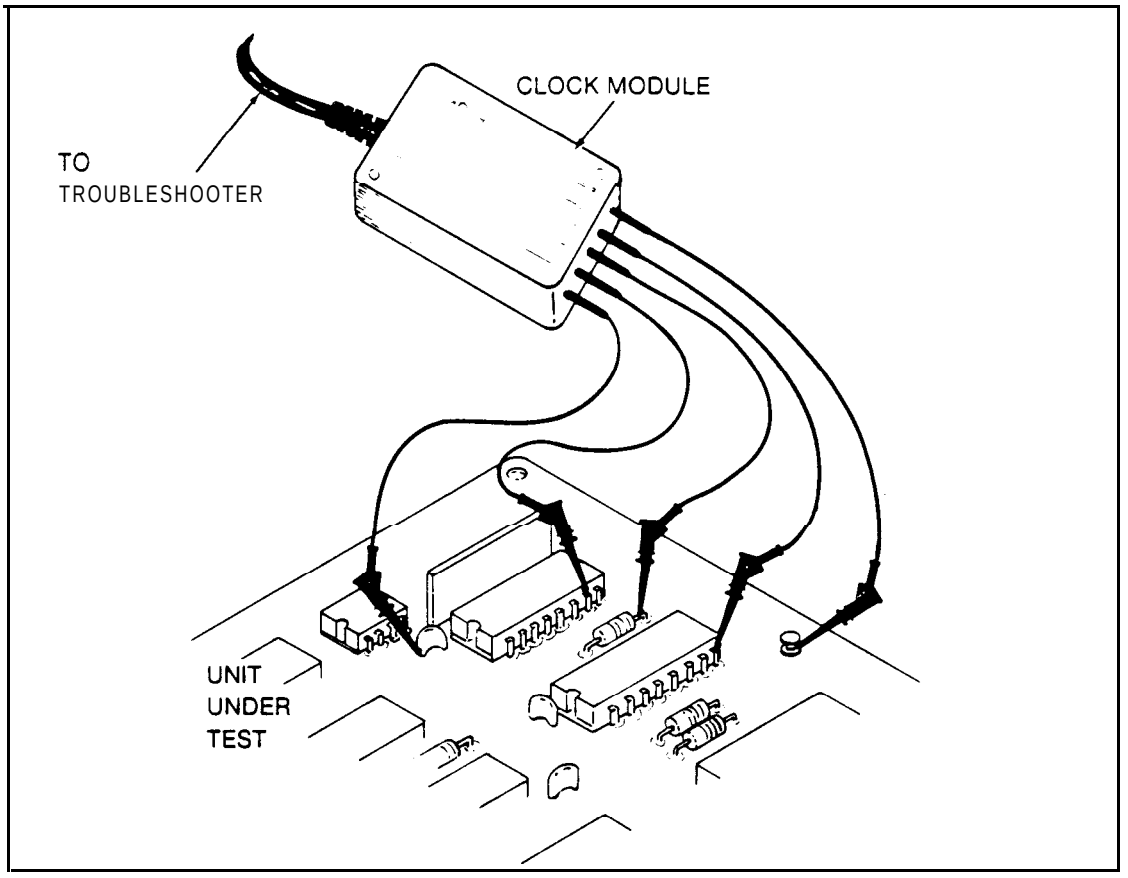

Figure 2-3. Connection of the Clock Module to the UUT (Typical)

2-16. TAKING SIGNATURES AND EVENT COUNTS

2-17. Introduction

Taking a signature, although a simple operation, requires that the following operations be completed:

- The signature mode programs must be loaded and selected on the Troubleshooter. (Refer to Entering the Signature Mode.)
- If necessary, initialization (setup) parameters must be selected. (Refer to Initialization (Setup) of the Signature Function.)
- Connections of the **Clock** Module to the Troubleshooter and UUT must be made. (Refer to Making Connections to the Troubleshooter and Making Connections to the UUT.)
- The documentation (such as connection details, test points, and signatures) for the particular UUT being checked must be referenced.
- The UUT must be provided with a suitable stimulus.

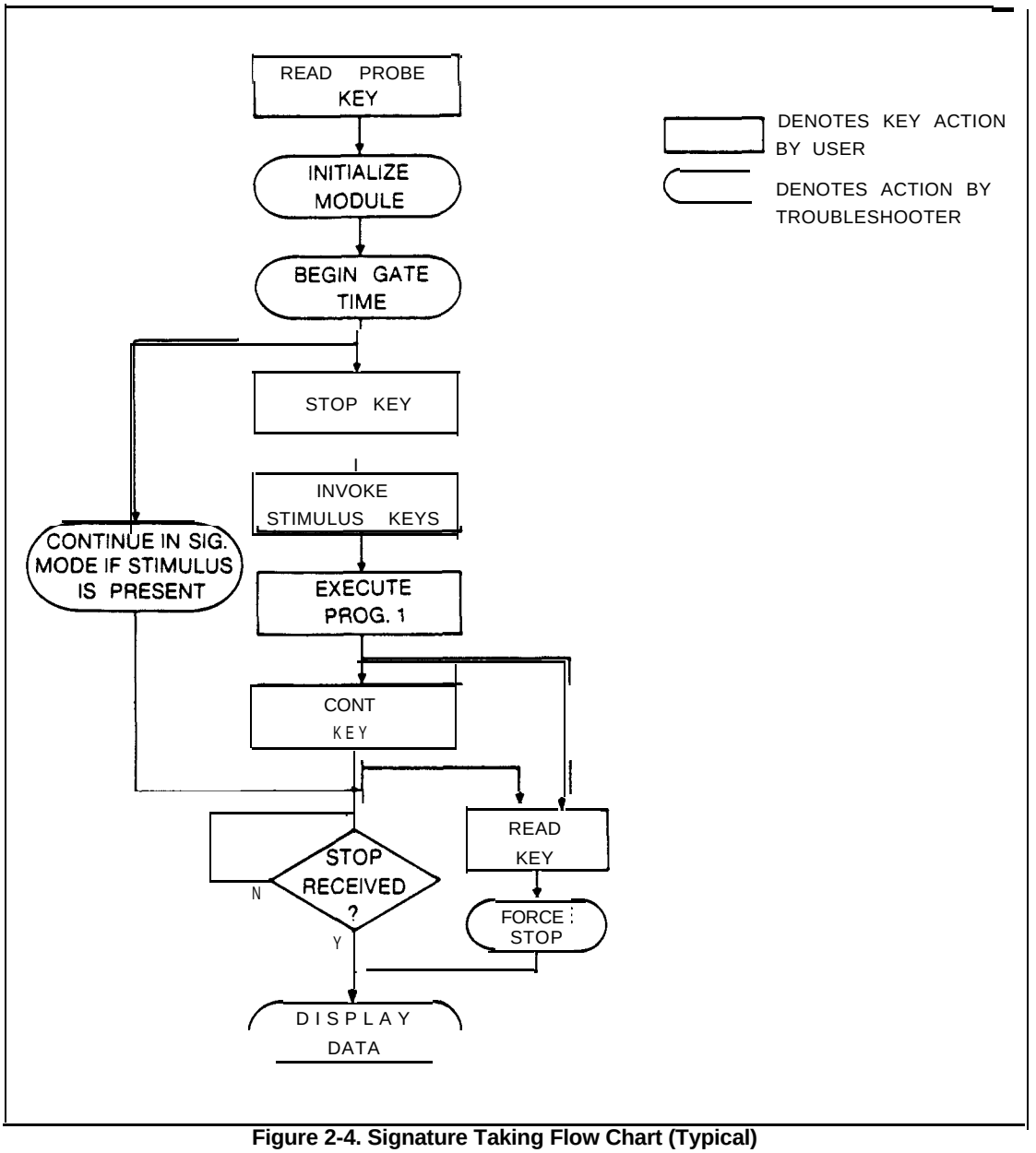

Figure 2-4. Signature Taking Flow Chart (Typical)

2-18. Using the Troubleshooter to Stimulate the UUT

Each UUT must be stimulated as specified in the test documentation for the particular UUT. The UUT may be stimulated by means of the Troubleshooter (by the front panel keys or by executing one or more programs) or by some other method such as self-test. If the Troubleshooter is to be used to stimulate the UUT, refer to the following procedure. If the Troubleshooter will not be used for UUT stimulus, refer to Using Non-Troubleshooter Stimulus.

Note that once operation of the Troubleshooter is initiated in the signature mode, this mode is placed in the background while the Troubleshooter stimulates the UUT and the Signature Module reads the signature. When the stimulus operation is complete, operation in the signature mode is resumed to read the signature, event count, and waveform. Refer to Figure 2-4.

Perform signature and event count operations as follows:

1. Touch the data probe to the desired test node, and press the READ PROBE key. The display reads

   WAIT

   This display indicates that the Asynchronous Signature Module is ready to receive (or may have already received) the necessary START signal, followed by the test data, and STOP signal.

2. Press the STOP key to leave the signature program and use the Troubleshooter to stimulate the UUT. (The Signature Module remains active and ready to receive control signals via the Clock Module and test data via the probe.)

   Stimulate the UUT according to the instructions provided with the UUT test documentation. Stimulating the UUT may consist of some key-selectable test on the Troubleshooter, such as a RAMP, TOGGL DATA, etc. Or the stimulus may be provided by executing a program, specially written to stimulate this UUT, and previously loaded into the Troubleshooter memory.

3. To read the signature and event count resulting from the stimulus operation, press the EXEC key and the display reads

   EXECUTE PROGRAM (flashing cursor)

   Enter 1 and press the ENTER/YES key. The display indicates that the Troubleshooter has returned to operation in the signature mode when it reads

   ASYNCSIGNATURE PROBE READY

4. To display the signature and event count, press either the CONT key (step 4a) or the READ key (step 4b).

   a. The CONT key allows the Signature Module to continue the Read Probe operation if it is not already terminated by the occurrence of a STOP signal. If the Read Probe operation is still in progress (no STOP signal received yet), the display reads

      WAIT

      and then when the STOP signal is received, the display reads

      SIGNATURE xxxx COUNTYYYYYYYY

      where xxxx is the signature and yyyyyyyy is the event count.

      If the WAIT display persists for a longer than normal time, it is likely that a STOP signal has not been received. In this case. Proceed to step b.

   b. The READ key stops the read probe operation whether or not a STOP signal has been received, and the display reads

      SIGNATURE xxxx COUNTYYYYYYYY

      where xxxx is the signature, and yyyyyyyy is the event count.

      If the test has been designed to end with a STOP signal, pressing the READ key before the stop is received will yield invalid signatures and counts.

5. To display the waveform representing the last 640 nanoseconds of data occurring during the Read Probe operation, press the MORE key.

6. To display the signature and event count, press the PRIOR key. The PRIOR and MORE keys toggle the display between the signature/count and waveform capture displays.

2-20. Using Non-Troubleshooter Stimulus

When you are taking signatures without using the Troubleshooter to stimulate the UUT, it is unnecessary to suspend operation in the signature mode. With non-Troubleshooter stimulus, it is only necessary to take signature readings as the UUT is stimulated, either on a continuous basis, or on command at the stimulus source. Proceed as follows to take signatures when you are not using the Troubleshooter as the source of stimulus:

1. Touch the data probe to the desired test node, and press the READ PROBE key. The display reads

   WAIT

   indicating that the Asynchronous Signature Module is ready to receive (or may have already received) the necessary START signal, followed by the test data, and STOP signal.

2. Stimulate the UUT according to the instructions provided with the UUT test documentation.

3. When the STOP signal is received, the display reads

   SIGNATURE xxxx COUNTYYYYYYYY

   where xxxx is the signature and yyyyyyyy is the event count.

   a. If the WAIT display persists for a longer than normal time, it is likely that a STOP signal has not been received via the Clock Module. In this case, press the READ key to display the signature and event count readings.

   b. The READ key stops the read probe operation whether a STOP signal has been received or not, and the display reads

      SIGNATURE xxxx COUNTYYYYYYYY

      where xxxx is the signature, and yyyyyyyy is the event count.

4. To display the waveform representing the last 640 nanoseconds of data occurring during the Read Probe operation, press the MORE key.

5. To display the signature and event count, press the PRIOR key.

6. The PRIOR/MORE keys toggle the display between the signature/count and waveform capture displays.

Section 3
Test Preparation

3-1. INTRODUCTION

This section contains information regarding the implementation of signature, event count, and waveform troubleshooting methods for a particular model of UUT. Implementation consists of preparing a particular model of UUT for testing (usually by the test engineer). One-time implementation is required before any meaningful testing of the UUT can take place using the signature option. In preparing a UUT for this type of testing, the following tasks must be completed:

- Determine the polarity and source of the control signal (START, STOP, CLOCK, and ENABLE) within the UUT.
- Determine the nodes within the UUT that provide meaningful test signals.
- Determine any special test conditions required such as delay compensation, setting the gate period to a specific number of CLOCK pulses, etc.
- Determine the required stimulus condition that causes the UUT to generate consistent and repeatable test data at the chosen test nodes.
- Take signature and/or event counts at the selected test nodes of a known-good UUT, and annotate a schematic diagram with the signatures and event counts. A list of the signatures and event counts could also be used.
- Provide documentation to the technician that details the above selections, considerations, and expected test results so that efficient and effective troubleshooting/testing can be performed.

3-2. CONTROL SIGNALS

3-3. General

In addition to the test pattern or data stream taken from the UUT, the signature module must also receive certain control signals. These control signals, taken from the UUT by the Clock Module, or possibly from the Troubleshooter's Interface Pod, include the START, STOP, CLOCK, and ENABLE signals. The following paragraphs briefly describe these signals since the user must be aware of their role in the signature operation.

3-4. START Signal

The START signal may be a positive-going or negative-going edge supplied by the UUT or the Interface Pod SYNC signal, as selected during initialization. The gate section within Signature Module is armed or preset to accept the START signal level change as shown in note 2 of Figure 3-1. (Rising CLOCK edges are chosen for this example.) The gate section operates so that it then passes the next valid CLOCK signal edge, shown in note 3 of Figure 3-1. Clocking of signature data (test pattern) begins with the occurrence of this CLOCK edge (note 2 of Figure 3-l).

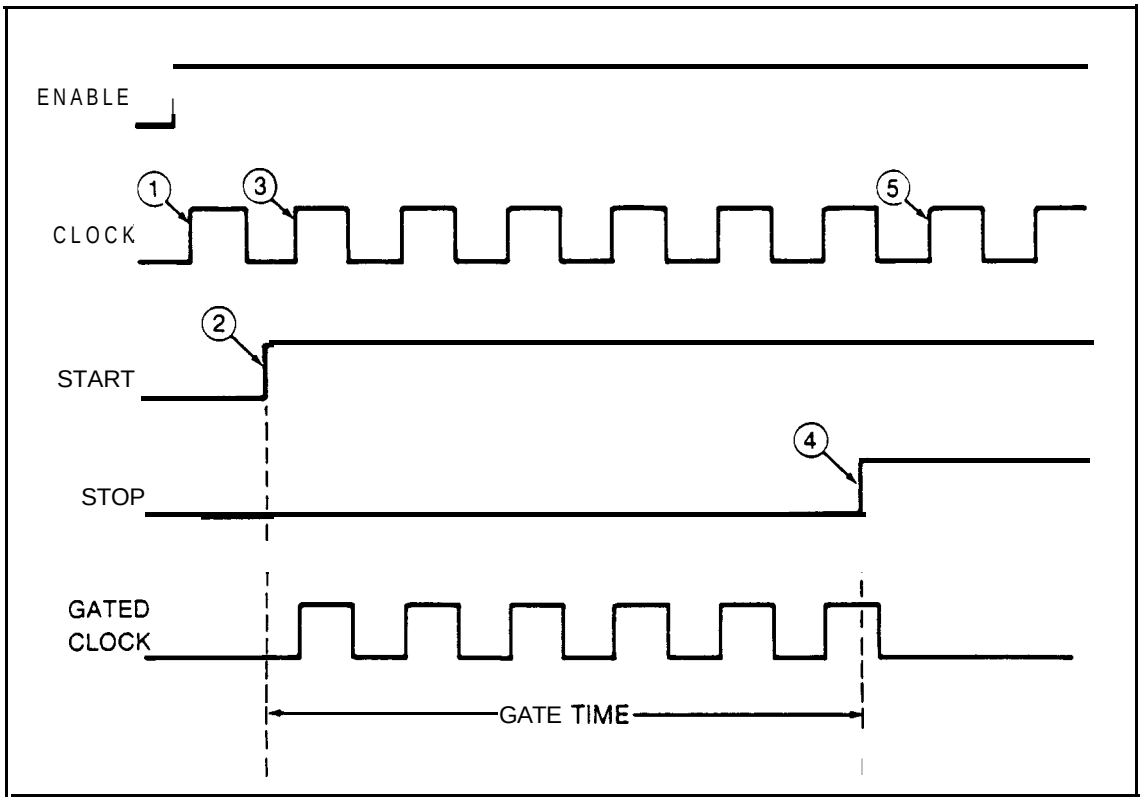

Figure 3-1. Typical Signature Gate

3-5. STOP Signal

The STOP signal is also level sensitive, and it may be supplied by either the UUT or the Interface Pod SYNC signal. Note 4 in Figure 3-1 shows the typical STOP level change. The STOP signal allows any already-gated clock signal to be completed. The next valid CLOCK edge, following the STOP signal, does not clock in any signature data, and signature computation is halted (note 5 of Figure 3-1).

3-6. CLOCK Signal

The typical CLOCK signal is also shown in Figure 3-1. The Troubleshooter allows you to select either positive-going edges, negative-going edges, or both positive-going and negative-going edges for the CLOCK signal. You can also select the source of the signal (the Troubleshooter Interface Pod SYNC signal or the CLOCK lead of the Clock Module). The CLOCK edge selected must be synchronized to the valid data times of the circuit being probed with the Troubleshooter data probe. A correctly selected CLOCK edge prevents errors from occurring during unsettled signal times, such as during tri-state conditions and signal transition times .

3-7. ENABLE Signal

The ENABLE signal, level-sensitive instead of edge-sensitive, provides a means of inhibiting or enabling the computation of the signature. This signal enables the CLOCK signal developed within the Signature Module to clock-in the test data appearing at the probe tip. The ENABLE signal provides a means of controlling the signature computation period of the measurement.

3-8. GATE SECTION

All control signals are applied to the gate section of the Signature Module. The function of the gate section is to accept START, STOP, CLOCK, and ENABLE signals from the Clock Module (or possibly from the Interface Pod in the case of the START, STOP, and CLOCK signals) and output a gated CLOCK signal to the signature generator and events counter. The following statements describe the general operation of the gate section:

- The gate section accepts a START edge only if it is armed.
- Once armed, the gate section assumes the started condition at the time of the first START edge.
- Once started, the gate section stops on the first STOP edge.
- The ENABLE signal does not affect the recognition of START and STOP edges.
- The gate is considered on only after it has been started and has not yet been stopped, and the ENABLE signal is asserted.

3-g. CONTROL SIGNAL EXAMPLES

Figure 3-1 shows a typical arrangement of control signals required to produce a gated CLOCK signal and compute a signature from the data appearing at the Troubleshooter probe tip. To further illustrate the function of the control signals, Figures 3-2 through 3-7 show different control signal situations and their effect on the gated CLOCK signal. The gated CLOCK signal, which occurs when the gate section is in the "on" condition and CLOCK pulses are present, clocks the data appearing at the test probe into the signature generator and event counter. It is during the time of the gated CLOCK signal that signature generation takes place. Without the gated CLOCK signal, there is no signature computation within the module.

NOTE

In Figures 3-2 through 3-7, all active edges are positive-going, although you may select edges to be either positive or negative.

Figure 3-2 shows the resulting gated CLOCK when the START and STOP edges occur before the CLOCK signal. Even when the ENABLE line is asserted (held high in this case), there is no gated CLOCK signal. This is due to the lack of a CLOCK pulse (from the UUT or pod SYNC) after the START signal edge and before the STOP signal edge.

Figure 3-3 illustrates the edge sensitivity of the START and STOP signals. Note that the gated CLOCK signal does not occur until after the selected edge of the START signal, and it does not cease until after the selected edge of the STOP signal.

Figure 3-4 illustrates the effect of the ENABLE line on the gated CLOCK signal. In this example, the ENABLE line is asserted for only a portion of the time between the START and STOP signals. As a result, gated CLOCK signals are produced only during the time of the ENABLE signal.

Figure 3-5 shows more graphically that a full CLOCK width passes the gate after the occurrence of the STOP signal.

3-10. SELECTING THE CONTROL SIGNAL SOURCES

Since each troubleshooting/test situation is unique, there are no set rules for selecting the source for each control signal. An understanding of these four signals, as presented in the previous paragraphs, is the best tool for determining the source of these signals for a particular UUT.

The control signals include the START, STOP, CLOCK, and ENABLE signals. Connection of these signals (when used) from the UUT to the Signature Module is provided by the Clock Module and individual clip leads. Typically, START, STOP, and CLOCK signals are required, while the ENABLE signal is optional.

The pod SYNC signal, generated each time the Interface Pod executes a read or write operation with the UUT, may be **used** for the CLOCK and/or START/STOP signals. These signals may also be taken from the UUT by connecting the

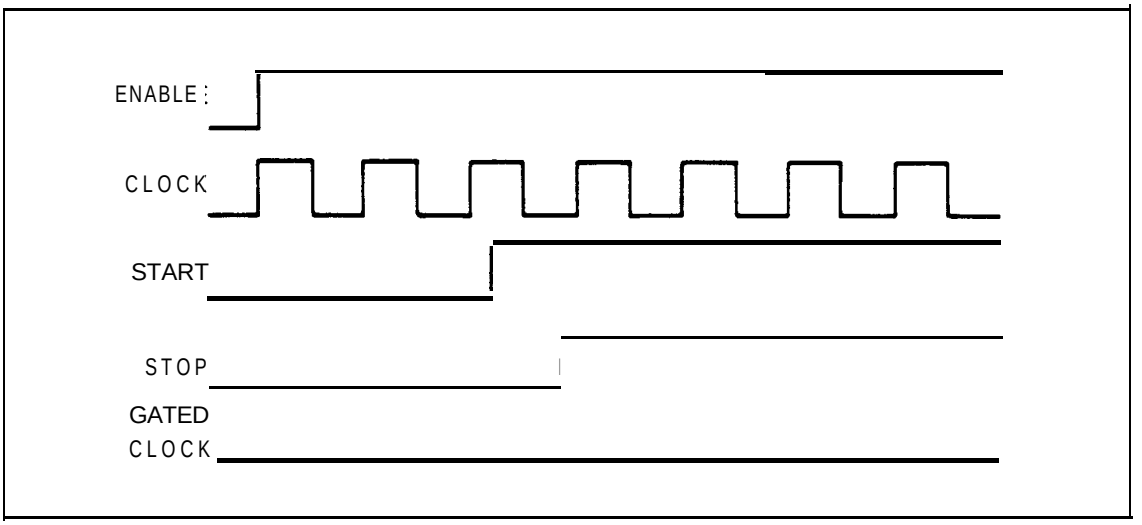

Figure 3-2. Stop Received Before Clock

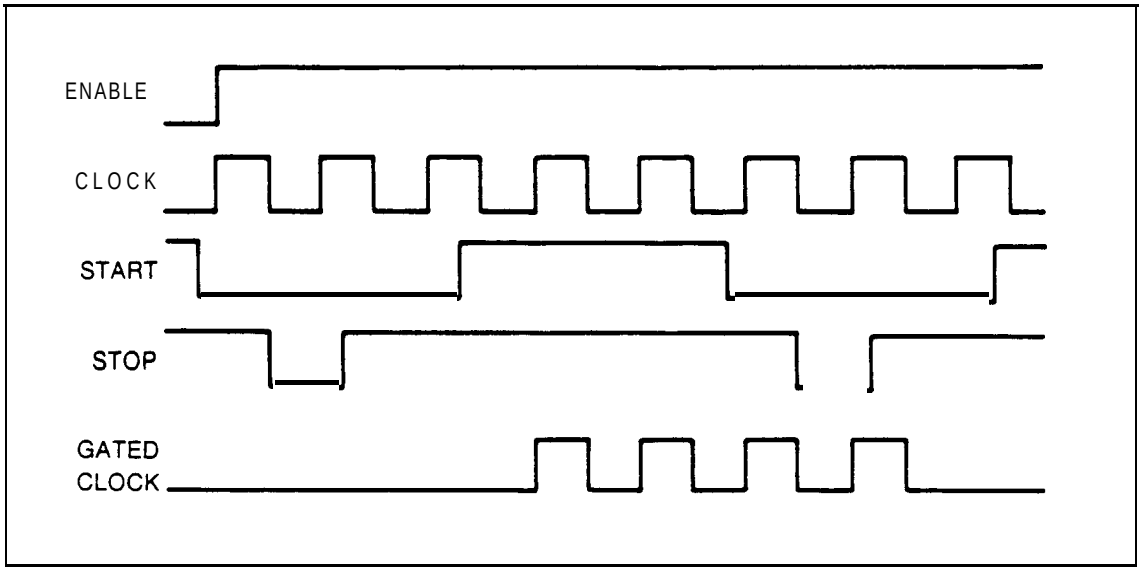

Figure 3-3. Start and Stop Are Edge Sensitive

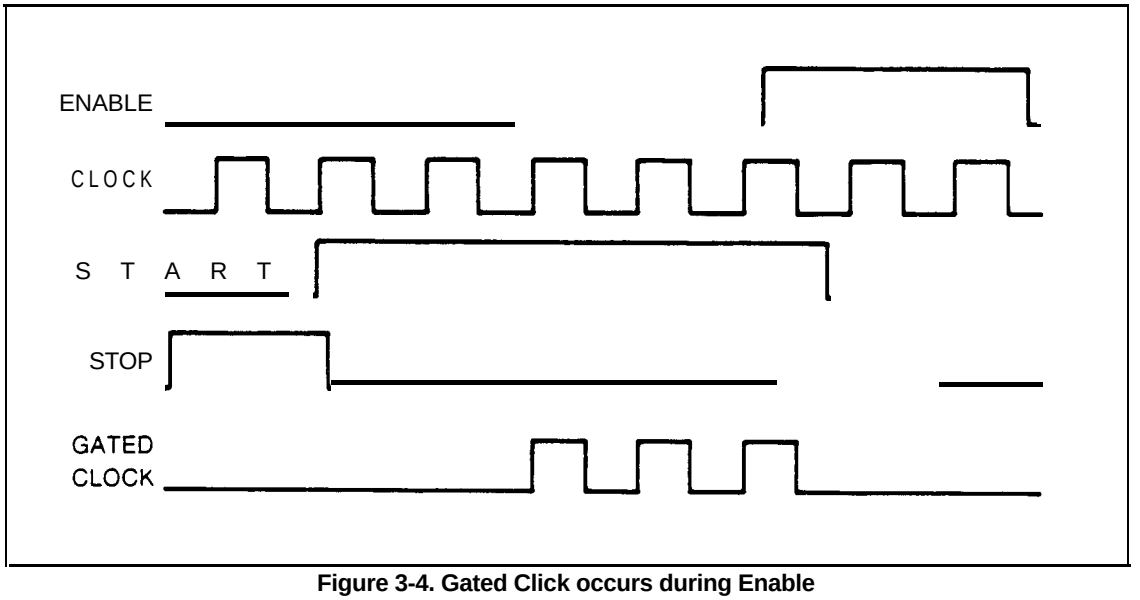

Figure 3-4. Gated Click occurs during Enable

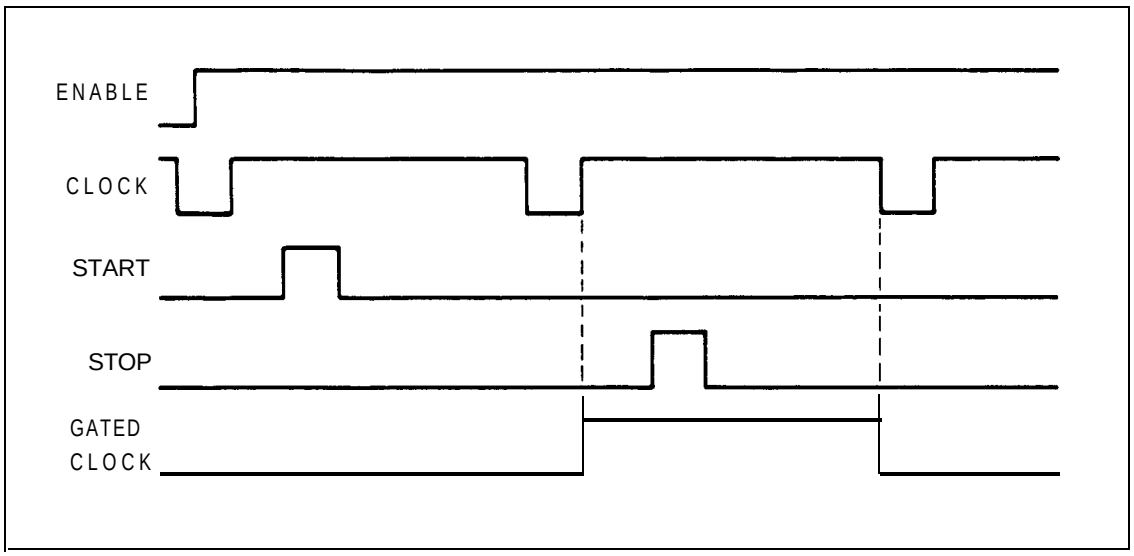

Figure 3-5. Gate Passes Full Clock Width

appropriate clip lead of the Clock Module. The ENABLE signal may be taken from some point on the UUT, or it may be selected to be held in the enabled condition.

While the ENABLE signal is level-sensitive, the START, STOP, and CLOCK signals are all edge-sensitive. Level and edge selection for the control signals is specified during the initialization (setup) of the Troubleshooter for operation in the signature mode.

3-11. CLOCKING ON BOTH EDGES

In some applications it may be desirable to sample UUT data on both edges of the CLOCK signal signal applied to the Signature Module. When clocking on both edges is selected (during initialization), a narrow-width CLOCK pulse is provided to the gate section of the Signature Module for each edge (rising and falling) of the selected CLOCK signal. Refer to Figure 3-6.

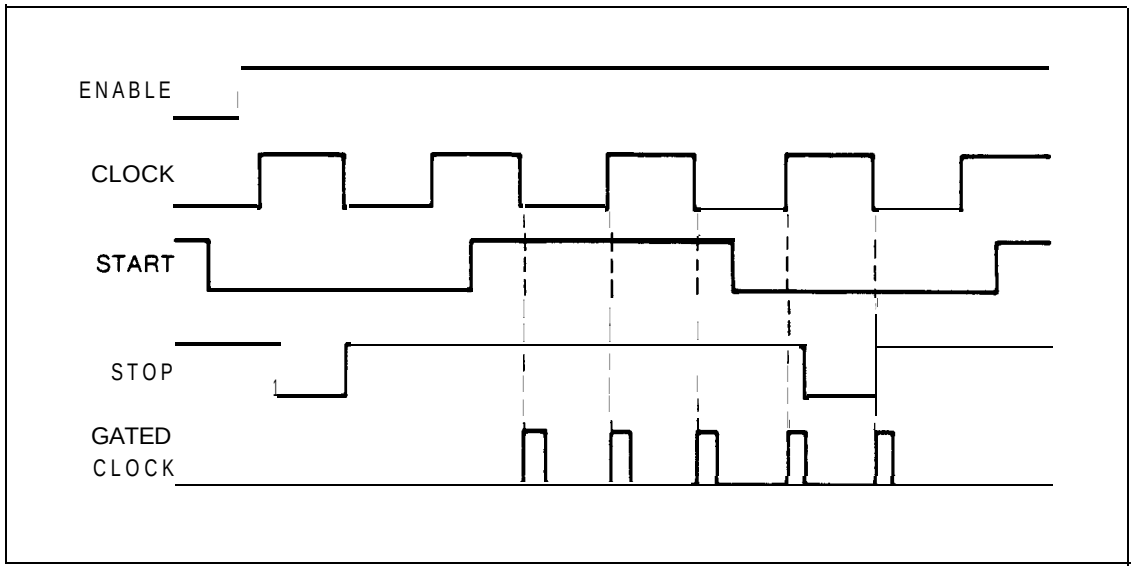

Figure 3-6. Effects of Selecting Both Clock Edges

3-12. ESTABLISHING UUT TEST NODES

The main function of the Asynchronous Signature Module is to take signatures at selected nodes of a UUT and present them on the Troubleshooter display as a four-character hexadecimal value. In addition to displaying the signature, the Troubleshooter also displays the accumulated count of the transitions contained in the data used to calculate the signature (unless the free-run mode is selected for the event count function).

When implementing the signature method of troubleshooting, it is necessary to first take signatures at selected points within a known-good UUT. Troubleshooting by taking signatures on a defective (or suspected defective) UUT is of little value if no valid signatures are available for reference and comparison. The assignment of test points in a particular UUT requires a detailed knowledge of UUT operation. Avoid assigning test points that may yield invalid or unstable signatures and event counts.

3-13. USING THE STOP COUNTER MODE

During initialization of the signature function, the user is prompted to select the STOP count function. This feature, when selected by the user, causes termination of signature-taking after a specified number of gated CLOCK pulses (i.e., CLOCK pulses passed to the signature generator and event counter by the gate section).

During operation in the stop counter mode, each gated CLOCK signal decrements a counter provided within the Signature Module from its preset count. Any CLOCK pulses inhibited by an invalid ENABLE signal do not reach the stop counter. The stop counter is only decremented by gated CLOCK pulses; i.e., those that reach the signature generator and event counter circuits.

When the counter reaches the zero condition, it generates the STOP signal necessary to terminate the signature-taking operation. Figure 3-7 shows an example of stop counter use. In this example, the stop counter is set to a value of 3, and the ENABLE signal goes low (inhibit condition) for a duration that masks two valid (rising) CLOCK edges.

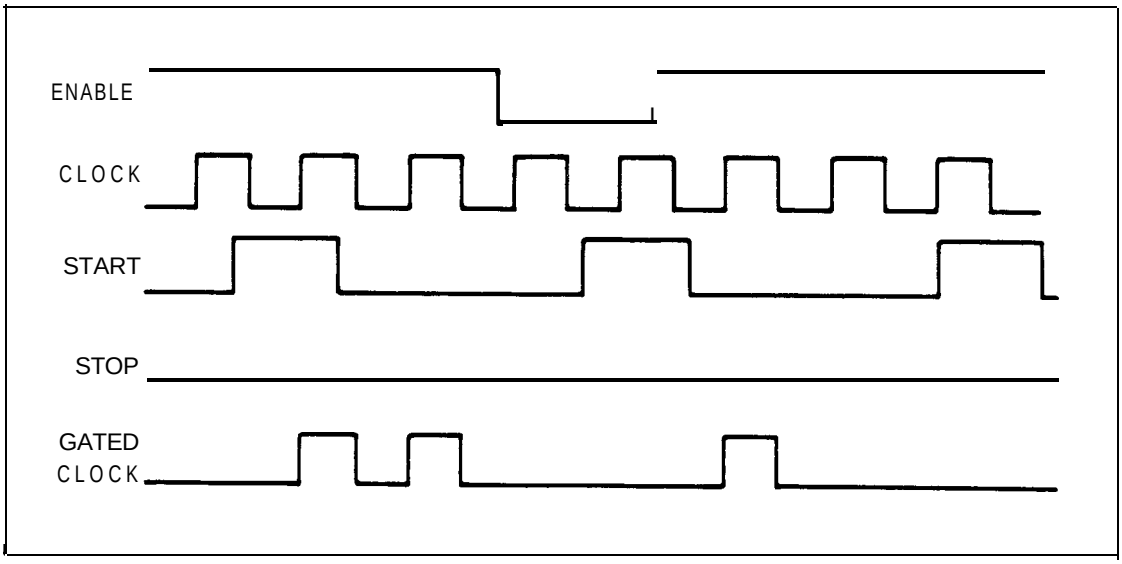

Figure 3-7. Stop-After-Count Mode Example (count =3)

The stop counter generates its STOP output in parallel with any STOP signal provided over the STOP clip lead of the Clock Module. Consequently, the occurrence of any STOP signal over the Clock Module clip leads before the stop counter is fully decremented will terminate the gate time and signature operation. If you want the stop counter to provide the STOP signal, an external STOP signal must not be received before the counter reaches zero (before the specified number of gated CLOCK pulses have occurred).

3-14. USING DELAY COMPENSATION

Delay compensation allows for the insertion of delay between the input from the data probe and the signature generator, the event counter, and the waveform register of the Signature Module. Delay may be inserted into the data path in increments of approximately 3 nanoseconds, up to a total of 12 increments. Selection of delay allows for the detection of and compensation for marginal timing conditions in the UUT.

Delay compensation is used most often in high CLOCK-rate systems. In such systems, determine the amount of delay compensation (which allows stable and repeatable testing of a known-good UUT) then specify that amount of delay for testing similar UUTs. In systems that use low-to-moderate CLOCK speeds (up to lOMHz), a delay setting in the middle of the range (4 units) may usually be selected for satisfactory testing.

3-15. STIMULATING THE UUT

3-16. Self-Test

In order for repeatable testing of a UUT to take place using the signature, event count, or waveform display features provided by the Asynchronous Signature Module Option, the UUT must be stimulated into operation in some stable and repeatable manner. Some microprocessor-based systems include a self-test feature that, as long as the microprocessor section is operational, stimulates various portions of the UUT in the required manner. However, self-test routines usually provide stimulus to limited sections of the UUT. Also, any problem in the microprocessor section, such as a stuck line on the address or data bus, usually prevents any self-test operation.

3-17. Using Troubleshooter Front Panel Functions

The 9000A Series Microsystem Troubleshooter is an ideal source of UUT stimulus. Since the programs provided with the option allow the Troubleshooter to be first set up for signature taking and event counting, and then return to normal Troubleshooter operation, any Troubleshooter function can be used to stimulate the UUT.

In order to use the Troubleshooter to stimulate the UUT, operation in the signature mode must be stopped (STOP key). The Troubleshooter can then be used to perform any desired test operation or execute a test program to stimulate the UUT. When the test operation (stimulus) is complete, the operator executes program 1 (if using the supplied programs) to return to the signature mode.

Once back in the signature mode, the user can observe the test results of the stimulus operation by means of the CONT or READ keys. Refer to Taking Signatures and Event Counts in Section 2.

3-18. Using Programmed Routines

Another method of using the Troubleshooter to stimulate the UUT is to write a test program that exercises the desired portions of the UUT. Such a program can be executed in place of pressing front panel keys, thereby simplifying the stimulus operation. The Troubleshooter can be used to run a repeated stimulus program while the Asynchronous Signature Module is used to take the signatures.

3-19. ESTABLISHING SIGNATURES AND EVENT COUNTS

As part of the implementation of signature testing, it is necessary to provide test/repair personnel with valid signatures or event counts for the specific UUT. The procedure for establishing signatures and event counts within the UUT consists of using the 9OlOA or 9005A Troubleshooter in the signature mode as described in Section 2 of this manual. In this mode, use the Troubleshooter to take signatures and event counts at the established test nodes while stimulating the UUT as specified for testing. List each of the signatures and event counts required for testing as part of the documentation for the UUT.

3-20. USING THE WAVEFORM DISPLAY

The waveform display feature may be used to measure the time relationship between two signal edges within the UUT. This feature is useful when viewing signals of less than 10 MHz due to asynchronous sampling and data probe bandwidth limitations. A typical use of this feature is checking the time relationships between such signals as the RAS (row address strobe) and WRITE ENABLE lines of a dynamic RAM. This feature can also be used to check the time relationship of the CAS and address multiplexer ENABLE lines or any other portion of a circuit where the timing of two signals is critical to UUT operation.

The waveform display feature allows the Troubleshooter to display the last 640 nanoseconds of signals applied to the data probe before a STOP was received (or before the stop counter decremented to zero). The data signal appears as logic high, logic low, or tri-state, as shown in Figure 3-8. The latest samples of the signal appear at the right side of the display. The signal edge used to STOP the gate section and halt the gathering of data does not appear on the display, but if visible, it would appear just to the right of the rightmost display character.

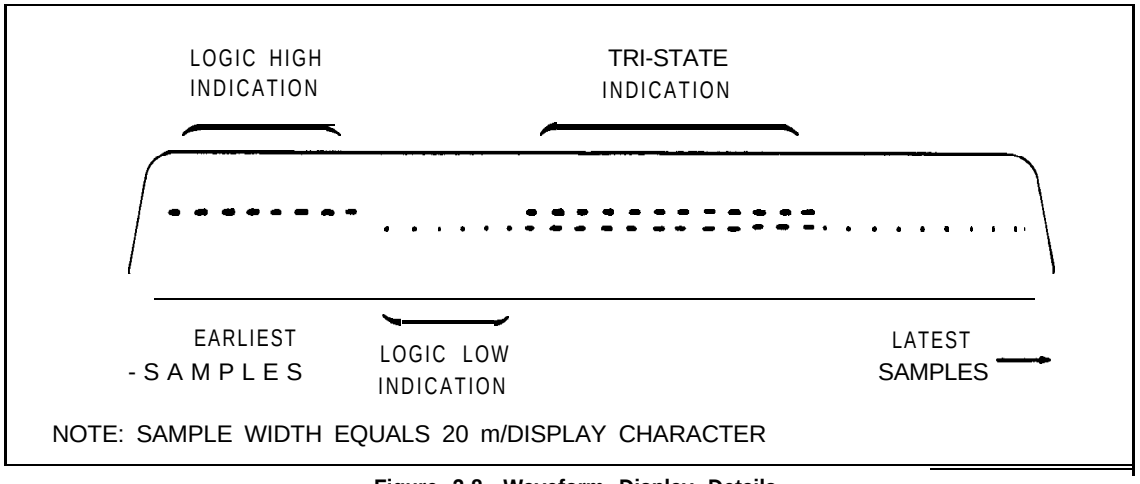

Figure 3-8. Waveform Display Details

Figure 3-9 shows a waveform display of the time relationship between the rising edge of the CAS signal and the rising edge of the multiplexer ENABLE signal found in a dynamic RAM circuit. To achieve this display, the CA.5 signal is connected to the STOP lead of the Clock Module and selected as the STOP signal during initialization. Since the CAS signal is used to terminate the gate time, it cannot appear on the display, but is assumed to occupy the next 20-nanosecond position to the right of the display.

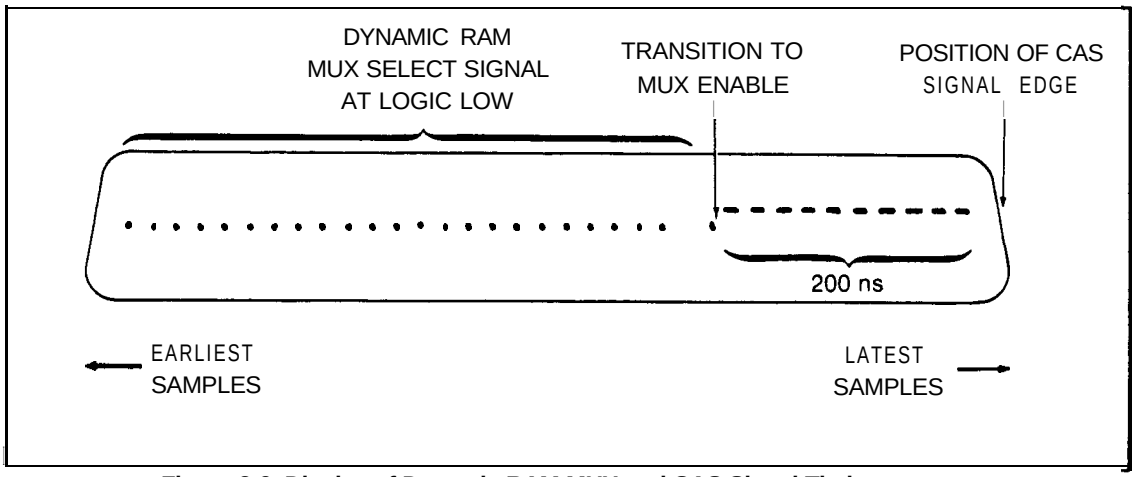

Figure 3-9. Display of Dynamic RAM MUX and CAS Signal Timing

In Figure 3-9, the rising edge of the multiplexer ENABLE signal (picked up by the data probe) is shown to occur ten display characters from the right side of the display. Each character position represents 20 nanoseconds, so the interval between the CAS signal edge and the multiplexer ENABLE signal is approximately 200 nanoseconds.

The waveform display feature can be used to verify the time relationship of any two signal edges that occur within the 640-nanosecond range of the Troubleshooter display. Connect the data probe to the leading signal and the STOP lead of the Clock Module to the lagging signal. Perform a read-probe operation with the UUT under stimulus, then read the waveform display, counting each display character as 20 nanoseconds.

3-21. DOCUMENTING THE UUT FOR TESTING AND TROUBLESHOOTING

As signature-mode troubleshooting is implemented for a particular UUT, the appropriate documentation should be created and provided to personnel having the responsibility of testing and/or repairing the UUT. The documentation required may vary somewhat, depending upon the complexity of the equipment, the qualifications of the personnel, and the level of testing and troubleshooting to be undertaken. Typically, the documentation created during implementation of signature-mode testing includes the following:

- Annotated schematic diagram(s) or node lists of the UUT that show the required signatures at each test node.
- Complete description of the test setup: initialization parameters and connection of the control signal leads of the Clock Module.
- Description of the action required to stimulate the UUT in the desired manner.
- Description of any event count testing and the expected results.
- Step-by-step test procedures.
- Appropriate documentation for any custom testing programs, plus back-up copies of any cassettes.

3-22. PROGRAMS SUPPLIED ON THE CASSETTE

3-23. General

Several programs are supplied on the cassette included with the Asynchronous Signature Probe Option. These programs, listed and described in Table 3-1, fall into the following categories:

- User interface programs
- Library programs
- Troubleshooting Self-Stimulus
- Tape merge utility

The user interface programs (program numbers 0 through 11 on tape side A) are used by the option when it is operating in the interactive mode. These programs provide the necessary user interface by reading the 9000A mainframe keyboard and displaying the appropriate messages to the operator. The user interface programs rely heavily on the library programs, and on each other, and cannot be used outside the interactive mode of the Asynchronous Signature Probe Option.

The library programs (program numbers 12 through 20 on tape side A) operate independently from each other, and from the user interface programs, allowing them to be copied from the tape (using the merge tape utility). The library programs, some written in binary format, can be selectively copied from the cassette as required to create custom routines as required for any custom fault-isolation procedure.

Copying and renumbering programs provided in the tape is made possible by means of the Merge Tape Utility Program, also supplied on the cassette, but on side B. Also contained on side B are a pair of programs used to stimulate the module during troubleshooting operations on the module itelf.

In the paragraphs that follow, each of these programs is described in sufficient detail to enable the experienced 9010A programmer to write additional programs that provide interaction with the operator.

Table 3-1. Programs Contained on the Cassette

PROGRAM NAME	PROGRAM NUMBER/ TAPE SIDE	DESCRIPTION
Initialize	0/A	A program that loads the initialization register (register 8) with the default hardware (module) setup parameters then executes the Interactive Operation Program.
Interactive Operation	l/A	A program that executes other programs in response to front panel keys, to allow interactive user operation of the Troubleshooter/Signature Module.
Service Gate Keys	2/A	A program that executes other programs in response to the front panel READ, READ PROBE, and CONT keys.
Service SETUP Key	3/A	A program that executes other programs to initialize the module when the Setup Hardware Program is executed. Refer to Section 2 for information pertaining to initialization of the Signature Module.

Table 3-l. Programs Contained on the Cassette (cont.)

PROGRAM NAME	PROGRAM NUMBER/ TAPE SIDE	DESCRIPTION
Display Gate	4/A	A program that monitors the occurrence of the start, stop, and clock signal; and indicates the condition of these signals on the Troubleshooter display.
Start Setup	5/A	A program called upon by the Service SETUP Key Program to allow operator selection of the START signal.
Stop Setup	6/A	A program called upon by the Service SETUP Key Program to allow operator selection of the STOP signal.
Clock Setup	7/A	A program called upon by the Service SETUP Key Program to allow operator selection of the CLOCK signal.
Enable Setup	8/A	A program called upon by the Service SETUP Key Program to allow operator selection of the ENABLE signal.
Stop Count Setup	9/A	A program called upon by the Service SETUP Key Program to allow operator selection of gated CLOCK pulses for stop.
Delay Setup	10/A	A program called upon by the Service SETUP Key Program to allow operator selection of the delay compensation.
Event Setup	11/A	A program called upon by the Service SETUP Key Program to allow operator selection of the event count parameters.
Setup Hardware	12/A	A binary program that initializes the module in accordance with the contents of register 8 (the initialization register) by sending a series of op codes to the module.
Arm Gate	13/A	A binary program that resets all registers within the module and then arms it to receive control signals (START, STOP, and CLOCK).

Table 3-l. Programs Contained on the Cassette (cont.)

PROGRAM NAME	PROGRAM NUMBER/ TAPE SIDE	DESCRIPTION
Get Signature	14/A	A binary program that retrieves the signature data from the module and places it in the B register.
Get Events	15/A	A binary program that retrieves the events data from the module and places it in the A register.
Get Waveform	16/A	A binary program that retrieves the waveform data from the module and places it in the A and B registers.
Read Data and Status	17/A	A binary program that directs the Signature Module to read one nibble of data and one nibble of status.
Send Op Code	18/A	A binary program that sends one byte over the pod bus to the Signature Module.
Display Waveform	19/A	A program that presents the contents of the two waveform data registers on the troubleshooter display.
Append Signature	20/A	A utility program that appends the value in user register B to the display in signature format.
Merge Tape Program	O/B	A utility program that allows taking programs from the supplied cassette for use as part of a custom troubleshooting program.
Stimulus Program A	l/B	A program used to stimulate the control and gate sections of the Signature Module during troubleshooting procedures.
Stimulus Program B	2/B	A program used to stimulate the signature, events, and waveform sections of the Signature Module during troubleshooting procedures.

3-24. 9000A Register Usage

Several of the programs supplied on the cassette use specific registers within the 9000A mainframe. It is important to keep this in mind when you are using the registers in related 9000A programs. Table 3-2 lists the 9000A mainframe registers and their usage by the supplied programs.

Table 3-2. 9000A Register Usage

REGISTER NO.	USAGE
8	Contains the setup parameters
9	Used for internal program control (unavailable to the user)
A	Waveform capture mode: high data samples
A	Contains the op code sent by send op code program (no. 18)
B	Waveform capture mode: low data samples
B	Contains data/status from get data/status program (no. 17)

NOTE

Refer to the Operator Manual that accompanied your Troubleshooter for an explanation of and the standard uses for the 16 data registers within the Troubleshooter.

3-25. LIBRARY PROGRAMS

3-26. Setup Hardware Program

PROGRAM NUMBER: 12

NAME: Setup hardware

ACTION: Configures the asynchronous signature module with setup values.

USER REGISTERS REFERENCED: Register 8.

USER REGISTERS AFFECTED: None.

DESCRIPTION: The Setup Hardware Program is a binary program used to initialize the Signature Module to the setup values established for the control signals, delay compensation, etc. The setup values are taken from register 8, the initialization register, which is preloaded as defined in Table 3-3 prior to execution of the program.

The Setup Hardware Program performs the following basic operations:

1. Disarms the module
2. Resets the module (gate function)
3. Checks each field of the initialization register and sends the corresponding op code to the module.

Table 3-3. Initialization Register, Field Definitions

FIELD DESIG.	POSITION (REG. BITS)	FIELD FUNCTION	ENCODING (bits 2,1,0)
a	0, 1, 2,	Designates the field displayed when setup is interrupted (used by Service SETUP Key Program)	000 = field b 001 = field c 010 = field d 011 = field e 100 = field f 101 = field g 110 = field h 111 (not used)
b	3, 4	Designates the START signal selection	bit 3: 0 = rising edge 1 = falling edge bit 4: 0 = external START lead 1 = pod SYNC

'Table 3-3. Initialization Register, Field Definitions (cont.)

FIELD DESIG.	POSITION (REG. BITS)	FIELD FUNCTION (bits 2,1,0)	ENCODING
c	5, 6	Designates the STOP signal selection	bit 5: 0 = rising edge 1 = falling edge bit 6: 0 = external STOP lead 1 = external START lead
d	7, 8, 9	Designates the CLOCK signal selection	bit 7: 0 = single edge 1 = both edges bit 8: 0 = rising edge 1 = falling edge bit 9: 0 = external CLOCK lead 1 = pod SYNC
	10, 11	Designates the ENABLE signal selection	bit 10: 0 = external enable 1 = held enabled bit 11: 0 = ENABLE on high 1 = ENABLE on low
	12 - 23	Specifies the count for the stop-on-count function	zero = disable function 1 to 4095(decimal) sets the stop-on count
	24 - 27	Specifies the amount of delay compensation (1 unit = 3 ns) Left to right is bit 27, 26, 25, and 24.	0000 = no delay 0001 = 1 unit of delay 0010 = 2 units of delay 0011 (not used) 0100 = 3 units of delay 0101 = 4 units of delay 0110 = 5 units of delay 0111 (not used) 1000 = 6 units of delay 1001 = 7 units of delay 1010 = 8 units of delay 1011 (not used) 1100 = 9 units of delay 1101 = 10 units of delay 1110 = 11 units of delay 1111 = 12 units of delay
	28, 29	Designates the event count selection	bit 28: 0 = gated mode 1 = free-run mode bit 29: 0 = count probe data 1 = count clocks
i	30, 31	Not used	

If a timeout occurs during communications with the signature module, the user is given an error message and asked to press the CONT key before proceeding. All other keys will produce a beep (including STOP).

3-27. Arm Gate Program

PROGRAM:13

NAME: Arm Gate

ACTION: Initializes the gate section to prepare for an acquisition period. The acquisition period begins on the first start edge after this routine is executed.

USER REGISTERS REFERENCED: Register 8.

USER REGISTERS AFFECTED: None.

DESCRIPTION: The Arm Gate Program is a binary program that is executed to reset and arm the Signature Module in preparation to begin a gate period. Upon execution of this program, the gate period begins at the time of the next START edge.

This program first terminates any acquisition period in progress. It then resets the signature, event, and waveform registers and reinitalizes the stop counter and transition count mode from user register 8. Finally, the program arms the gate section to begin an acquisition period on the first start edge.

If a signature module timeout occurs, the user is given an error message and asked to press the CONT key before proceeding. All other keys will produce a beep (including STOP).

The program performs the following operations:

1. Disarms the module

2. Resets the module (all registers and gating)

3. Arms the module in preparation to receive the selected control signals

3-28. Use of the Get Signature, Get Events, and Get Wave Programs

The architecture of the Asynchronous Signature Module requires that these programs be used in a specified order. The signature, event, and waveform registers are connected as a four-bit-wide by 26-long shift register. At the end of the acquisition period, when the registers contain the results, the program Get Signature must be used first because the signature data is at the first four four-bit locations in the shift register. The Get Signature program shifts the entire register four times, reading a nibble of the signature at each shift. The signature is read destructively; that is, once it is read by Get Signature, it is no longer available from the hardware.

As the signature register is shifted, so are the event and waveform registers, so that at the end of the Get Signature program, the event count is at the first six locations in the shift register (occupying the signature register and part of the event count register). The Get Events program can be used at this stage (if desired) to return the event count by shifting and reading the shift register six times. The event count is also read destructively. After the Get Signature and Get Events programs have been used, the waveform data has been shifted to the first 16 locations in the shift register. The Get Waveform program can then retrieve the waveform data (if desired). Again, the read operation is destructive.

3-29. Get Signature Program

PROGRAM:14

NAME: Get Signature

ACTION: Returns the signature from the last acquisition period.

USER REGISTERS REFERENCED: None.

USER REGISTERS AFFECTED: Register B.

DESCRIPTION: This program reads the signature from the signature module hardware. It should be the first program used to read the acquired data. Use of the Get Events and Get Waveform programs, if any, must follow the Get Signature program (see paragraph 3-28 for more information).

If an acquisition period is still in progress (STOP signal not yet received), the period is terminated before the data is read. See Figure 3-10 for the format of the returned signature.

If a signature module timeout occurs, the user is given an error message and asked to press the CONT key before proceeding. All other keys will produce a beep (including STOP).

The data is read one nibble at a time so that the signature data is placed in the 16 low-order positions of register B (refer to Figure 3-10). The data is read from the registers of the Signature Module destructively; once it is read, it cannot be read again.

The program performs the following operations:

1. Disarms the module

2. Resets the module (gating function)

3. For each of four nibbles: Sends the read op code
   Receives a byte (data nibble/status)
   Places nibble in register B
   Sends the register shift op code

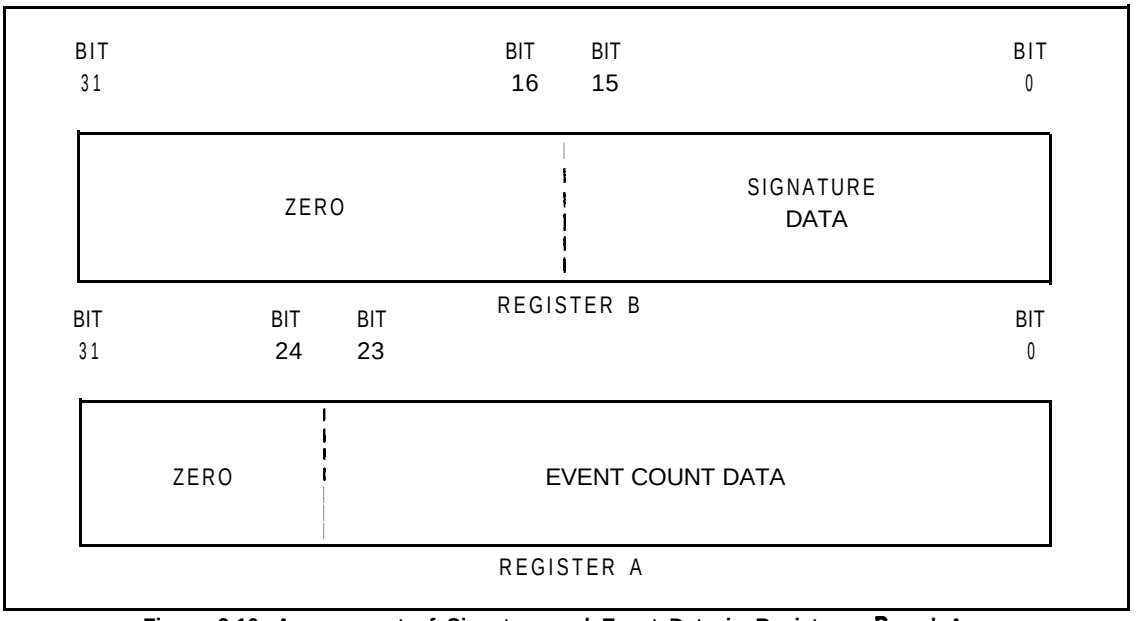

Figure 3-10. Arrangement of Signature and Event Data in Registers B and A.

3-30. Get Events Program

PROGRAM: 15

NAME: Get Events

ACTION: Returns the event count from the last acquisition period.

USER REGISTERS REFERENCED: None.

USER REGISTERS AFFECTED: Register A.

DESCRIPTION: This program reads the event count from the signature module hardware. The Get Events program must be preceded by the Get Signature program. The Get Waveform program, if used, should follow Get Events (see paragraph 3-28 for more information).

If an acquisition period is still in progress (STOP signal not yet received), the period is terminated before the data is read. See Figure 3-10 for the format of the returned event count.

If a signature module timeout occurs, the user is given an error message and asked to press the CONT key before proceeding. All other keys will produce a beep (including STOP).

The data is read one nibble at a time so that the events data is placed in the 24 low-order positions of register A (refer to Figure 3-10). The data is read from the registers of the Signature Module destructively; once it is read, it cannot be read again.

The program performs the following operations:

1. Disarms the module

2. Resets the module (gating function)

3. For each of six nibbles: Sends the read op code
   Receives a byte (data nibble/status)
   Places nibble in register A
   Sends the register shift op code

3-31. Get Waveform Program

PROGRAM:16

NAME: Get Wave.

ACTION: Returns the waveform capture data from the last acquisition period.

USER REGISTERS REFERENCED: None.

USER REGISTERS AFFECTED: Registers A and B.

DESCRIPTION: This program reads the captured waveform data from the signature module hardware. For proper operation, the Get Waveform program must be preceded by the Get Signature and Get Events programs (see paragraph 3-28 for more information).

If an acquisition period is still in progress (STOP signal not yet received), the period is terminated before the data is read. See Figure 3-11 for the format of the returned waveform data.

If a signature module timeout occurs, the user is given an error message and asked to press the CONT key before proceeding. All other keys will produce a beep (including STOP).

This program reads the waveform data contained in the waveform register, one nibble at a time, through the event count and signature registers into registers A and B (global registers). Sixteen read operations in conjunction with register-shifting functions place the valid-high samples in register A and the valid-low samples in register-B as shown in Figure 3-11.

The data is read from the module destructively; once it is read, it cannot be read again. Also, the waveform data must be read (this program executed) after the Get Signature/Events Program is executed, since the latter shifts the waveform data so that the first nibble is available for output to the Troubleshooter.

The program performs the following operations:

1. Disarms the module

2. Resets the module (gating function)

3. For each of 16 nibbles: Sends the read op code
   Receives a byte (data nibble/status)
   Decodes nibble-- 2 bits for each register
   Sends the register shift op code

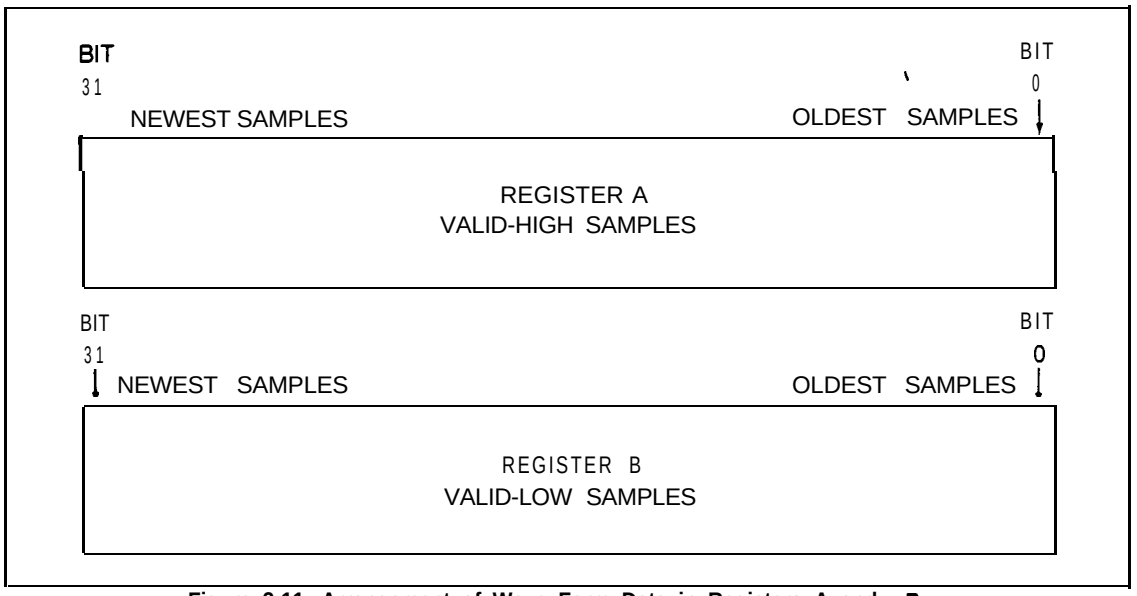

Figure 3-11. Arrangement of Wave Form Data in Registers A and B.

3-32. Get Data and Status Program

PROGRAM: 17

NAME: Get Data and Status

ACTION: Returns the current gate status and the first nibble of the shift register.

USER REGISTERS REFERENCED: None.

USER REGISTERS AFFECTED: Register B.

DESCRIPTION: This program non-destructively reads the most-significant nibble of the CRC register and the current status of the signature module hardware. The Get Data and Status program may be used any time the data or status is desired. The program will not disturb an acquisition period in progress. See Table 3-4 for the format of the returned information.

If a signature module timeout occurs, the user is given an error message and asked to press the CONT key before proceeding. All other keys will produce a beep (including STOP).

The Get Data and Status Program performs the following operations.

1. Sends op code 80 to place a nibble of data and a nibble of module status on the pod bus.

2. Reads the contents of the pod bus into the low-order eight bits of register B. (Once in register B, the data can be examined and/or displayed.)

The significance of the eight bits read from the module over the pod bus is listed in Table 3-4.

Table 3-4. Byte Received from Signature Module

BIT	SIGNATURE MODULE FUNCTION
0	Output shift register, bit 0
1	Output shift register, bit 1
2	Output shift register, bit 2
3	Output shift register, bit 3
4	A CLOCK edge has occurred in the last 200 milliseconds
5	A START edge has been received
6	A STOP edge has been received
7	Clock Module is properly grounded at the UUT

3-33. Send Op Code Program

PROGRAM: 18

NAME : Send Opcode

ACTION : Sends an opcode byte to the module's control section

USER REGISTERS REFERENCED: Register A.

USER REGISTERS AFFECTED: None.

DESCRIPTION: This program sends the low-order eight bits of register A over the pod bus. Op codes from those listed in Table 3-5 are sent to the module , by placing the desired op code in register A and executing the program.

If a signature module timeout occurs, the user is given an error message and asked to press the CONT key before proceeding. All other keys will produce a beep (including STOP).

The 00 command cannot be embedded in a string of other commands to the signature module, but must be preceded by a delay of at least 200 milliseconds. Failure to precede the command by a 200-millisecond (or greater) pause, causes the Signature Module to ignore the command and causes the Interface Pod (if connected) to require a reset.

Connecting the Signature Module to the pod bus (00 op code) and disconnecting it from the pod bus (FO op code) is necessary since the Interface Pod is also connected to the pod bus. When the Signature Module is connected to the bus, the Interface Pod is unaware of any activity on the bus, However, when the module is connected, the Interface Pod is able to receive and send data in a normal manner, until the 00 op code is again placed on the pod bus.

Table 3-5 lists the available op codes with a brief description of each. Refer to Section 6 for additional op code information.

Table 3-5. Signature Module Op Codes

OP CODE	FUNCTION
00	Turn on the Signature Module to the pod bus (precede with delay)
10	ENABLE signal to be from Clock Module
11	ENABLE signal to be held in the high (enabled) state
12	CLOCK signal to be from UUT via Clock Module CLOCK lead
13	CLOCK signal to be SYNC signal from Interface Pod
14	START signal to be from UUT via Clock Module START lead
15	START signal to be SYNC signal from Interface Pod
16	STOP signal to be from UUT via Clock Module STOP lead
17	STOP signal to be SYNC signal from Interface Pod
18	ENABLE signal level to be valid high
19	ENABLE signal level to be valid low
1A	CLOCK signal, select rising edge (overridden by op code 30)
1B	CLOCK signal, select falling edge (overridden by op code 30)
1C	START signal, select rising edge
1D	START signal, select falling edge
1E	STOP signal, select rising edge
1F	STOP signal, select falling edge
20	Delay compensation, deselect 3 ns unit
21	Delay compensation, select 3 ns unit
22	Delay compensation, deselect 6 ns unit
23	Delay compensation, select 6 ns unit
24	Delay compensation, deselect 9 ns unit
25	Delay compensation, select 9 ns unit
26	Delay compensation, deselect 18 ns unit
27	Delay compensation, select 18 ns unit
28	Disarm (causes the module to ignore START signals)
29	Arm (cause the module to act on START signals)
2A	Disable the stop-on-count function (stops on no. of gated CLOCK)
2B	Enable the stop-on-count function
2c	Event count from start to stop
2D	Event count continuously
2E	Define events as the selected CLOCK source and edges
2F	Define events as low- or tri-to-high probe data transitions
30	CLOCK signal, select both edges
40	CLOCK signal, permit the selection of op codes 1A and 1B
5x	Load stop-on-count value, where x is the least-significant nibble
6x	Load stop-on-count value, where x is the intermediate nibble
7x	Load stop-on-count value, where x is the most-significant nibble
80	Notify the module that the next operation will be a read
90	Shift all registers (next data nibble to the output buffer)
B0	Clear the signature register (prepare for next gate time)
c0	Clear the events counter
D0	Clear the waveform register
E0	Clear the gate section (prepare for nextgate time)
F0	Turn off the Signature Module from the pod bus

3-34. Display Waveform Program

PROGRAM: 19

NAME: Display Waveform

ACTION: Displays data on the 9000A as a waveform.

USER REGISTERS REFERENCED: Registers A and B.

USER REGISTERS AFFECTED: None.

DESCRIPTION: The Display Waveform program translates data in user registers A and B to characters for the 9000A display. The data in the registers are assumed to be of the form returned by the Get Waveform program. Each bit position in the user registers is mapped to a character position in the 9000A display. Highs are displayed as "-" (hyphen), lows are displayed as "." (period), and invalid levels as "=" (equal).

The 32-character display presents 640 nanoseconds of waveform data (20 nanoseconds per character) with the latest data at the left side of the display, and the earliest at the right side. A logic high condition is displayed when register A contains a 1 for the 20-nanosecond period. A logic low condition is displayed when register B contains a 1, and a tri-state condition is indicated when registers A and B each contain a zero.

3-35. Append Signature Program

PROGRAM: 20

NAME: Append Signature

ACTION: Appends the value in user register B to the display in signature format.

USER REGISTERS REFERENCED: Register B.

USER REGISTERS AFFECTED: None.

DESCRIPTION: The Append Signature program reads the value in user register B and appends it to the 9000A display in hexadecimal notation. Values with less than four digits are padded with leading zeroes as required to make the displayed number four hex digits wide. Values of four hex digits or more are displayed "as is".

3-36. MERGE TAPE PROGRAM

The Merge Tape Program is contained on side B of the supplied cassette. This program permits the reading of specific programs from any cassette, including side A of the supplied cassette. The Merge Tape Program allows the user to renumber specific programs without the time-consuming and error-prone process of reentering the programs manually. The Merge Tape Program reads specified programs and renumbers them, without destroying the programs already in the Troubleshooter memory.

3-37. Program Restrictions

Some restrictions are imposed upon the user of the Merge Tape Program. These restrictions are listed below.

1. The Merge Tape Program occupies 2419 bytes of 9010A user memory, thereby reducing the memory available for the programs to be merged.

2. The user must know which programs need to be read from the source tape and which programs already exist in the Troubleshooter memory.

3. The Merge Tape Program has no provisions for helping the user to keep track of program numbers currently assigned, so the user must keep careful account of the renumbering of programs. It is possible to lose a program by assigning two programs to the same number. (Only the last program assigned to the number will be copied.)

4. The Merge Tape Program must be executed as program 0, so no user program can be copied as program 0.

NOTE

If program 0 on the source tape is the main executive program in a program set, duplicate number conflict can be circumvented by renumbering program 0 to another available program number. Then, after deleting the Merge Tape Program, a new one-line program 0 can be created which simply executes the renumbered main executive program.

3-38. Definition of Terms

Table 3-6 lists several terms used in the following paragraphs and their definitions.

Table 3-6. Definition of Terms

TERM	DEFINITION
Source Tape	The tape from which programs are being read.
Source Program Number	The number of a program as stored on a source tape.
Object Tape	The tape to which programs are being written.
Object Program Number	The number of a program as stored on an object tape.
Number Conflict	This occurs when the user tries to assign a number that is already in use in Troubleshooter memory or has already been specified during the Merge Tape session.
Insufficient Memory	This condition occurs when there is not sufficient available memory to add the indicated program to those already specified.

3-39. Loading the Merge Tape Program

To load the Merge Tape Program, place the cassette in the tape drive, side B up, and press the READ TAPE key. When the Troubleshooter displays READ TAPE OK, execute the program.

3-40. Program Execution

To run the Merge Tape Program, press the EXEC, 0, and ENTER/YES keys on the Troubleshooter. The Troubleshooter then displays (C)FLUKE VER-n.n LOAD CASSETTE, prompting the user to remove the cassette containing the Merge Tape Program and insert the source tape cassette into the tape drive.

NOTE

The source tape loaded at this point must remain in the Troubleshooter tape drive until the Read-Source-Tape Phase is complete.

After the source tape is placed in the Troubleshooter tape drive, press CONT. If you press the STOP key or any other Immediate Mode key (WRITE, LEARN, etc.) at this point execution of the Merge Tape Program is terminated.

3-41. Read-Source-Tape-Header Phase

The Read-Source-Tape-Header Phase allows the Troubleshooter to determine the numbers and sizes of the programs contained on the source tape. When you press the CONT key, the Troubleshooter displays WAIT while it reads the source tape header, which contains the program numbers and sizes. The read operation takes only about six seconds, after which the Troubleshooter proceeds to the Read-All Phase (provided the tape header was read correctly). (If an error was detected due to a bad tape, no data on the tape, or no tape in the tape drive, the Troubleshooter displays FAIL, and program execution is terminated.)

3-42. Read-All Phase

The function of the Read-All phase is to specify all programs on the source tape for the Read-Source-Tape phase or to step through to the Specification phase where only the desired programs are specified. When the Troubleshooter enters the Read-All Phase, it displays READ ALL? If you press the ENTER/YES key in response to the READ ALL? prompt, the Troubleshooter specifies all the programs that are on the source tape for the Read-Source-Tape Phase. If there are no errors, the Troubleshooter displays OK.

If there are program number conflicts (where two or more programs have the same number), the Troubleshooter lists the conflicting program numbers although the conflicts are not resolved at this point. The Troubleshooter lists only the first 11 conflicting program numbers. Any program renumbering must be performed in the Specification Phase.

If insufficient memory is available (for the upcoming Read-Source-Tape phase), the Troubleshooter beeps and displays INSUF MEM, plus the number of the program causing the condition. That program and all subsequent programs on the source tape will be ignored and not specified. (The operator may choose to enter some of those programs individually during the Specification Phase.)

To exit the Read-All Phase, press the CONT key, and the Troubleshooter continues to the Specification Phase.

3-43. Specification Phase

The function of the Specification Phase is to specify one or more program numbers (of programs contained on the source tape) for reading into the Troubleshooter memory. (The reading of the specified programs to memory occurs during operation of the Read-Source-Tape phase, and the subsequent writing of the programs to the object tape in the Write-Object-Tape Phase. The Specification Phase also permits the renumbering of source programs, although number references within the programs must be changed manually.

When the Troubleshooter enters the Specification Phase, it displays PROGRAM. The two correct responses to the PROGRAM prompt are:

- A source program number (to specify a program)
- READ TAPE (to proceed to the Read-Source-Tape Phase)

When you enter a source program number, the Troubleshooter first checks that there is indeed a program with that number on the source tape. If there is no such program, the Troubleshooter beeps and displays NOT FOUND. The Troubleshooter then waits for the user to press the CONT key before it returns to the PROGRAM prompt.

When a valid source program number is entered, the Troubleshooter displays one of two messages:

- Y,N,NUM (flashing cursor) if there is no source program conflict
- N,NUM (flashing cursor) if there is a source program number conflict. (A valid entry of 00 always results in this display since the Merge Tape Program is also numbered 00.)

You can do the following to respond to the PROGRAM (entered number) Y,N,NUM (flashing cursor) display:

- Press the YES/ENTER key to select the entered/displayed source program number for reading from the source tape during the Read-Source-Tape Phase.
- Press the CLEAR/NO key (to prevent specifying the entered/displayed source program number and also remove any specification previously entered for that program number).
- Enter a new number to be assigned to this program when it is read from the source tape in the Read-Source-Tape Phase.

If you enter a new program number, then the Troubleshooter checks its validity. If there is a number conflict, the Troubleshooter displays CONFL. If an insufficient memory condition is detected, the Troubleshooter beeps and displays INSUF MEM. After either of these error messages, press the CONT key to return to the PROGRAM prompt.

You can do the following to respond to the PROGRAM (entered number) N,NUM (flashing cursor) display:

- Press the CLEAR/NO key (to prevent specifying the entered/displayed source program number and also remove any specification previously entered for that program number).

- Enter a new number to be assigned to this program when it is read from the source tape in the Read-Source-Tape Phase.

NOTE

Of the two source programs having the same number, the one that had the number assigned last becomes unspecified (by the CLEAR/NO key) or renumbered (by the entry of a new number).

If you enter a new program number, the Troubleshooter checks its validity. If there is still a number conflict, the Troubleshooter displays CONFL. If an insufficient memory condition is detected, the Troubleshooter beeps and displays INSUF MEM. After either of these error messages, press the CONT to return to the PROGRAM prompt.

When you have specified the object tape contents as desired, press the READ TAPE key in response to the PROGRAM prompt, and proceed to the Read-Source-Tape Phase.

3-44. Read-Source-Tape Phase

Upon entering the Read-Source-Tape Phase, the Troubleshooter displays READ TAPE - ARE YOU SURE? If you wish to abort the operation at this point, press the CLEAR/NO key, and the Troubleshooter displays READ TAPE ABORTED, indicting that a return has been made to the Immediate Mode.

If you have specified all the desired source programs and are ready to read them into the Troubleshooter memory, press the ENTER/YES key. At this point, the Troubleshooter proceeds to read only the specified programs from the source tape into memory. If the READ TAPE operation encounters an error, the Troubleshooter displays READ TAPE FAIL and will return to Immediate Mode. If the operation is performed successfully, the Troubleshooter displays READ TAPE OK and will return to Immediate Mode.

CAUTION

It is important that the source tape (which was loaded for the Read-Tape-Header Phase) is loaded into the Troubleshooter tape drive before you press the ENTER/YES key. If any other tape is in the drive, the Troubleshooter memory will be corrupted. If this happens, switch the Troubleshooter power off and on, and then START over. The source tape will not be damaged.

3-45. Write-Object-Tape Phase

The function of the Write-Object-Tape Phase is to write the entire contents of the Troubleshooter memory to the blank object tape, thereby creating a new tape of the source programs specified and read into memory during the previous phases of the Merge Tape operation.

The Write-Object-Tape Phase is performed independently of the Merge Tape program. When the Troubleshooter memory contains the desired source programs (upon completion of the Read-Source-Tape Phase), remove the source tape from the tape drive and insert the blank object tape. With the Troubleshooter in the Immediate Mode, perform a WRITE TAPE operation to transfer all programs currently in Troubleshooter memory onto the object tape.

3-46. Execute Program n Statements

When the number of a program is changed, the operator must then manually change all references to that program to reflect the number change. If for example, Program 2 is changed to be Program 3 and no correction is made to programs that call Program 2, then an "execute program 2" statement will find either no Program 2 or the wrong Program 2. The statement must be changed to "execute program 3".

3-47. Multiple Copies of a Program

Sometimes you may wish to duplicate a program under two (or more) program numbers. (This would be helpful, for example, when you are writing two programs that are similar.) To do this, the Merge Tape Program must be run more than once: once to load the program as Program nl, and a second time to load it as Program n2, etc. The Write-Object-Tape Phase need only be executed once, but it should be executed after the Troubleshooter memory contains the programs exactly as they should appear on the finished object tape.

Section 4
Theory of Operation

4-1. INTRODUCTION

This section contains two block diagram descriptions of the Asynchronous Signature Module housed within the case of the 9000A Series Troubleshooter. The first block diagram description is general; it describes the operating concept of the Signature Module and its relationship to the Troubleshooter and UUT. The second block diagram description covers the module in greater detail.

4-2. GENERAL OPERATION

The main function of the Signature Module is to receive streams of digital data from the UUT and generate a test result that the Troubleshooter can display as a four-character hexadecimal value (signature). During operation in the signature mode, the Troubleshooter uses the data probe to read the data appearing at the test nodes of the UUT, and it uses the Clock Module to obtain the START, STOP, CLOCK, and ENABLE control signals.

The START, STOP, and ENABLE signals (plus the pod SYNC signal if selected) establish a gate time, and generate CLOCK pulses during the gate time. The START, STOP, and ENABLE signals synchronize the measurement period to the data being read from the UUT by the data probe. The selected START signal specifies the beginning of the signature measurement interval (gate time), which should coincide with the beginning of the test pattern being stimulated within the UUT.

During the measurement interval, the data probe feeds test data through to the data input of the Signature Module, which accepts the data into three separate sections:

1. CRC (signature) section

2. Events section

3. Waveform section

When the selected STOP edge occurs, the gate time concludes, leaving registers in the CRC section loaded with the signature of the clocked-in test data, registers in the events section loaded with the number of selected transitions, and the waveform section registers loaded with a binary representation of the last 640 nanoseconds of probe data. The contents of these three sections are available over the pod bus for display by the Troubleshooter.

Figure 4-1 shows that the Signature Module is connected across the pod bus. Connection to the bus allows the transmission of op codes and data to the module. Connection to the bus also allows the transmission of signature, events count, waveform data, and module status back to the Troubleshooter. The module also uses the handshaking signals (MAINSTAT and PODSTAT) between the Troubleshooter and the Interface Pod; however, these signals are meaningful to only the signature module or the Interface Pod.

The Signature Module begins operation when it is selected by the Troubleshooter. To select the Signature Module, the Troubleshooter provides the MAINSTAT signal and sends the module turn-on op code over the pod bus. The control section of the module recognizes the turn-on op code and effectively disconnects the Interface Pod from the pod bus. The Interface Pod remains disconnected from the pod bus until the Troubleshooter releases the Signature Module by means of the turn-off op code.

With the Signature Module selected, the control section receives the op codes from the Troubleshooter and produces the signals necessary to control the various sections of the module shown in Figure 4-1. For example, op codes supplied by the Troubleshooter perform the following operations:

- Place the status of the Signature Module on the pod bus.
- Send control signals to set up the gate and delay sections in accordance with the setup selections previously made on the Troubleshooter.
- Clear the gate section, the CRC section, the events section, and the waveform section, then arm the gate section in preparation for the START and STOP signals required to clock in the data from the data probe.
- Place the status of the module on the pod bus during the gate time and when the STOP signal is received.
- Disarm the gate section to prevent further gate action from subsequent START signals.
- Reset (clear) the gate section.
- Send four step commands to shift the signature data (nibble-by-nibble) on the pod bus.
- Send six step commands to shift the event count data (nibble-by-nibble) on the pod bus.
- Send sixteen step commands to shift the waveform data (nibble-by-nibble) on the pod bus.

These Signature Module operations take place when operating the Troubleshooter in the signature gathering mode and when the READ PROBE key is pressed. The control section uses each op code listed in Table 4-1 to perform a specific operation. The overall result of the operations is to take a signature (plus events count and waveform data) and place it on the pod bus where it can be read by the Troubleshooter.

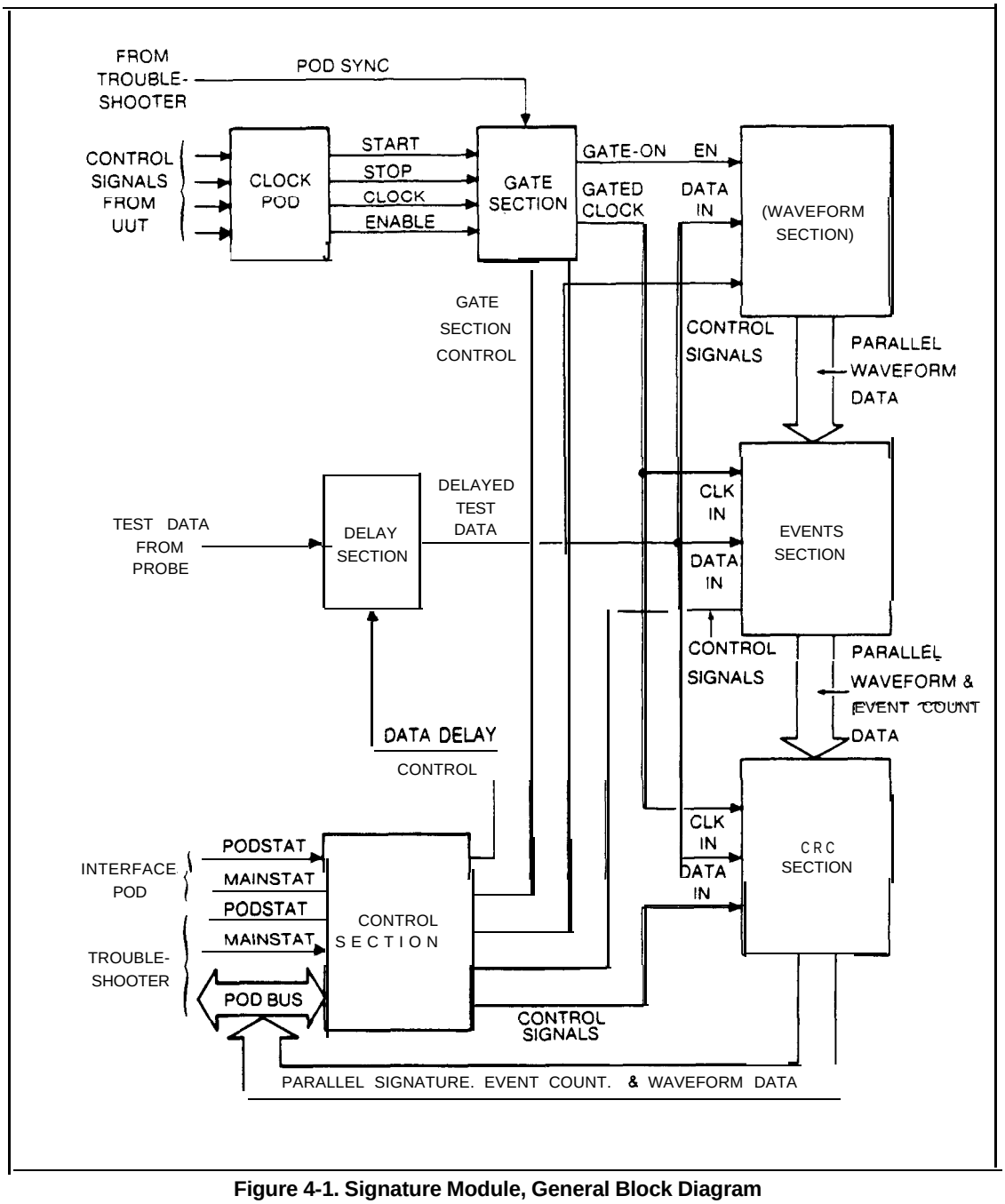

Figure 4-1. Signature Module, General Block Diagram

Table 4-1. Signature Module Op Codes

OP CODE	FUNCTION
00	Turn on the Signature Module to the pod bus (precede with delay)
10	ENABLE signal to be from Clock Module
11	ENABLE signal to be held in the high (enabled) state
12	CLOCK signal to be from UUT via Clock Module CLOCK lead
13	CLOCK signal to be SYNC signal from Interface Pod
14	START signal to be from UUT via Clock Module START lead
15	START signal to be SYNC signal from Interface Pod
16	STOP signal to be from UUT via Clock Module STOP lead
17	STOP signal to be SYNC signal from Interface Pod
18	ENABLE signal level to be valid high
19	ENABLE signal level to be valid low
1A	CLOCK signal, select rising edge (overridden by op code 30)
1B	CLOCK signal, select falling edge (overridden by op code 30)
1C	START signal, select rising edge
1D	START signal, select falling edge
1E	STOP signal, select rising edge
1F	STOP signal, select falling edge
20	Delay compensation, deselect 3 ns unit
21	Delay compensation, select 3 ns unit
22	Delay compensation, deselect 6 ns unit
23	Delay compensation, select 6 ns unit
24	Delay compensation, deselect 9 ns unit
25	Delay compensation, select 9 ns unit
26	Delay compensation, deselect 18 ns unit
27	Delay compensation, select 18 ns unit
28	Disarm (causes the module to ignore START signals)
29	Arm (cause the module to act on START signals)
2A	Disable the stop-on-count function (stops on no. of gated CLOCK)
2B	Enable the stop-on-count function
2C	Event count from start to stop
2D	Event count continuously
2E	Define events as the selected CLOCK source and edges
2F	Define events as low- or tri-to-high probe data transitions
30	CLOCK signal, select both edges
40	CLOCK signal, permit the selection of op codes 1A and 1B
5x	Load stop-on-count value, where x is the least-significant nibble
6x	Load stop-on-count value, where x is the intermediate nibble
7x	Load stop-on-count value, where x is the most-significant nibble
80	Notify the module that the next operation will be a read
90	Shift all registers (next data nibble to the output buffer)
B0	Clear the signature register (prepare for next gate time)
C0	Clear the events counter
D0	Clear the waveform register
E0	Clear the gate section (prepare for next gate time)
F0	Turn off the Signature Module from the pod bus

Figure 4-1 shows the relationship of the control section to the other sections of the module (which it controls in response to op codes from the Troubleshooter). Figure 4-1 also shows the control signals from the UUT/and Clock Module and the path of the test data from the data probe.

The START, STOP, CLOCK, and ENABLE signals from the UUT are conditioned by the Clock Module and applied to the gate section of the module. The gate section also accepts the pod SYNC signal (produced by the Interface Pod) as a control signal. The main function of the gate section is to provide gated CLOCK signals to the CRC and events registers. The source of the CLOCK signals may be the clock lead of the Clock Module, or the pod SYNC signal, depending upon the selection made during the setup of the Troubleshooter for signature operation. The control section causes the gate section to select the correct source of the CLOCK signal in response to op codes sent by the Troubleshooter.

The gate time (during which the gate section produces the **gated** CLOCK signals) begins with the selected START signal and ends with the selected STOP signal. The source of the START signal may be the corresponding lead of the Clock Module (i.e., the UUT) or the pod SYNC signal. The source of the STOP signal may the corresponding lead of the Clock Module or the SYNC signal from the Interface Pod. Selection of the START and STOP signals is a function of control lines from the control section, which in turn are a result of op codes sent by the Troubleshooter.

The gated CLOCK signals cause the CRC and events sections to clock in the test data from the data probe. Before the test data reaches the CRC and events sections (and also the waveform section), it is passed through the delay section. The delay section delays the test data by a selected amount in the range of zero to approximately 36 nanoseconds, in approximately j-nanosecond increments. This selectable delay allows for timing adjustment of the test data relative to the control signals, which is necessary in many applications where marginal time relationships exist.

The CRC section generates the 16-bit signature by using the gated CLOCK pulses to receive the UUT data fed to the module by the data probe. In the absence of the **gated** CLOCK signals, the CRC section ignores data from the data probe. The four-bit parallel output of the CRC section is available to the pod bus (via a transmit buffer) but is not placed on the bus until commanded to do so by the Troubleshooter. Since only four bits of signature data are placed on the pod bus at a time, four read operations are required by the Troubleshooter to shift all four characters of signature data through the CRC section and onto the bus.

The events section generates a 24-bit (six hex-digit) count of events (transitions) that take place in the test data or the selected CLOCK signal input. Events counting is selected to **take** place only during the gate-time, or continuously (free-running mode). Control lines from the control section select the signal source to be counted and determine whether to count on a continuous basis or only during the time of the gated signals. The output of the events section is applied in four-bit parallel form to a parallel load input of the CRC section. As the Troubleshooter reads the signature from the CRC section, the event section is pulsed to shift its contents into the CRC section behind the CRC data being shifted onto the pod bus. To read the entire contents of the event section over the pod bus, the Troubleshooter

performs six more read operations subsequent to the four used to the transfer the signature data.

The waveform register receives the serial data fed from the UUT and loads it serially into a 32-bit shift register. The operation of the shift register is such that it always contains a binary representation of the last 640 nanoseconds of test data fed from the probe. This test data can be displayed on the Troubleshooter as a waveform.

The output of the shift register is 4-bits (one nibble) wide, and is available to the Troubleshooter via the events section, the CRC section, and the pod bus. (The other nibble contains module status information.) To read the contents of the shift register for display, the Troubleshooter commands the control section to issue the necessary shift commands to the register in the waveform section, placing each nibble of waveform data on the pod bus. Once the Troubleshooter has read the contents of the waveform section, it can display a representative waveform of the last 640 nanoseconds of probe data.

4-3. DETAILED BLOCK DIAGRAM DESCRIPTION

4-4. Control Section

The main functions of the control section are as follows:

0 Recognize the turn-on op code from the Troubleshooter.

0 Prevent the Interface Pod from receiving the MAINSTAT signal after the turn-on op code and before the turn-off op code have been received.

0 Decode the op codes sent by the Troubleshooter over the pod bus and generate the corresponding control signals to the gate, delay, CRC, events, and waveform sections.

Figure 4-2 shows the main elements of the control section, with the Troubleshooter/Interface Pod connections on the left side and the connections to the remainder of the module on the right side. During operation, the Troubleshooter addresses both the Interface Pod and the Signature Module as required to fullfill testing requirements. The Interface Pod and the Signature Module are both connected to the same I/O port of the Troubleshooter, and the Signature Module examines each op code placed on the pod bus (by the Troubleshooter) to determine if the Signature Module should turn on or if the Interface Pod should be allowed to respond.

When the Troubleshooter places a command (op code) on the pod bus destined for the Interface Pod, it pulls the MAINSTAT signal low. The MAINSTAT signal is fed through delay circuit, U29/U52, and gate U37 out to the interface pod as the SW-MAINSTAT signal. The delay circuit allows time for the turn-on detector to examine the op code placed on the pod bus to determine whether or not it is a OOH, the Signature Module turn-on op code. Since operation of the pod is asynchronous to the Troubleshooter, the delay

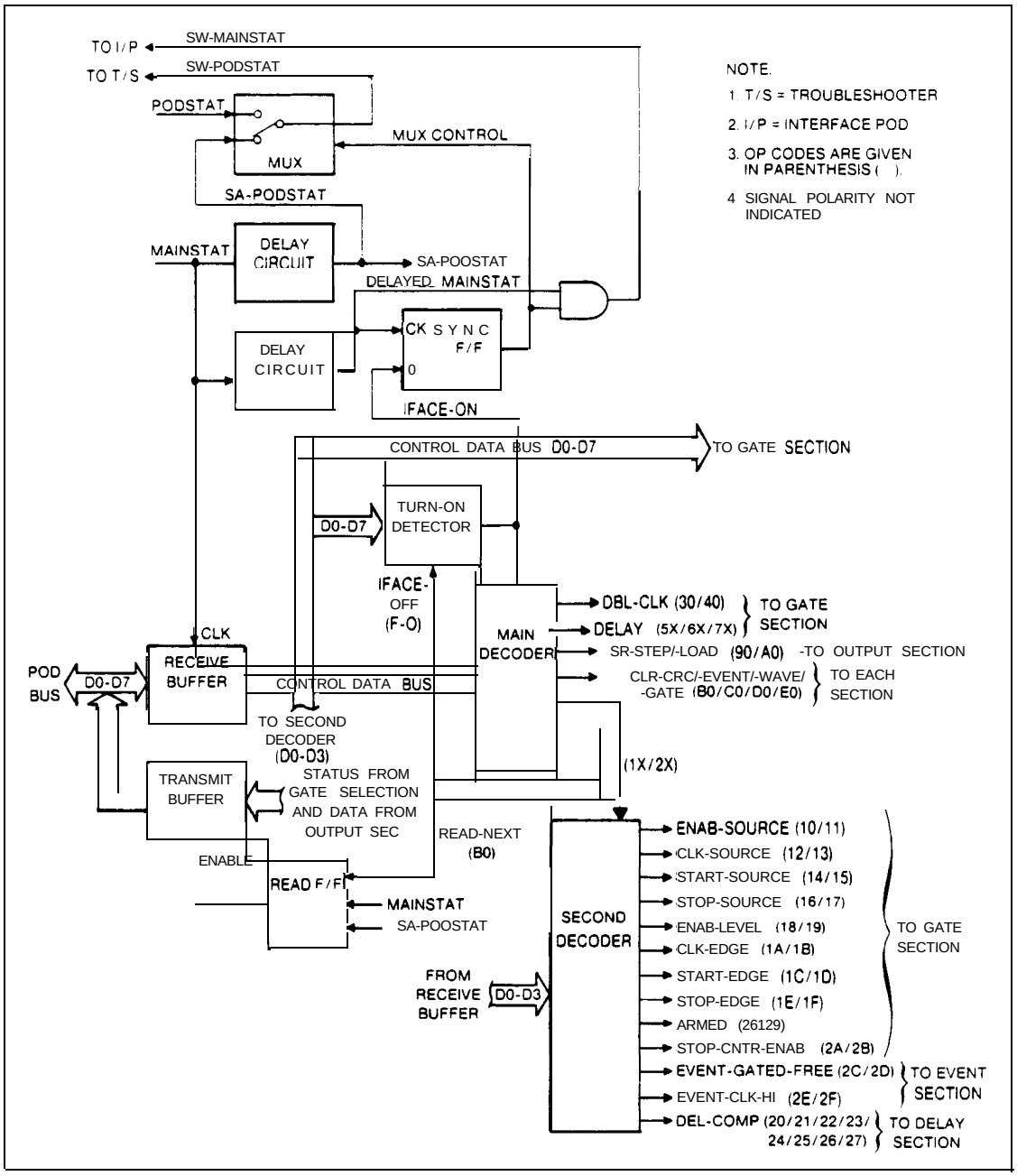

Figure 4-2. Control Section, Block Diagram

provided by U29/U52 is transparent to the pod (i.e., it does not affect pod operation). The PODSTAT signal, required by the Troubleshooter software for handshaking purposes, is routed back from the Interface Pod, through the multiplexer (U52) to the Troubleshooter as the SW-PODSTAT signal.

When the Troubleshooter addresses the Signature Module, it places the turn-on op code (OOH) on the pod bus and pulls the MAINSTAT line low. The MAINSTAT signal clocks the receive buffer (U4), applying the op code to the turn-on detector (U7, U16, and U33). The output of the detector enables the main decoder (U18 and U17) and also sets the SYNC F/F (U6) to prevent the MAINSTAT signal from reaching the Interface Pod. (If the MAINSTAT signal was allowed to reach the Interface Pod, it would also read the op codes placed on the pod bus for the Signature Module.)

The output of the SYNC F/F (U6) also controls the PODSTAT signal multiplexer (U52). When the SYNC F/F is set, the multiplexer (U52) is switched so that the PODSTAT signal required by the Troubleshooter software is provided by simply delaying the MAINSTAT signal. The PODSTAT signal is a requirement of Troubleshooter/Interface Pod handshaking, and the fake PODSTAT signal sent as a result of delaying the MAINSTAT signal satisfies these requirements.

With the main decoder (U18, U17) enabled, each op code placed on the pod bus by the Troubleshooter and latched (clocked) into the receive buffer (U4) is decoded to a specific Signature Module function. Two of the decoded functions (op codes 1x and 2x) enable the second decoder (U11 and U12). That is, whenever an op code is received that has 1H or 2H as the high nibble, the second decoder latches an output that corresponds to the low nibble. For example, op code 12H sets the CLK-SOURCE line low, while op code 13H sets the same line high. The CLOCK-SOURCE line is used within the gate section to select the source of the CLOCK signal between the Clock Module and the pod sync signals.

When the Troubleshooter issues a read-next op code (80H) to the control section, the main decoder (U18, U17) enables the transmit buffer (U13) by read F/F (U13 and U16). The function of the read F/F is to enable the transmit buffer at the time required by the Troubleshooter software. The transmit buffer is enabled after receipt of the next MAINSTAT signal from the Troubleshooter, and at the time of the SA-PODSTAT signal (delayed MAINSTAT signal).

As long as the main decoder (U18 and U17) does not receive the turn-off op code (FOH) from the Troubleshooter, the second decoder continues to decode the received op codes into specific commands to control the gate, delay, CRC, events, and waveform sections of the module. However, when the Troubleshooter places the turn-off op code (FOH) on the pod bus, the main decoder generates the IFACE-OFF signal. The IFACE-OFF signal resets the turn-on detector (U7, U16, and U33) to inhibit the main decoder and remove the set input from the SYNC F/F (U6). With the set input removed from U59, the next MAINSTAT signal causes U6 to change state, allowing the MAINSTAT signal to pass through to the Interface Pod and the PODSTAT signal to pass from the Interface Pod to the Troubleshooter. Under these conditions, communication is restored between the Troubleshooter and the Interface Pod.

4-5. Gate Section

The main function of the gate section is to provide gated CLOCK pulses, using the START, STOP, CLOCK, ENABLE, and pod SYNC signals, as selected by the operator of the Troubleshooter. The gated CLOCK signals are required by the CRC section to clock in the data appearing at the data probe and to calculate the signature of the data occurring during the gate time. (The gate time is that period between the first selected START edge and the first STOP edge.) The gate section also provides an output (GATE-ON) to the events section so that events can be counted during the gate time (when not operated in the free-running mode).

When the setup of the Troubleshooter is performed (see Section 3), selections regarding the control (START, STOP, CLOCK, and ENABLE) signals are made and stored within the Troubleshooter. When the operator presses the READ PROBE key to read a signature, events count, or waveform, the Troubleshooter sends the control signal selections made during setup to the Signature Module. The setup selections are sent as op codes, decoded within the control section and applied to the gate section as individual control lines.

Figure 4-3 shows each of the control lines from the control section, plus the control signals themselves from the Clock Module and Interface Pod (pod SYNC). The control signal source selector (U34 and U35) permits selection of the source for the START, STOP, CLOCK, and ENABLE signals. The source for the START signal may be the start lead of the Clock Module (EXT-START) or the pod SYNC signal. The source for the STOP signal may be either the stop lead (EXT-STOP) or the SYNC signal from the Interface Pod. The source for the CLOCK signal may be the clock lead (EXT-CLOCK) of the Clock Module or the POD-SYNC signal. The source for the ENABLE signal may be the enable lead (EXT-ENAB) of the Clock pod or the +5-volt supply (always enabled).

The control signal sources are selected by the four control lines designated START-SOURCE, STOP-SOURCE, ENAB-SOURCE, and CLOCK-SOURCE from the control section. The four control lines reflect the op codes sent by the Troubleshooter to initialize the Signature Module prior to taking a signature, and cause the selector (U34 and U35) to connect the appropriate signal source through to its output. At the output, the selected control signals are applied to the control signal edge selector.

The edge selector (U36) allows selection of the rising or falling edge of each of the selected control signals. (The ENABLE signal is selected as either a high or low level since it is not edge-sensitive.) As in the control signal source selector, the edge selector acts upon op codes decoded by the control section and passed on as control lines to the selector made up of U36. These control lines are designated START-EDGE, STOP-EDGE, CLK-EDGE, DBL-CLK, and ENAB-LEVEL.

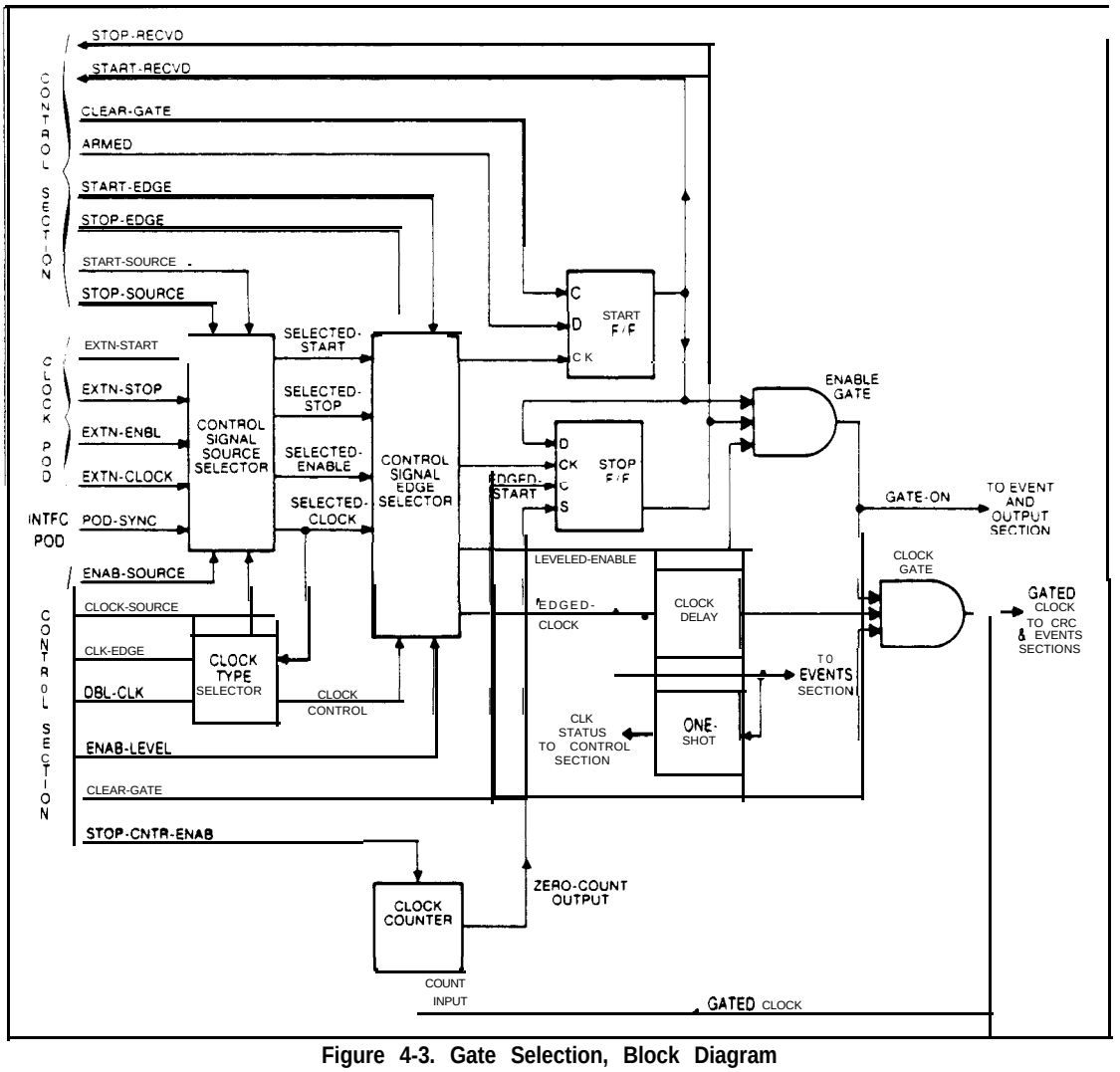

Figure 4-3. Gate Selection, Block Diagram

The CLK-EDGE and DBL-CLK control lines are applied to selector U25 along with the selected CLOCK signal. Selector U25 causes U36 to output CLOCK pulses at a rate of one per selected edge, or one per edge (both edges), depending on the control lines from the control section. In the one-per edge mode, the selected CLOCK signal is doubled, since a CLOCK pulse is provided at the output of U36 for each CLOCK signal edge, both rising and falling.

Operation of the gate section from this point is such that when a selected START edge occurs, the start flip-flop (U48A) is clocked. If the start flip-flop was previously armed (by the ARMED control line and the arm op code), it changes state to produce the START-RECVD signal. The START-REC'JD signal is fed to the enable gate (U49), to the stop flip/flop (U48B), and back to the control section as a status line to the Troubleshooter. Assuming no STOP edge has yet been received, and assuming the enable level is in the enabled state, the enable gate (U49) provides a GATE-ON signal to the clock gate (U24 and U23) (and to the events and waveform sections).

At the time of the first CLOCK pulse after the START signal edge, the clock gate produces its first gated CLOCK pulse to the CRC and events sections.

The CLOCK pulse is a result of the edged CLOCK signal, delayed by U49 (to match the delay of the start and stop flip-flops) and applied to the clock gate. The clock gate remains enabled until the selected STOP signal occurs and the stop flip-flop (U48B) changes state to inhibit the enable gate (U49). The enable gate inhibits the clock gate and halts the generation of gated CLOCK pulses. The output of the stop flip-flop is also fed to the control section as a status line back to the Troubleshooter.

Once the STOP edge has been received and the stop flip-flop is set, the control section must produce a CLEAR-GATE signal. The CLEAR-GATE signal is required for the next START edge to set the start flip-flop and begin a new gate time.

Clock counter (U20A, U8, U9, U10) creates a STOP edge after a certain number of gated CLOCK pulses. This feature allows selection of a gate time that is equivalent to a specified number of gated clock pulses. The clock counter receives the gated CLOCK pulses fed to the CRC and events sections and decrements from a preset (at the time of initialization) count. When the counter reaches zero, it generates a zero-count output to set the stop flip-flop (U48B) and immediately inhibit the generation of gated CLOCK pulses.

4-6. Delay Section

The delay section inserts a specified amount of time delay into the data path of the test data picked up by the data probe and applied to the CRC, events, and waveform sections. The amount of delay can be selected in the range of zero to approximately 36 nanoseconds in increments of approximately 3 nanoseconds.

Figure 4-4 shows how the valid data from the probe is applied to a series of delay elements and a pair of selectors. The selectors are l-of-4 types that receive the individual taps of the series delay arrangement. The first series delay arrangement consists of 3-nanosecond elements, while the second consists of 9-nanosecond elements. The control lines from the control section determine which delay taps will be selected by U30 and U43 for application to the CRC, events, and waveform sections.

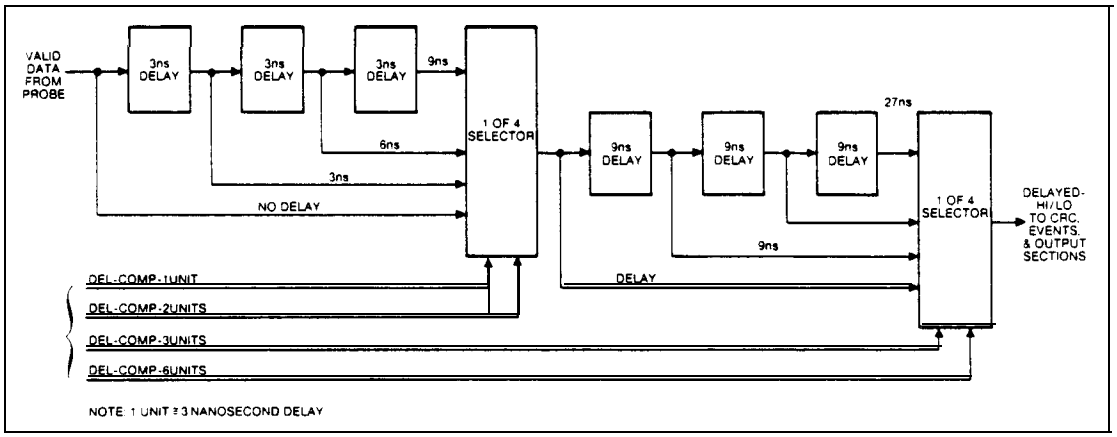

Figure 4-4. Delay Section, Block Diagram

4-7. CRC Section

The CRC section receives the gated CLOCK pulses from the gate section and the delayed data (high and low) from the delay section and generates the hexadecimal signature of the data through a cyclic redundancy check. As shown in Figure 4-5, the delayed data from the probe is applied through a feedback gating circuit to a 16-bit shift register. The shift register consists of four 4-bit registers, U63 through U66. Each register has serial and four-bit parallel inputs and outputs, where the output of the first is connected to the input of the second, etc. This arrangement allows data to be shifted through the registers in either serial or four-bit parallel fashion. The four-bit parallel output of the fourth register is fed to the transmit buffer, U3, located in the control section.

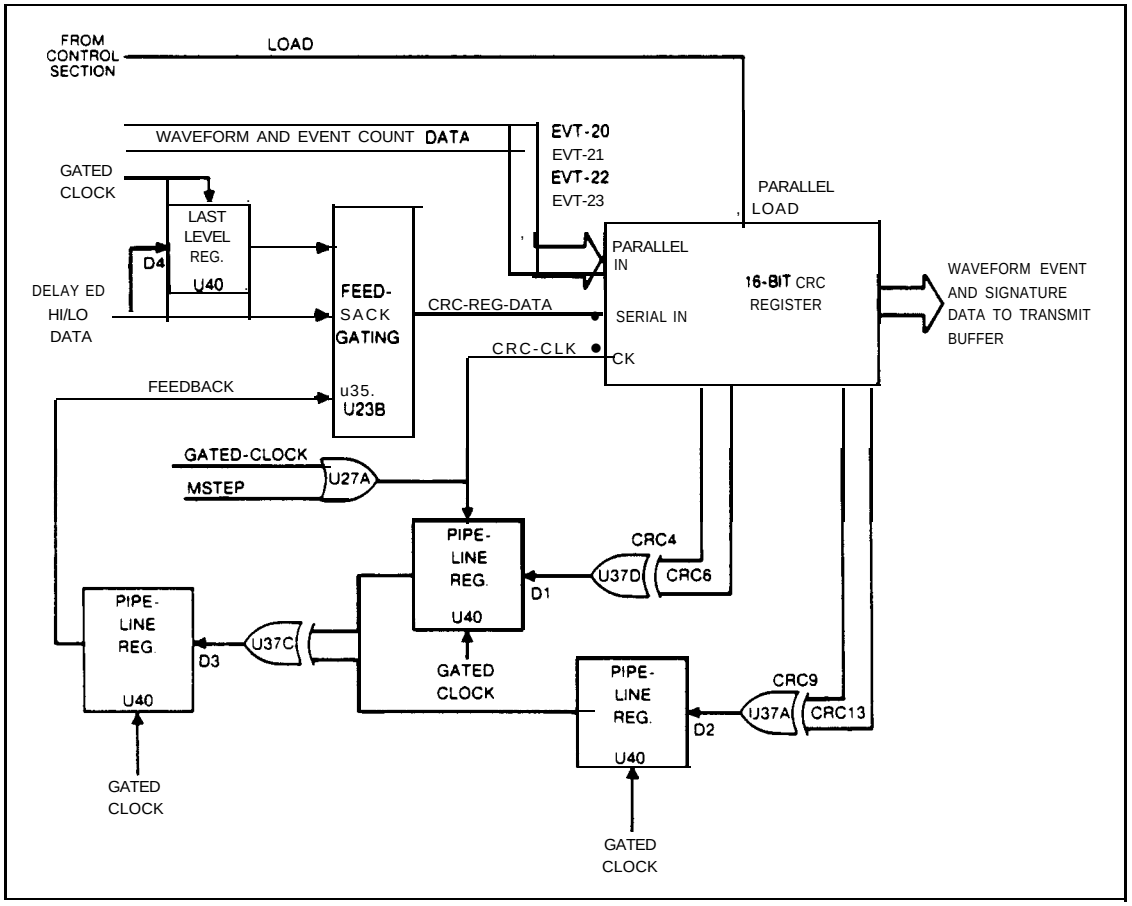

Figure 4-5. CRC Section, Block Diagram

Since the CRC register has both parallel and serial inputs/outputs, it can be operated in both parallel and serial modes. When a read probe operation is in progress, the gated CLOCK signal operates the register in the serial mode. In the serial mode, delayed high and low data is applied to the serial input of the first of the four registers and carries through to the fourth as gated CLOCK signals occur. To provide the CRC action of the register, four outputs are taken from the registers. These outputs are fed through exclusive-or gates and clocked through pipeline registers back to the feedback gating circuit formed by U21, U25, and U20.

The feedback gating is necessary to achieve the standard CRC signature result from the probe data and gated CLOCK pulses. The pipeline registers permit the CRC section to operate at a higher speed than that possible with the exclusive-or gates alone. Without the registers, the rate of the gated CLOCK pulses is limited by the cumulative delay of the exclusive-or gates (arranged in series) in the feedback path. The registers, clocked simultaneously, latch the feedback level appearing at the output of the preceding gate, reducing the effect of the total delay from the CRC register to the feedback gating and allowing higher clock and data speeds.

To prevent invalid data levels (both DELAYED-HI and DELAYED-LOW signals at a low level) from reaching the data input of the CRC register, a last level register (2D input of U22) is used to store the last valid data level and apply it to the feedback gating. This feature prevents the CRC register from attempting to generate a signature using invalid data. Each register in the CRC section is cleared by the CLR-CRC signal from the control section.

The CRC register also operates in the parallel mode. This mode is used at the end of the signature computation to shift the accumulated signature, four bits (nibble) at a time, onto the pod bus via the transmit buffer. Four shift (load) operations are used to place the four nibbles of signature data on the pod bus. As each shift operation takes place, the parallel output of the events section (EVT-20 through EVT-23) is shifted into and through the CRC register. The CRC register provides the path for the event count and waveform data to reach the transmit buffer and pod bus.

The four-bit output of the last CRC register is fed to the input of the transmit buffer (U3) located in the control section. When the Troubleshooter issues a read-next op code (80H) to the control section, the main decoder enables the transmit buffer. Since the transmit buffer contains the output of the last CRC register, the output of the last CRC register is placed on the pod bus to the Troubleshooter.

4-8. Events Section

The events section contains a 24-bit binary counter that consists of six 4-bit registers, U57 through U62. Each register has four-bit parallel inputs and outputs, where the output of the first is connected to the input of the second, etc. As in the CRC register, this arrangement allows data to be shifted through the registers in four-bit parallel fashion. The four-bit parallel output of the sixth register is fed to the parallel input of the CRC register, providing a means for the event count data to be shifted through to the transmit buffer, U3, located in the control section.

As shown in Figure 4-6, the input to the counter is selected from GATED-CLK, EDGED-CLK, GATED-HI, or DELAYED-HI by l-of-4 selector, U19. The selected input to the counter is determined by the EVENT-(SATED-FREE and EVENT-CLK-HI signals from the control section. The EVENT-GATED-FREE signal causes U19 to select between EDGED-CLK or DELAYED-HI and GATED-CLK or GATED-HI. The EVENT-CLK-HI signal causes U4119 to select between GATED-CLK or EDGED-CLK and GATED-HI or DELAYED-HI.

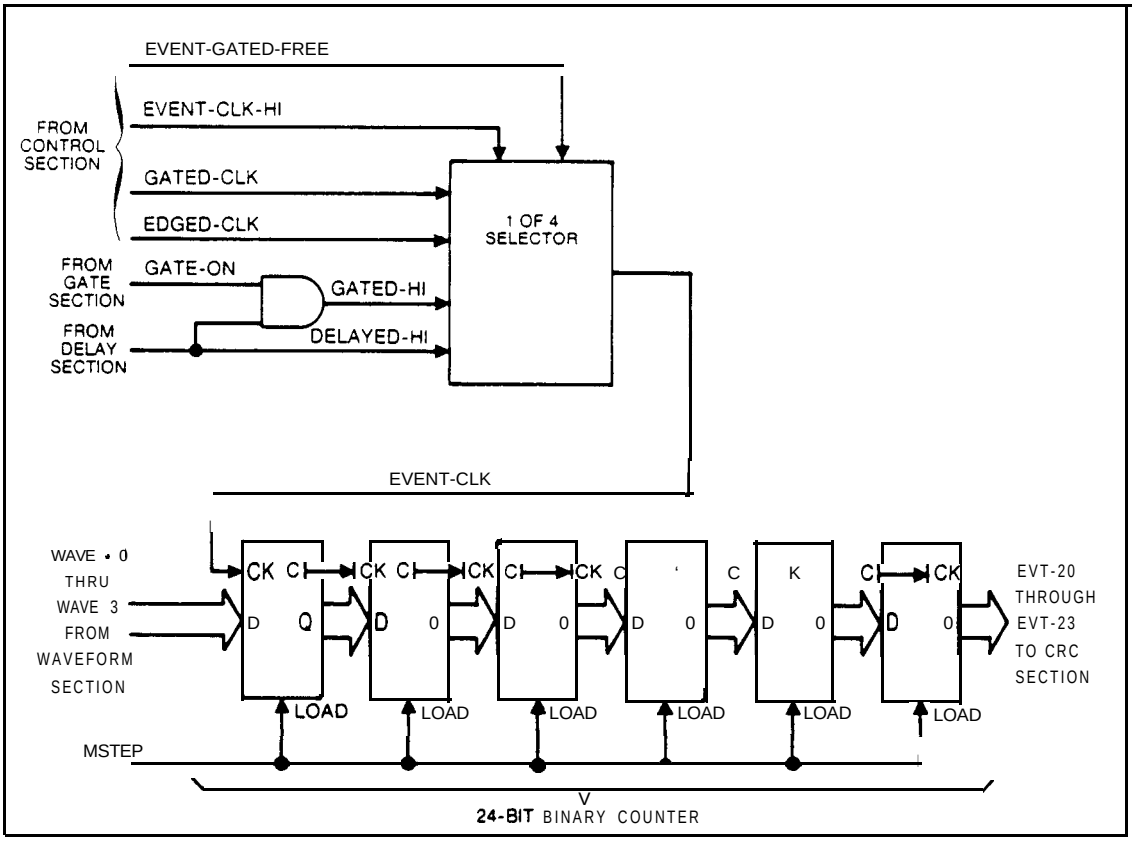

Figure 4-6. Events Section, Block Diagram

The events counter, U57 through U62, counts up using the selected input to clock the first stage. The parallel output of each stage connects to the succeeding stage, and the output of the final stage connects to the parallel input of the CRC register.

4-9. Waveform Section

The function of the waveform section is to read the probe data on a continuous basis so that it always contains the last 64 nanoseconds of probe data in a binary form. Figure 4-7 shows that the waveform section consists of a four 16-bit shift registers, each made up of two 8-bit shift registers connected in series. (Hereafter in this description, the term shift register refers to one of the 16-bit registers, such as that formed by U14 and U15.) One shift register (U14 and U15) receives DELAYED-HI data from the probe and the PHASE1 signal from the GATED-OSC signal and U42. A second shift register (U40 and U41) receives DELAYED-HI data and the PHASE2 signal.

These two registers both receive high-level data samples (registers U27, U28, U55, and U56 receive low-level data samples) but are clocked 180 degrees out of phase and 20 nanoseconds apart. The effect of this parallel, but out-of-phase, register arrangement is a doubling of the operating speed. That is, the data can be clocked at double the 25 MHz speed of the registers since each register is clocked at the clock speed, but 180 degrees apart.

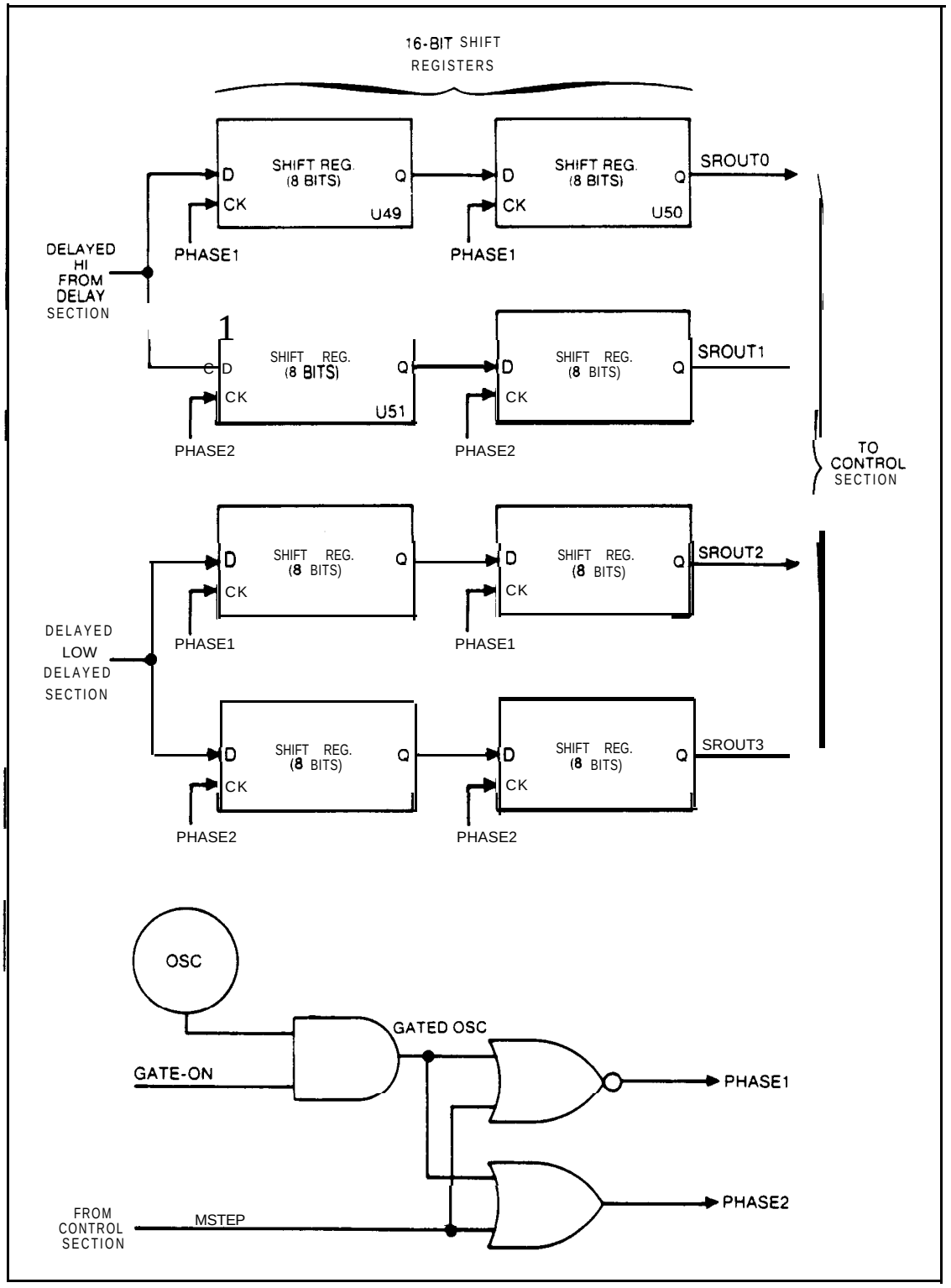

Figure 4-7. Waveform Section, Block Diagram

Since the two registers operate 180 degrees apart, they effectively appear as a single 32-bit register to the incoming high data (or the incoming low data in the case of U27, U28, U55, and U56). As a result, the two registers together always contain a binary representation of valid high conditions at the data probe for the last 640 nanoseconds (32 times 20 nanoseconds). The other two registers, U27, U28, U55, and U56) receive valid low **data** from the data probe and operate in a manner similar to that described for U14, U15, U40, and U41 to **clock** in valid low probe data.

At the end of a read probe operation (at the end of the gate time), the signature module transmits the waveform data to the Troubleshooter by first halting the 25 MHz shifting action of the registers. With the registers halted, the serial outputs of the four registers apply the oldest nibble of waveform data to the parallel input of the event counter. Each time the Troubleshooter executes the step command (op code 90H), the control section generates the MSTEP signal to shift the waveform registers, the event count registers, and the CRC registers.

By shifting the registers with the MSTEP signal, the waveform data passes through the event count and CRC registers to the transmit buffer. When the Troubleshooter executes a next read command (op code 80H), the data appearing at the input of the transmit buffer is latched into the buffer and placed on the pod bus. To shift the entire contents of all registers onto the pod bus, 26 shift (step) operations are required: four for the CRC register contents, six for the event count register contents, and 16 for the waveform register contents.