Application Note 313-1

"Troubleshooting Microprocessor-Based Systems Using the 5180A Waveform Recorder and a Logic Analyzer"

Introduction

Have you ever wanted to stop your microprocessor-controlled system at a specific instruction address and look at a certain signal, which contained, for example, an unexpected transient or noise? It worked like the uncertainty principle, which says you can't determine position and momentum at the same time. Once you stopped the program in a specific location, perhaps using a logic analyzer, you couldn't see the signal of interest on your oscilloscope for long enough to figure out what was going on.

Maybe you tried taking the critical portion of the microprocessor program and putting it into a short program loop, so the signal would repeat more often. However, using a shortened program often eliminates the cause of the unexpected signal altogether. Even if it does still occur, low repetition rate often makes it difficult to see on an oscilloscope.

Instead of trying to look at a repeating signal, you might have recorded the noise or other transient using a storage oscilloscope, if you were able to capture the critical portion of the transient this way. Even if you could see the waveform, however, a lack of resolution made estimates of voltage levels inaccurate at best. Also, although this technique would help you to see the signal temporarily, the displayed recording faded away quickly.

Now, this problem is solved. (The uncertainty principle still holds, however.) By simply combining your logic analyzer with the HP 5180A Waveform Recorder, those impossible-to-see signals can be captured, stored in digital memory, and viewed on a CRT display for as long as you like. Using this technique, when the appropriate instruction address in the microprocessor program reaches the logic analyzer, it sends a trigger to the 5180A, recording the signal of interest. Since the 5180A digitizes the waveform before storing it, the waveform may be recalled and displayed at any time, and voltage levels may be easily obtained from the digital data. The 5180A even provides a feature which has never been available using an oscilloscope: pre-trigger recording makes it possible to begin recording a signal before the trigger is received.

Description of General Application

This application note describes how to set up and operate a system which triggers on a specific microprocessor address word and records an analog signal of interest beginning either before, at, or after the trigger point.

The general arrangement of instruments and signal flow for this application are shown in Figure 1. First of all, (1), the microprocessor instruction address is read continuously by the logic analyzer. When the address of interest reaches the logic analyzer, a trigger signal (2), is sent to the 5180A's external trigger input. This causes the analog signal (3) from the circuit to be recorded, storing the waveform samples beginning an exact time either before or after the trigger signal reaches the 5180A.

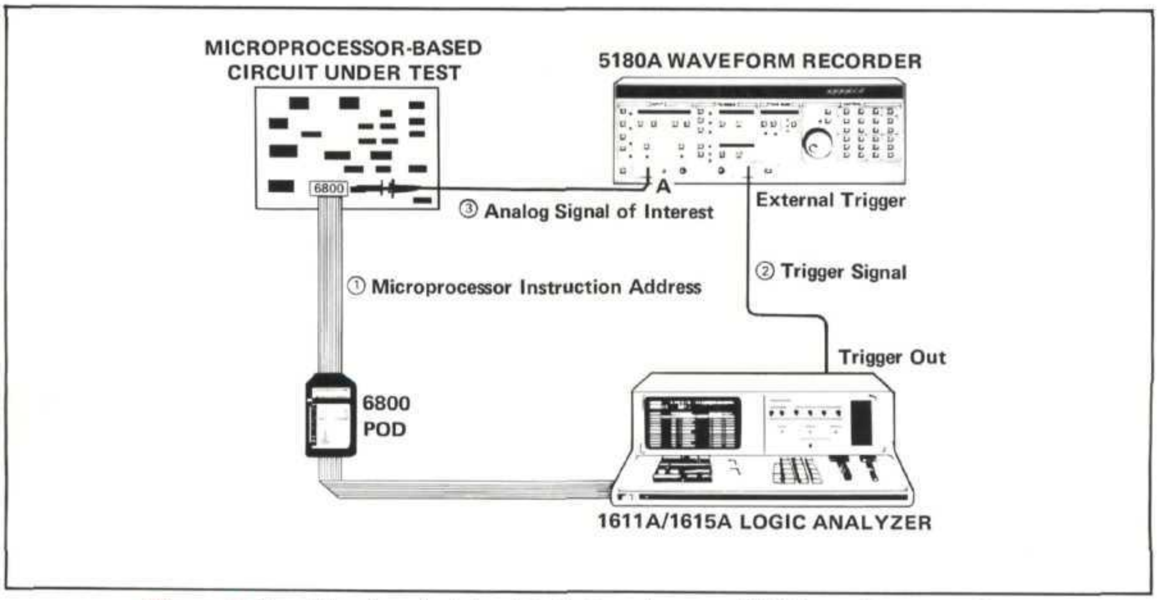
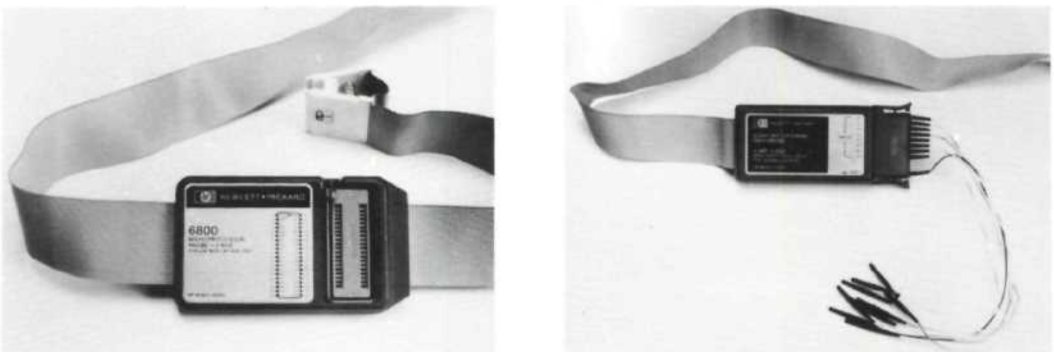


Figure 1. Signal flow from test circuit to logic analyzer and 5180A waveform recorder.

Setting Up The Instruments

I. SELECTING THE TRIGGER ADDRESS

For a logic analyzer with dedicated modules for specific microprocessors, such as the HP1611A, you just need to attach the special purpose connector to the microprocessor in the circuit under test. (See Figure 2A.) If a general-purpose logic analyzer, such as the HP1615A, is used, connect the probes individually to the microprocessor's address lines. (See Figure 2B.)



2A—DEDICATED MODULE   2B—GENERAL-PURPOSE CONNECTOR

Figure 2. Connection of logic analyzer to microprocessor.

Finally, select a microprocessor instruction address as a trigger point. Usually, this is done by specifying the instruction address of interest as a "trace" condition for the logic analyzer. For the 1615A, for example, the beginning of the trace is selected by entering the instruction address into a trace specification "menu". (See Figure 3.)

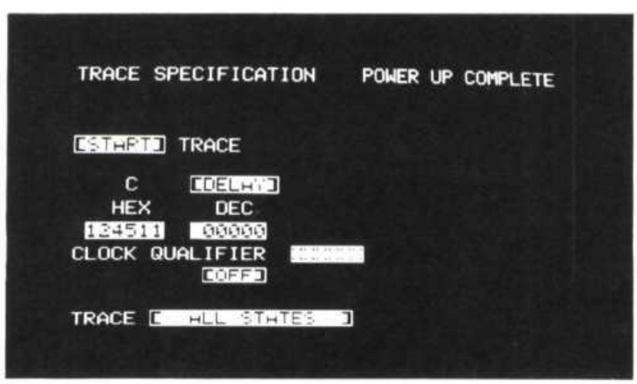


Figure 3. Selection of trigger instruction address on 1615A trace specification menu.

II. TRIGGERING THE 5180A

When the logic analyzer receives the selected instruction address from the microprocessor, it begins a trace. At the same time, the trigger output from the logic analyzer should externally trigger the 5180A. To do this, connect the logic analyzer's trigger output to the external trigger input on the 5180A. (See Figure 4.)

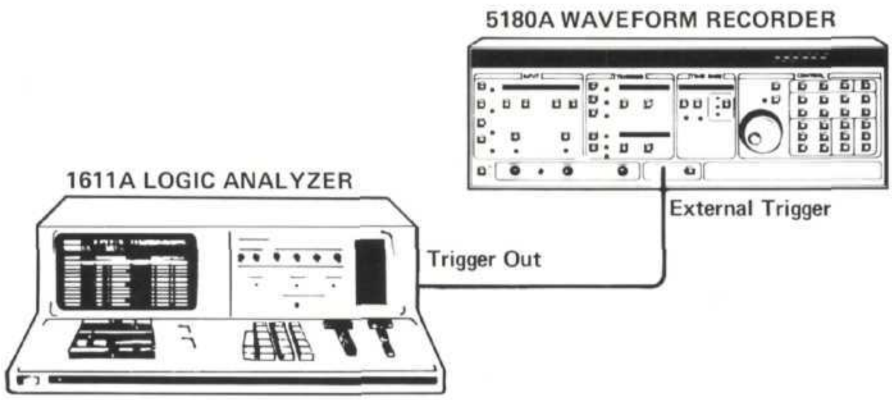


Figure 4. 1611A trigger output connected to 5180A external trigger input.

For Reference—Selecting External Trigger and Trigger Level for 5180A

To select external triggering for the 5180A, press the "SOURCE" key until the LED next to this key lights, indicating that the 5180A expects an external trigger signal. Select the trigger level by pressing the "VOLTS" key and turning the Data Entry Knob to enter the correct trigger level voltage. For example, when either the HP 1611A or the HP 1615A logic analzyer is used, a 1.5V trigger level should be selected.

III. USING PRE-TRIGGER MODE TO RECORD WAVEFORM INFORMATION PRIOR TO TRIGGER POINT

Since the signal of interest may occur before the microprocessor reaches the instruction address defined as the trigger, you may want to use the 5180A's pre-trigger mode to record waveform information before the 5180A receives a trigger signal. For example (See Figure 5), suppose you suspect a transient is the cause of an unwanted branch to a certain microprocessor instruction address. You might select this address to cause a trigger, and record the signal with the suspected transient beginning before the trigger point. Once recorded, you can analyze the transient in detail to determine whether it could indeed be the cause of the branch.

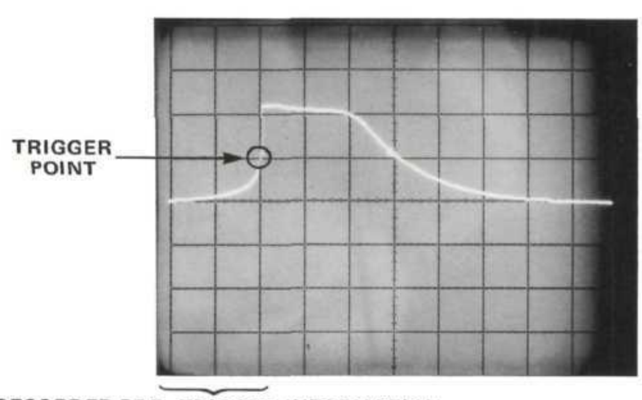


Figure 5. Transient recorded before trigger signal reaches 5180A.

Depending on the logic analyzer used, there will be some delay between the microprocessor reaching the selected instruction address and the 5180A receiving a trigger signal. For example, using the HP 1611A, this delay is about 400 ns. This delay should be taken into account when you select the 5180A's pre-trigger mode trigger position.

For Reference—Selecting the 5180A's Pre- or Post-Trigger Position

To record waveform information before the trigger point in the 5180A, pre-trigger mode should be selected. This is done by specifying a negative trigger position. For example, if a negative percentage is selected, this percentage of memory will be filled before the trigger occurs. If a positive trigger position is selected, the 5180A will insert a delay after the trigger point before recording begins. To specify the trigger position, press "% MEM" or "TIME" and turn the Data Entry Knob to select the desired value.

IV. INPUT SIGNAL TO 5180A

The final connection you need to make is between the signal to be recorded and one of the 5180A's input channels. (See Figure 6). For either the A or B channel, you should select the appropriate input voltage range for the signal.

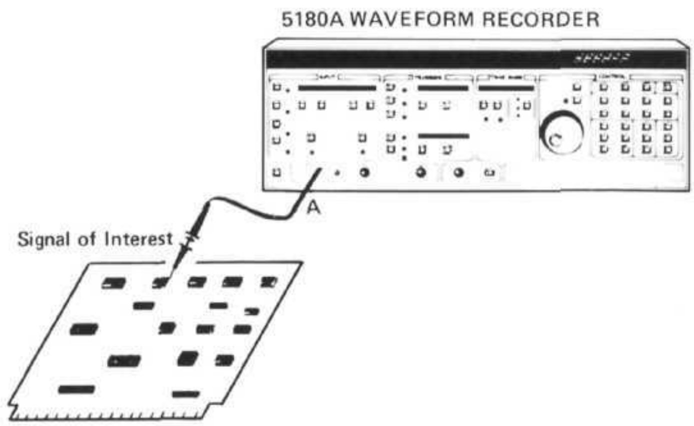


Figure 6. Connection of signal to 5180A input channel

For Reference—Selecting A or B Channel Input Voltage Range

It is important to select the appropriate voltage range for an input signal to the A or B channel. To do this, press "RANGE" and turn the Data Entry Knob to select the voltage range, between ±100mV and ±10V in a 1,2,5 sequence.

Now you're ready to record signals of interest in microprocessor-based systems, and use the results to solve problems. Two examples of typical applications, which may resemble measurements you will want to make, are described in the next section.

Examples

Using the procedure described, you'll be able to record and analyze signals occuring at specific times during the microprocessor program. For example, you may want to look at voltage level detail in digital signals, shape or duration of analog signals, or other changes in waveforms which may not be apparent using a logic analyzer alone. By using a logic analyzer to trigger your waveform recorder at the right time, recording these previously difficult-to-capture signals is easy, and the results obtained are better than have been available before. The two examples of applications given in this section show typical signals this procedure would be used to record.

I. MEASURING CRITICAL NOISE MARGINS

Whether you work with analog or digital circuitry, or both, you have probably needed to measure noise margins. In a microprocessor-based system, it is important to measure noise margins during critical portions of the microprocessor program.

For example, during an I/O operation, noise levels are often high; in digital circuitry, this noise may even cause an occasional bit to read high or low when it shouldn't. Recording the noisy signal, beginning when the I/O operation begins, enables you to determine whether erroneous bits are in fact due to noise. Also, knowing the noise level at critical times helps you, as you improve your design, to eliminate problems due to noise.

Analog signals may also be particularly noisy during specific portions of the microprocessor program, resulting in noise-related problems which are difficult to detect. For example, if two signals are required to be high simultaneously to generate a trigger, and both signals are noisy, trigger timing could be erratic and unpredictable. If you suspect this may be happening, the two signals can be recorded simultaneously to check this possibility. (See Figure 7.) The microprocessor instruction address which indicates the beginning of the subroutine servicing a trigger may be used as a trace condition for the logic analyzer. The logic analyzer trigger output then provides a trigger for the 5180A at the correct time, so that the signals of interest may be recorded.

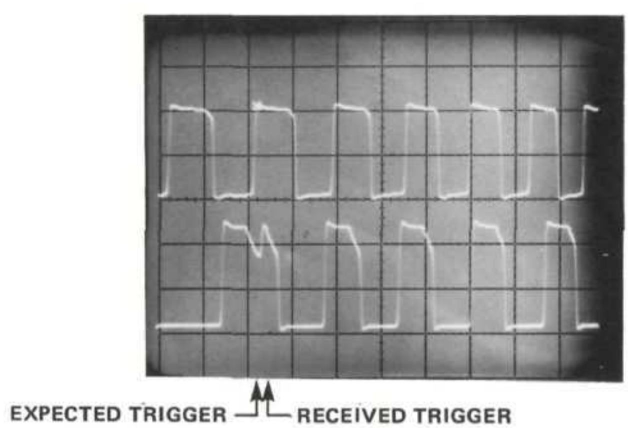


Figure 7. Record signals simultaneously to study effects of noise. Both signals must be "high" in this case to initiate a trigger.

II. RECORD CHARACTERISTICS OF POWER SUPPLY TURNOFF

During design or service of a microprocessor-based system, it is often important to look at power supply turnoff characteristics. Most microprocessor-controlled systems have an interrupt which causes the program to go immediately to a power-down subroutine when the microprocessor discovers that power is failing; an instruction address in this subroutine may be used as a trigger condition for the logic analyzer.

For example, you might trigger the waveform recorder when the logic analyzer receives the instruction address indicating the end of the power-down subroutine. It is then possible to measure the amount of time between the end of the power-down subroutine and the point at which the power supply voltage level is too low to use. (See Figure 8.)

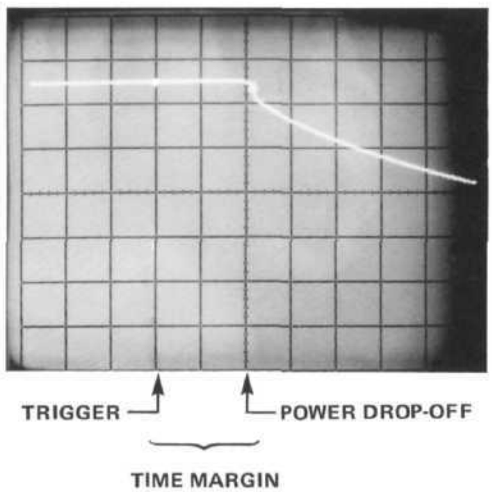


Figure 8. Measure time margin between end of power-down subroutine, power drop-off.

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