Errata

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Manual Part Number: 5953-3956

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HP References in this Manual

This manual may contain references to HP or Hewlett-Packard. Please note that Hewlett-Packard's former test and measurement, semiconductor products and chemical analysis businesses are now part of Agilent Technologies. We have made no changes to this manual copy. The HP XXXX referred to in this document is now the Agilent XXXX. For example, model number HP8648A is now model number Agilent 8648A.

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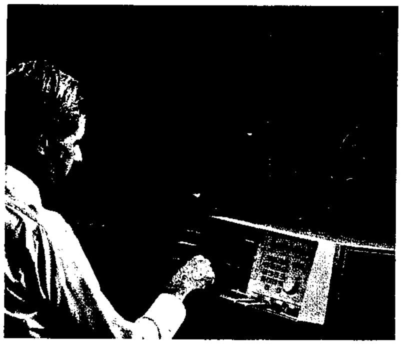
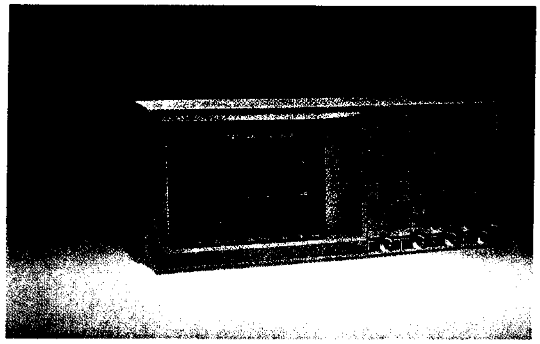
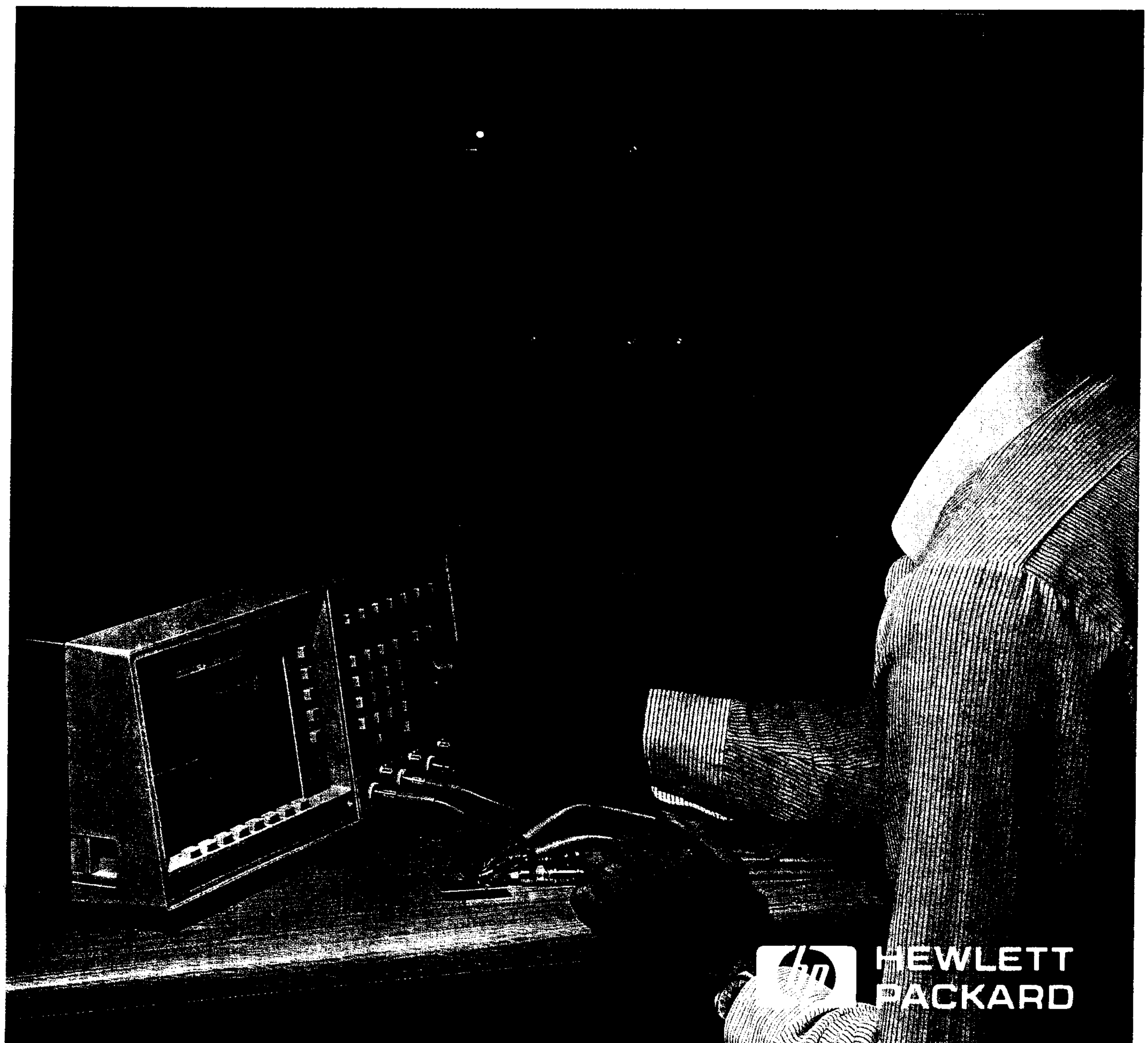
Agilent Technologies

HP 54100A/D Digitizing Oscilloscope

Users' Guide — October 1984







I. Front Panel Familiarization

II. Application Measurements

III. Front Panel Controls

Note: any signal, including the HP 54100A/D calibration signal, may be used for the demos listed in Section I, except for random-repetitive sampling, which requires a 50 MHz source. The special equipment required for Section II is listed at the beginning of each demo.

I. Front Panel Familiarization

This section familiarizes the user with the HP 54100A/D operation and capabilities.

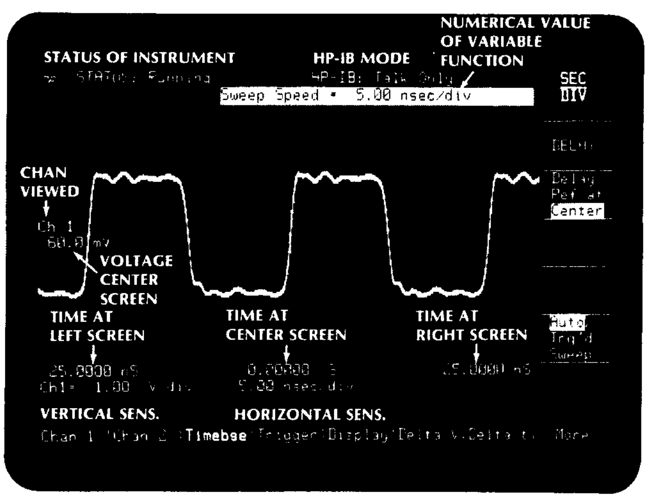
Introduction

The **HP 54100A/D** is a digitizing oscilloscope. Digitizing oscilloscopes have many advantages over their analog counterparts, most of them having to do with either increasing the productivity of their users or making new measurement capabilities possible. The demos in this manual illustrate both of these advantages while helping the user become familar with the **HP 54100A/D's** operation and its capabilities.

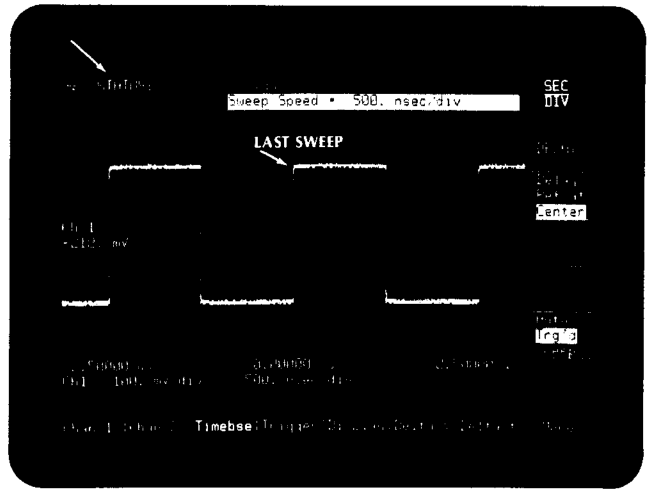
The most obvious productivity feature of the **HP 54100A/D** is the **AUTO-SCALE** key. It helps overcome a common frustration of conventional scope users—that is, finding the missing waveform. The blank screen facing a convential scope user requires adjusting any one or a combination of several different controls on the front panel. With the **AUTO-SCALE** feature, a single keystroke is all that is required to properly position, vertically and horizontally attenuate, and trigger a stable dispiay on screen.

Let's try it. Turn on the power (notice that the **HP 54100A/D** even checks itself out—**POWER SELF TEST PASSED**) and press **AUTO-SCALE**.

If you do not have a signal connected to either channel 1 or channel 2, the **NO SIGNAL FOUND** message reminds you that you need to connect a signal. With a signal connected, you should have a display on screen similar to the figure. Note the scale factors, sensitivity levels, and status conditions located at various positions on the display.

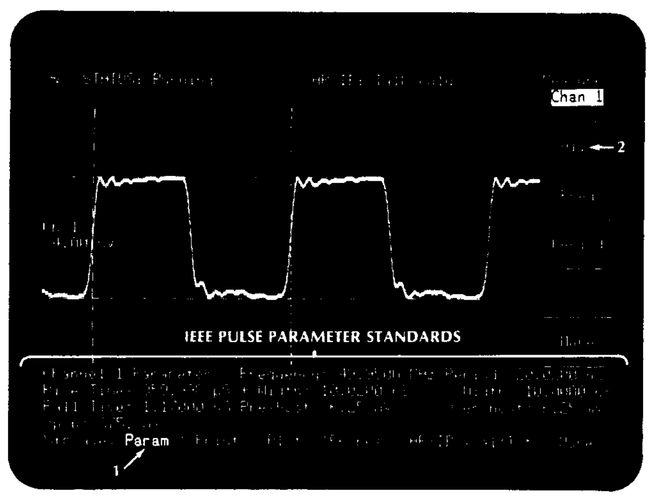


Press **TRG'D SWEEP** and remove the signal from channel 1. Note that the status is **AWAITING TRIGGER**, and that the last sweep remains on screen.



The Front Panel

Step through each one of the different key selections below the display and observe the different menus on the right. Notice that when the bottom **MORE** key is pressed, a second level of softkeys is displayed. While in the second level, press the **PARAM** key and then press the **ALL** key.



In just a few seconds, you have fully characterized a waveform with nine different parameters—a job that would have required several minutes using a conventional scope. Also, the measurements were made with a high degree of accuracy, totally eliminating the most common error source of all: the operator. We will use most of the other softkeys in the demos following.

Before going on, however, let's take a quick look at the hard keys and the control knob, located in the **SYSTEM CONTROL** and **ENTRY** sections. **CLEAR DISPLAY** is primarily used in the single-shot mode to clear the display between sweeps, **RUN** puts the scope in the repetitive sweep mode, while **STOP/SINGLE** puts it in the single-shot mode. A single-shot sweep occurs every time the **STOP/SINGLE** key is pressed. Later, we will use this key to make a measurement.

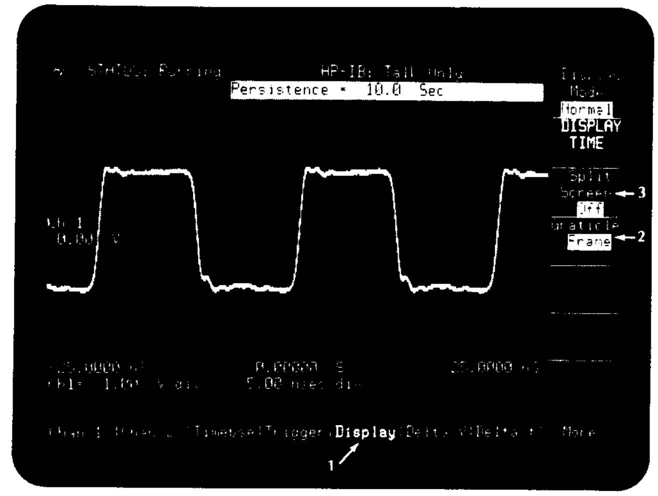
SAVE and **RECALL** are for storing front panel setups. Up to ten different front panel setups can be stored in non-volatile memory. The **RECALL** key can also be used to recover setups if **AUTO-SCALE** is inadvertently pressed. To recover the front panel setup that existed just prior to **AUTO-SCALE**, press **RECALL** and then **AUTO-SCALE**. The setup reappears, along with its display. If the scope is under HP-IB control and the controller's software permits, the operator can gain control of the front panel by pressing **LOCAL**. Finally, our favorite key of all, **AUTO-SCALE**, does exactly what it says.

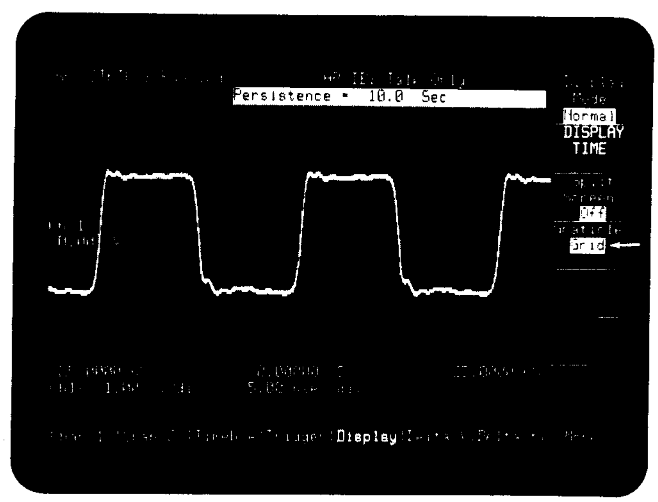
There are three different ways to change the many variable functions assigned by the softkeys. Marker position, volts per division, and delay time, along with all of the other variable functions can be changed with the control knob, the arrow keys or the numerical keyboard.

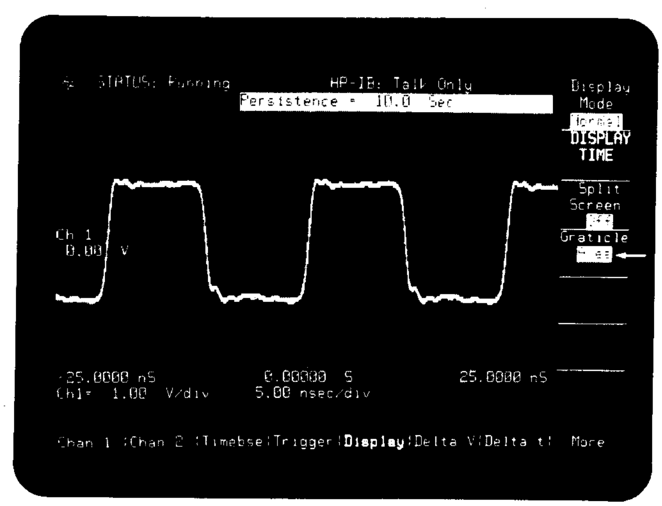
Entries from the numerical keyboard must be followed by pressing one of the keys in the **ENTER** column. Note that the **SEC/DIV** changes in the typical 1-2-5 sequence when using the arrow keys or the control knob to vary the time per division, while finite values such as 104 ps/div can be entered from the numerical keyboard. This is especially useful when more resolution is required for making a time-interval measurement. **VOLTS/DIV**, however, is limited to the 1-2-5 sequence. A more detailed description of the front panel and its contols can be found in Section III.

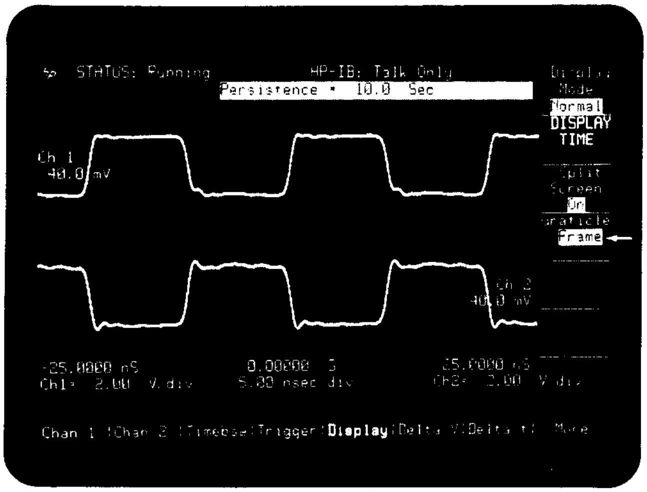
The Display Modes

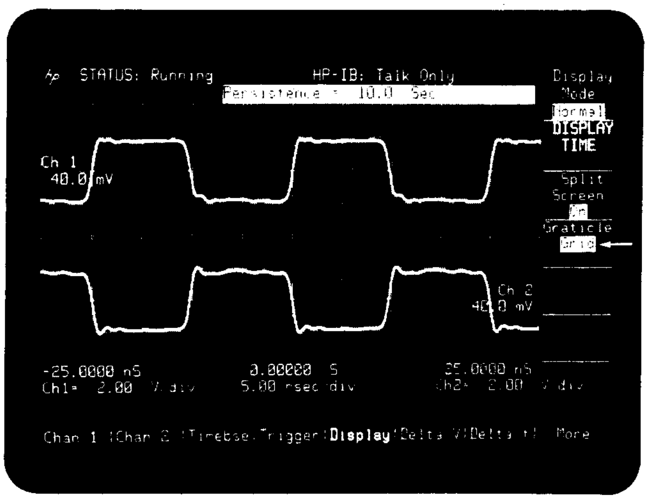
The **HP 54100A/D** display can be configured in one of several different modes. Either channel can be viewed independently or together on a single screen, or separately on split screens. Both screen versions also offer a **FRAME, GRID,** or **AXES** selection. Press **DISPLAY** and go through the **SPLIT SCREEN** and **GRATICULE** selections. The **DISPLAY MODE** and **DISPLAY TIME** functions will be used later.

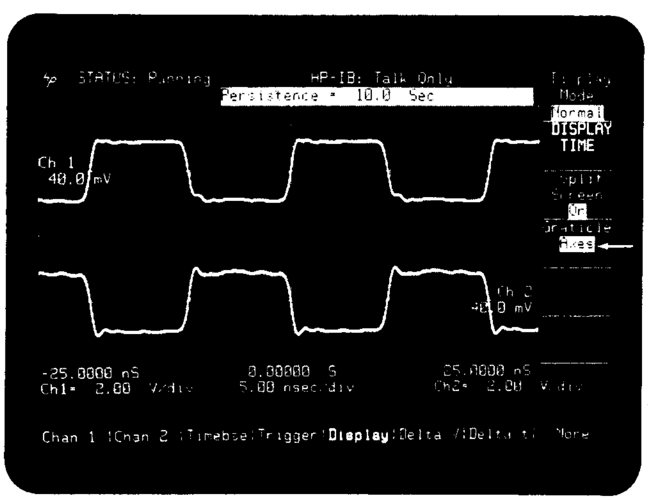






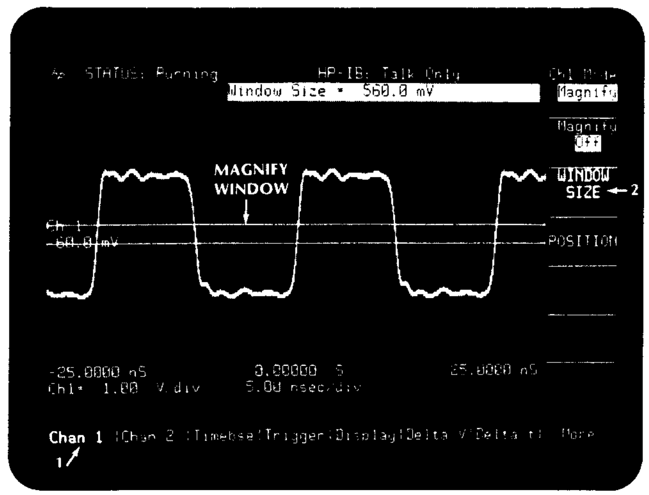




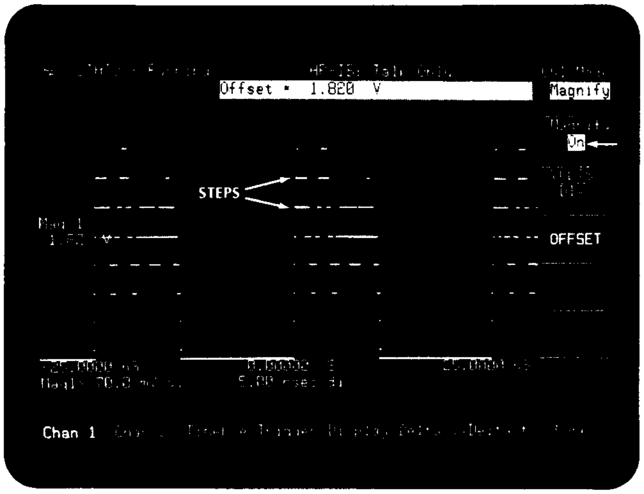


The Magnify Mode

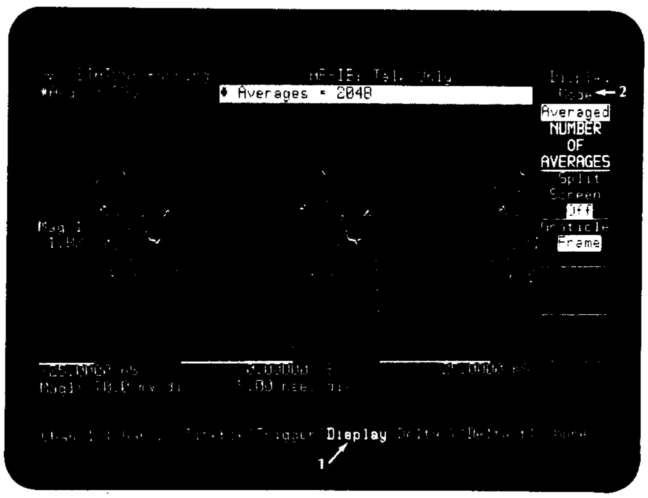
It is often desireable to view a magnified portion on a pulse, such as its top. The **HP 54100A/D** has a feature that allows the operator to select any part of the pulse and to magnify it by positioning a variable-height window over the point of interest. Press **AUTO-SCALE** to get a display on screen. Press **CHAN 1** and then select **CH 1 MODE**, then **CH 1 MODE MAGNIFY**. Note that **WINDOW SIZE** is turned on and its height in voltage is indicated above the display. With the control knob, reduce it to its minimum height.



Press **POSITION** and use the control knob to position the window over the top of the pulses. Turn **MAGNIFY ON** and observe the display. The steps on the edges are a result of our magnifying the vertical distance between the sample data points, along with the rest of the information inside the magnify **WINDOW**.



We can eliminate the steps by placing the display in the averaged mode. Press **DISPLAY** and toggle the **DISPLAY MODE** to **AVERAGED**. The number of averages can be varied from 1 to 2048.

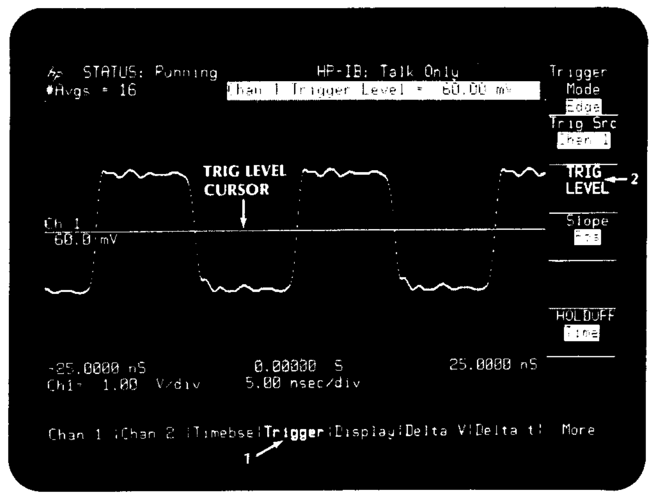


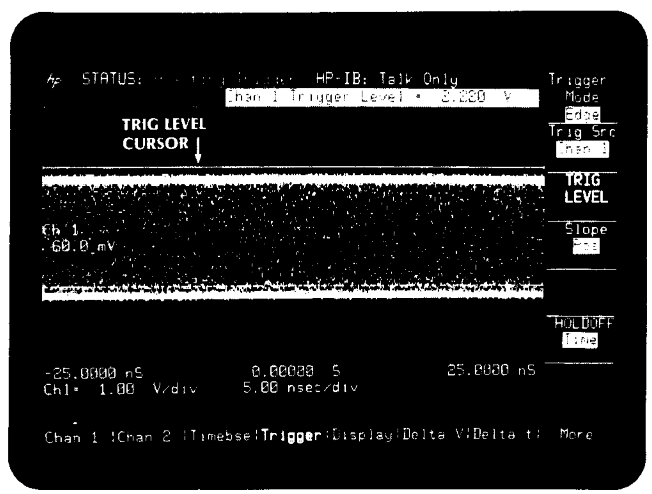
Placing the display in the averaged mode effectively increases vertical resolution. This is the true purpose of averaging.

A more popular application than the one used here is to use averaging to eliminate any random noise that is riding on a pulse. Through averaging, the noise is cancelled, leaving the true pulse to be viewed with better resolution. Note: be sure to return the display to the **NORMAL** mode when the **AVERAGED** mode is not required, because it significantly increases the time required for the automatic measurements.

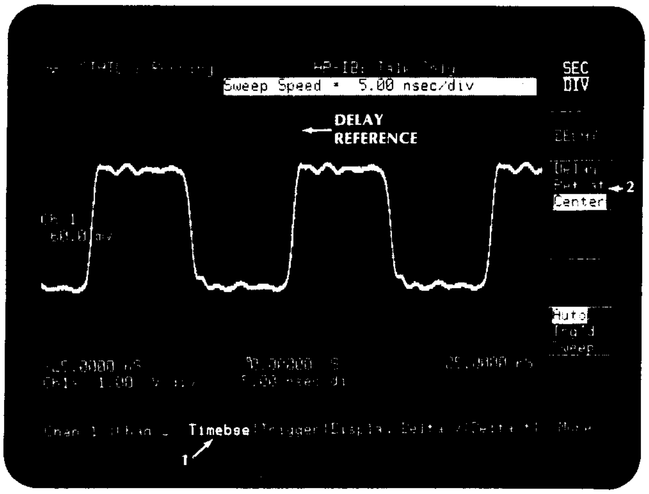
Trigger Conditioning

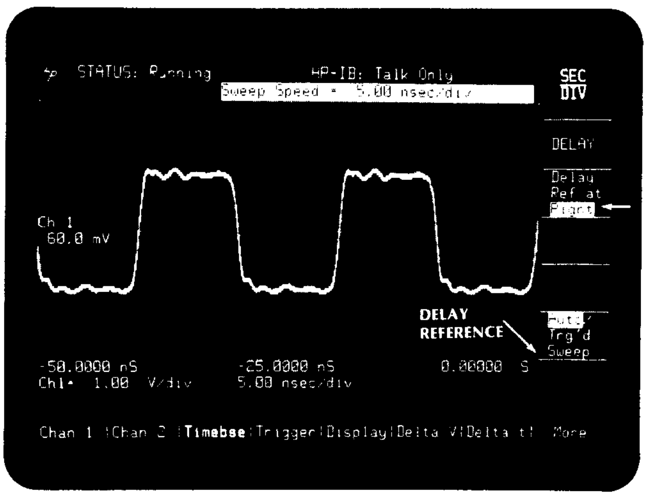
The **HP 54100A/D** provides a trigger-level marker that allows you to see where the trigger level is set as you adjust it. First, press **AUTO-SCALE**, then press **TRIGGER** and select **TRIG LEVEL**. Move the trigger level marker, and note its voltage reference above the graticule. Moving the marker either above or below the waveform causes the trace to free-run because the scope is trying to trigger on a voltage that is not present.

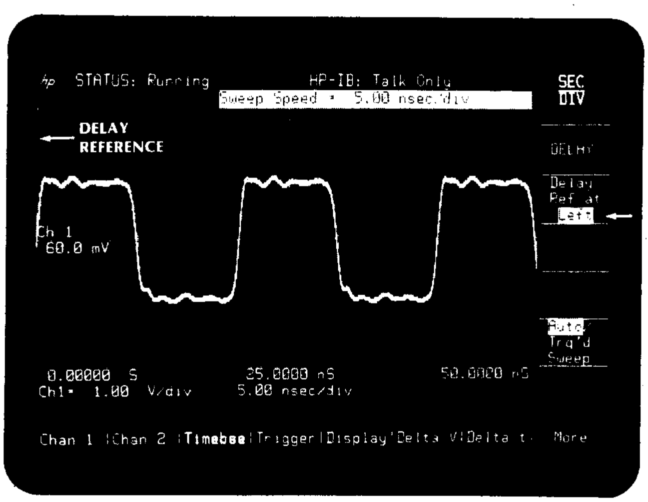




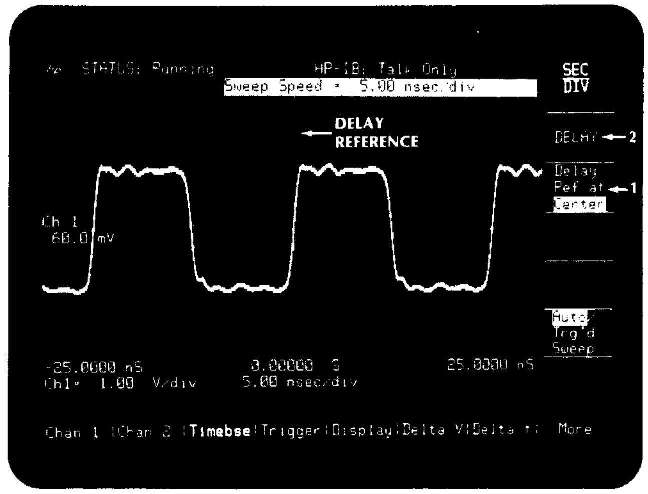
Press the **SLOPE POS/SLOPE NEG** key and change the edge selected for triggering. Note that the point of reference is center screen. The point of reference can also be to the left or right of the screen. To change the reference, press **TIMEBASE** and **DELAY REF AT CENTER/RIGHT/LEFT**. Note the time references changing just below the graticule.



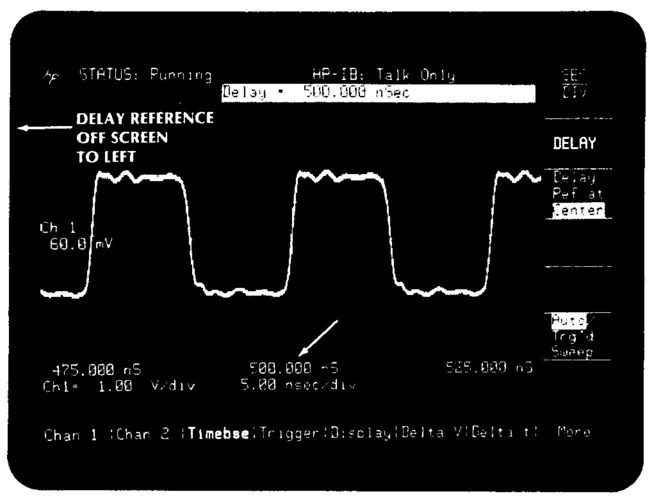




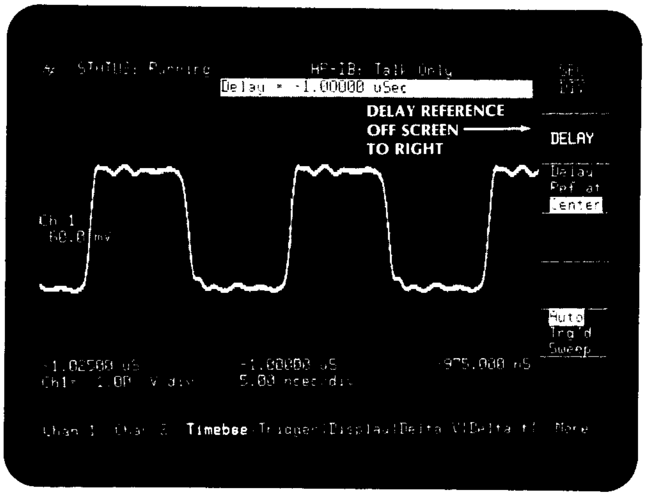
Place the **DELAY REF AT CENTER** and press **DELAY**.



Press the left arrow key repeatedly and note the **DELAY=** above the graticule. We are moving downstream from the trigger point, just as a conventional scope does when delayed sweep is used.

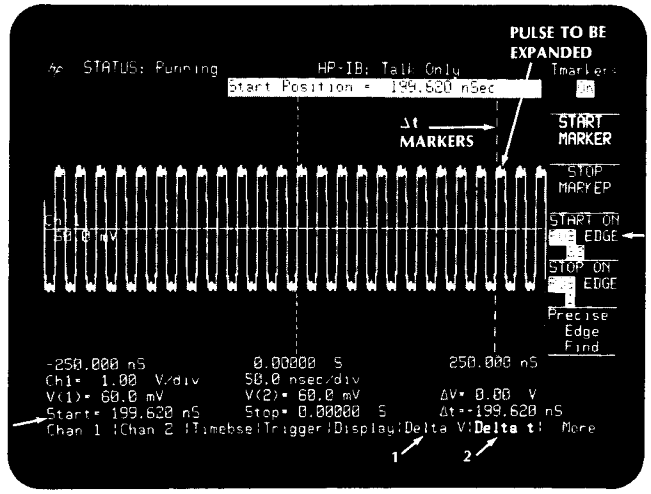


Press 0 on the keyboard and any of the enter keys. With the reference back to **DELAY=0.000000** sec, repeatedly press the right arrow key. We are now viewing the events that preceded the trigger point—that is, negative time. This capability is especially useful when troubleshooting glitches.

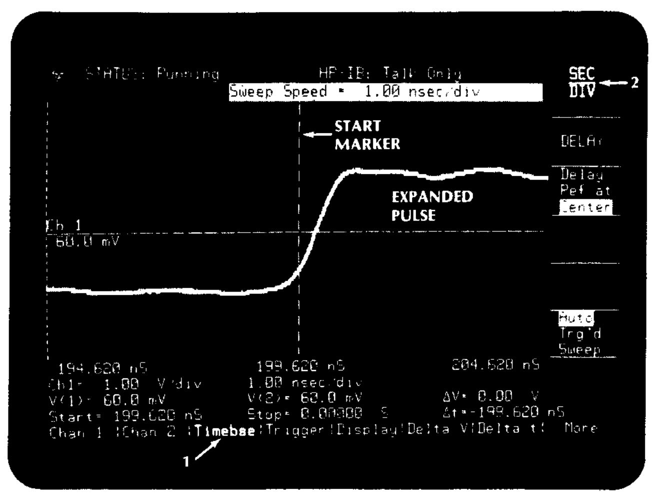


Locate And Expand

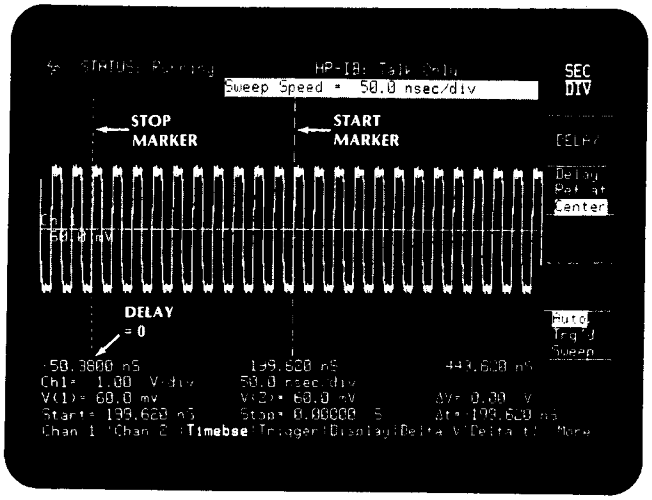
One use of delayed sweep on a conventional scope is to locate and expand one of the many pulses that are on screen. The **HP 54100A/D** has this capability. While the procedure differs slightly, it can be accomplished with much more precision. Place the delay reference back to 0.000000 and press **SEC/DIV**. Change the sweep speed to display several pulses. Press **DELTA V** and turn the V markers on. They are required to make semi-automatic time-interval measurements. Position the **DELTA V** markers at the 50% point if they are not already there. Press **DELTA** t and turn the t markers on. Press **START ON POS EDGE 1**, and position the marker on the pulse you want to expand. Press **START MARKER** and make a note of the **START POSITION=** time above the graticule.



Press **TIMEBSE** and **DELAY**, and then key in the exact time noted in the prior step from the numerical keyboard. Don't forget to also key in the appropriate **ENTER** key. Press **SEC/DIV** and change the sweep speed for more resolution. We are expanding the pulse that the start marker was placed on, and the leading edge is on screen. This is not always possible when using the locate-and-expand technique with conventional scopes. Note that the start marker is on screen with the pulse, while the stop marker is off screen, where delay time is equal to 0.



Change the **SEC/DIV** for several pulses on screen and note that the stop marker comes back on screen at the left.



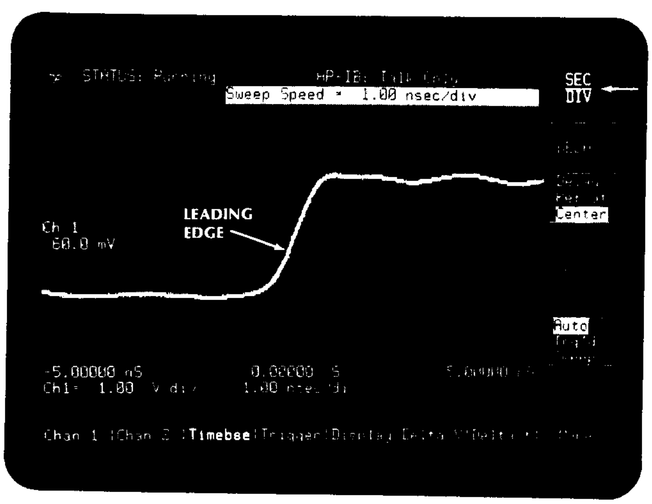
Delta Time Measurements

Rise Time Measurement

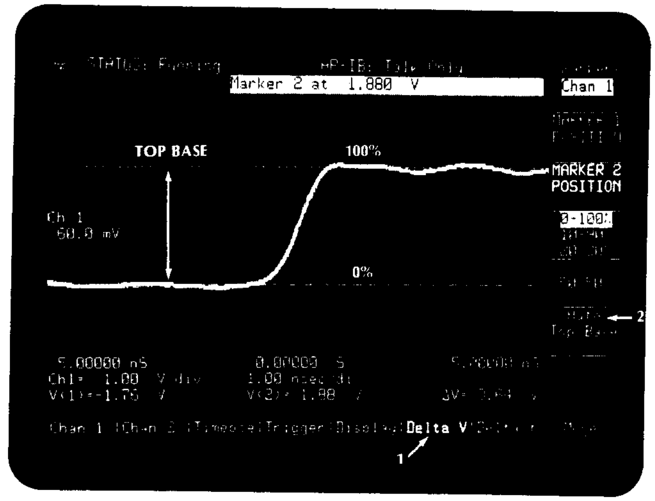
There are at least four different alternatives that can be used to make a rise-time measurement with the **HP 54100A/D**. The following procedure outlines the steps required for the alternatives.

Alternative #1

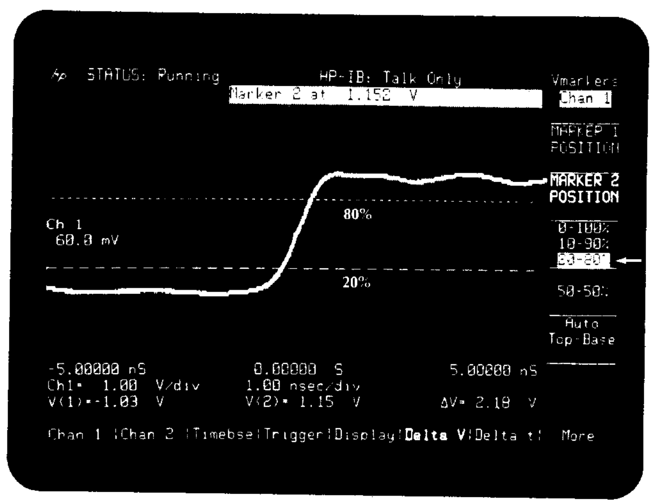
Press **AUTO-SCALE** to get the waveform on screen. Press **SEC/DIV** and change the sweep speed to get better resolution of a leading edge.

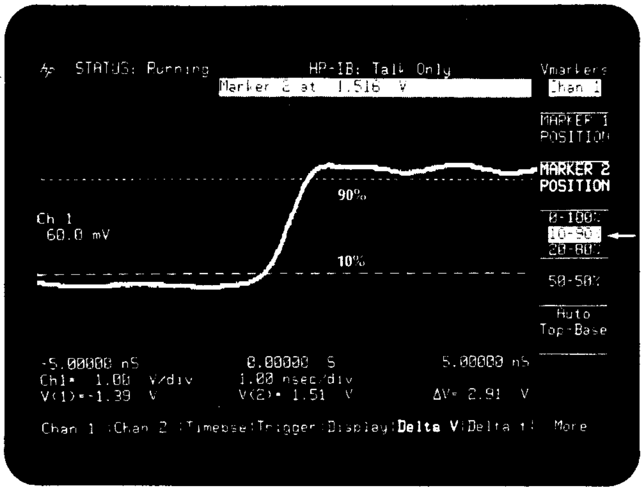


Next, we need to position the delta V markers as a reference for the delta t markers. Press **DELTA V**, turn the markers on, and press **AUTO TOP-BASE**.

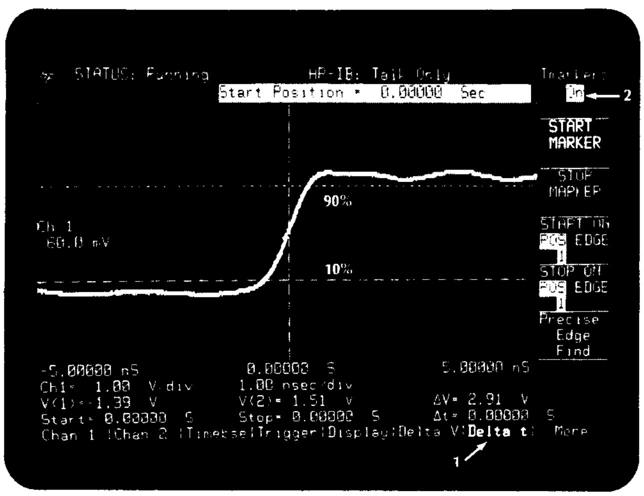


The **AUTO TOP-BASE** key automatically locates the top and base of the waveform. With these voltage levels as a reference, the delta V markers can now be positioned at the 0-100%, 10-90%, or 20-80% levels by toggling the indicated softkey.

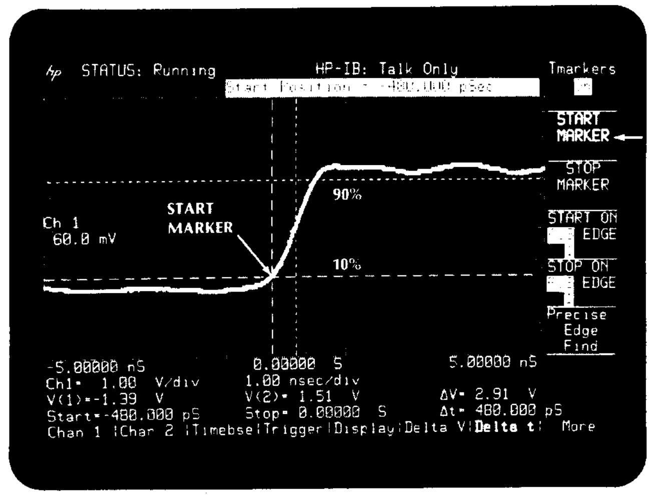




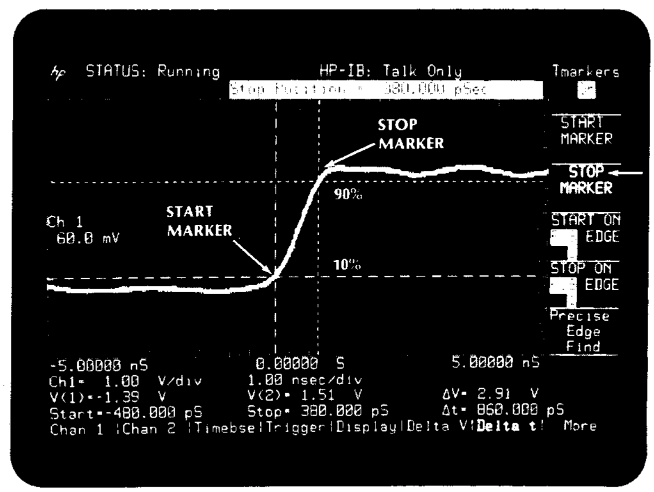
Position the markers on the 10-90% level, press **DELTA t**, and turn the delta t markers on.



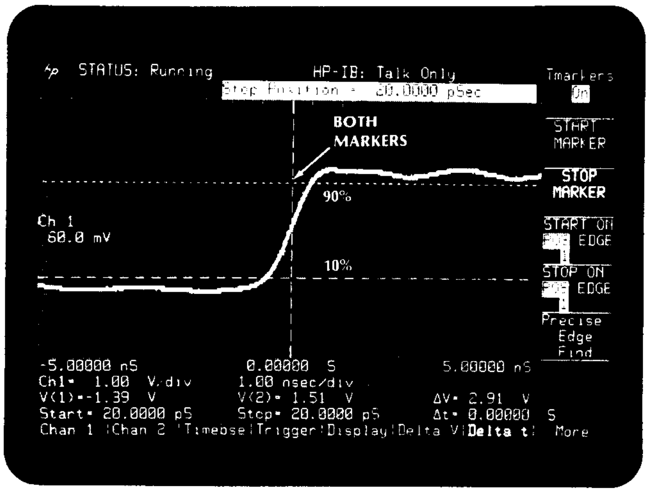
Press **START MARKER** and adjust the control knob to intersect the delta t start marker with the delta V start marker (10% level).



Press **STOP MARKER** and adjust it to intersect the delta V stop marker (90% point).

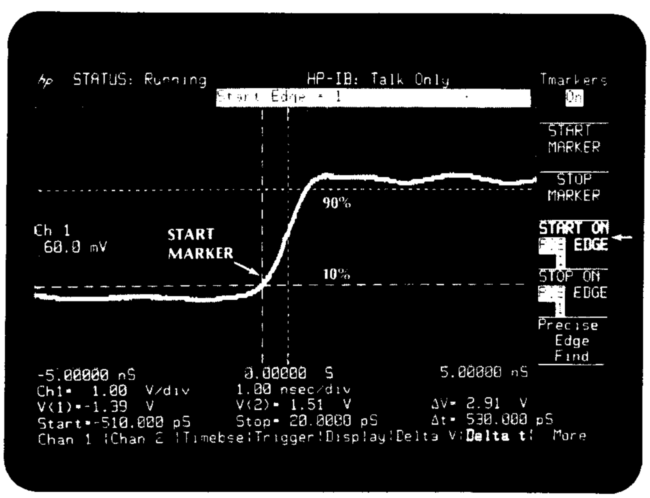


The delta time reading at the bottom of the screen is the rise time between the 10-90% points. Note that the start markers are represented by long dashes, while the stop markers are the shorter dashes. Return both delta t markers to center screen.

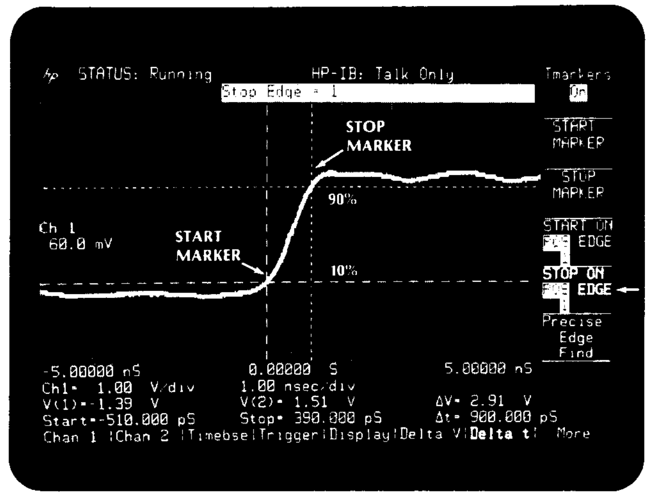


Alternative #2

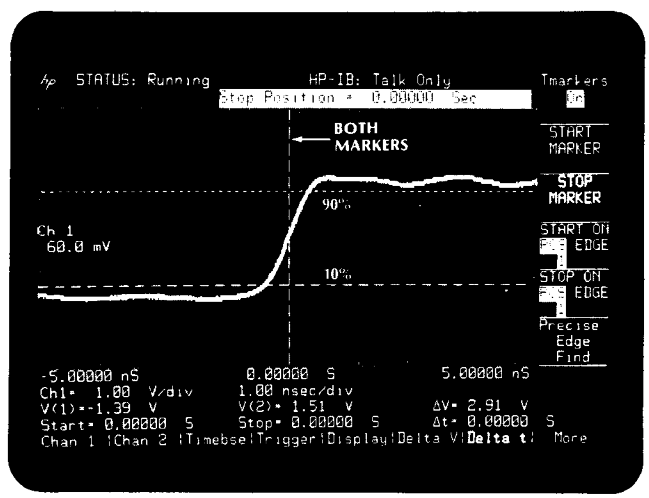
Press **START ON POS EDGE 1**, and note that the delta time start marker automatically jumps to the 10% point.



Press **STOP ON POS EDGE 1** and note that the delta t stop marker jumps to the 90% point.

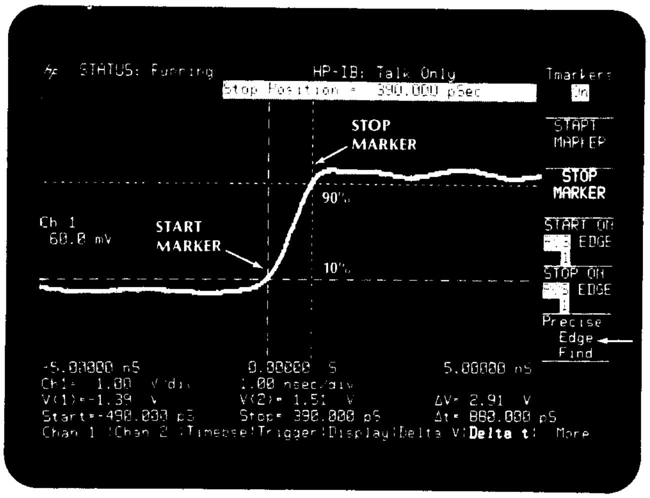


While not as accurate as alternative #3, the operator is not required to find the intersect points as in the previous example. Return both delta t markers to center screen by using the **START MARKER, STOP MARKER** keys, and the **CONTROL KNOB.**

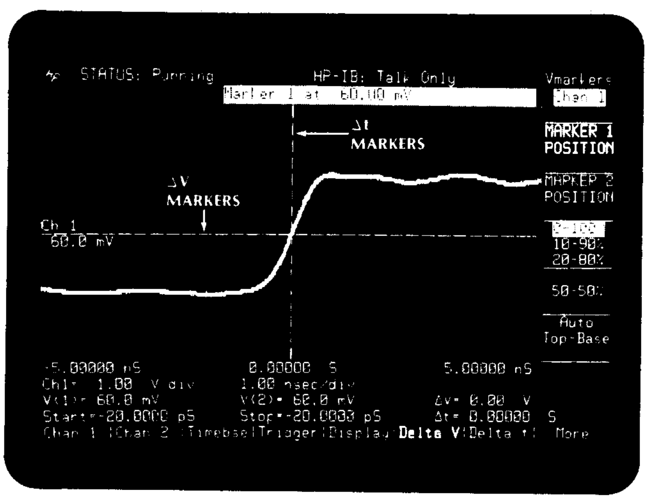


Alternative #3

Press **PRECISE EDGE FIND**, and the markers simultaneously jump to their respective positions.

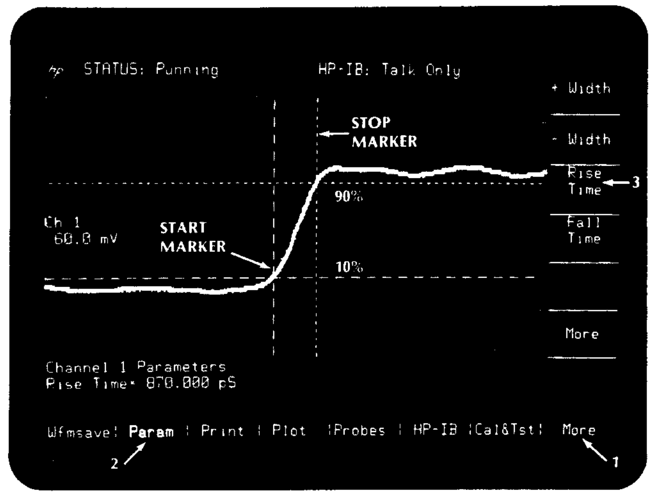


This alternative is considered to be more accurate than the previous two. When we make a pulse-width measurement in the following experiment, you will see why. Now, return both the delta t and the delta V markers to center screen.



Alternative #4

Press **MORE, PARAM,** the side **MORE** key, and **RISE TIME.**



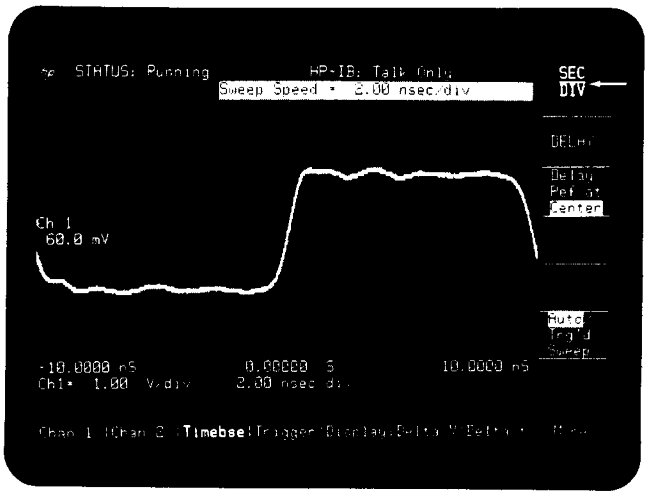
Using this alternative, we are not required to set any of the markers, because all four of them automatically find their respective positions. If the standard 10-90% rise time is the desired measurement, this is the preferred technique.

Pulse-Width Measurements

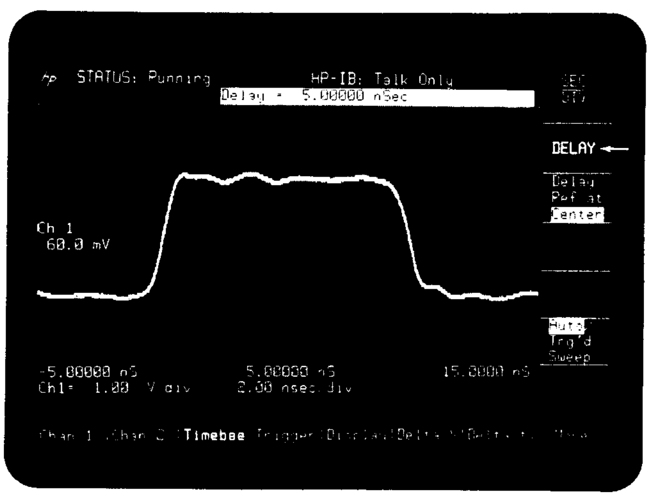
There are also at least four different ways to make pulse-width measurements with the **HP 54100A/D**. Essentially, we will use the same techniques we did while making the rise-time measurements, the only difference being where we place the markers.

Alternative #1

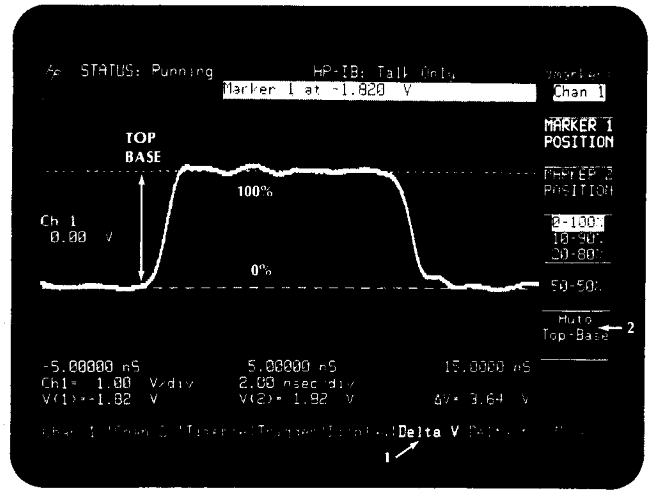
Press **AUTO-SCALE** and adjust **SEC/DIV** to get better resolution of one pulse on screen.



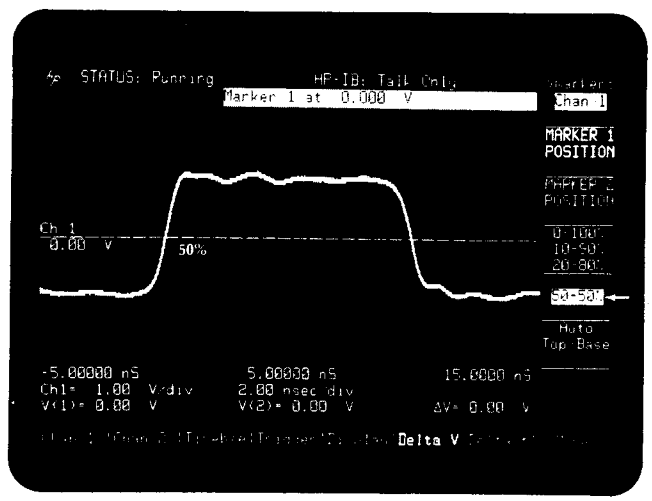
Press **DELAY**, and adjust it to center the pulse on screen.



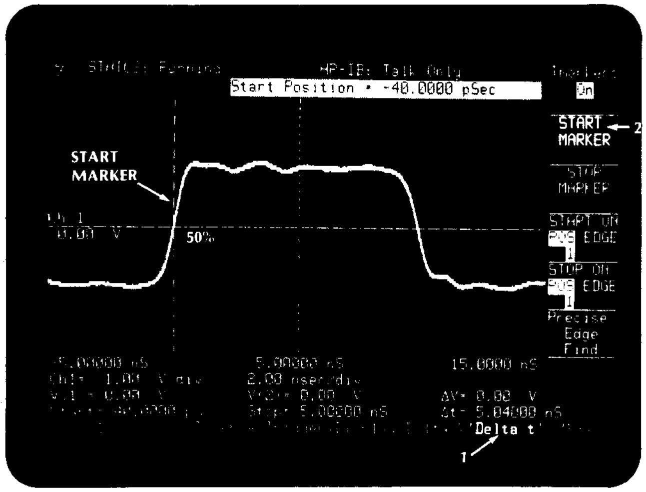
The delta V markers must be positioned at the 50% level as a reference for the delta t markers. Press **DELTA V**, turn the markers on, and press **AUTO TOP-BASE**.



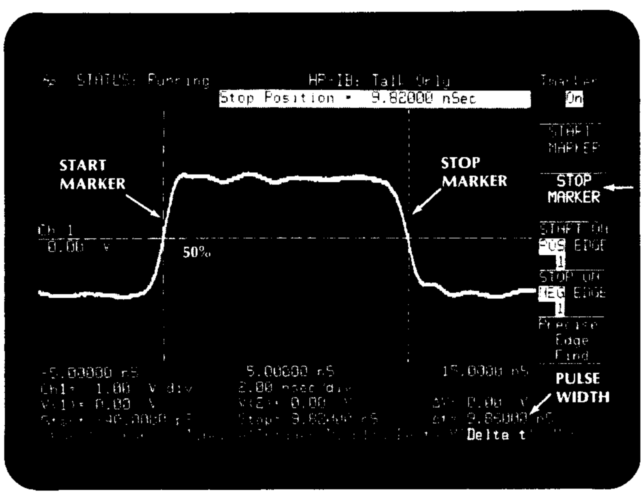
Press the **50-50%** key, and note that the markers move to the 50% point of the pulse.



Press **DELTA** t, and position the start marker so that it intersects with the delta V markers at the leading edge of the pulse.

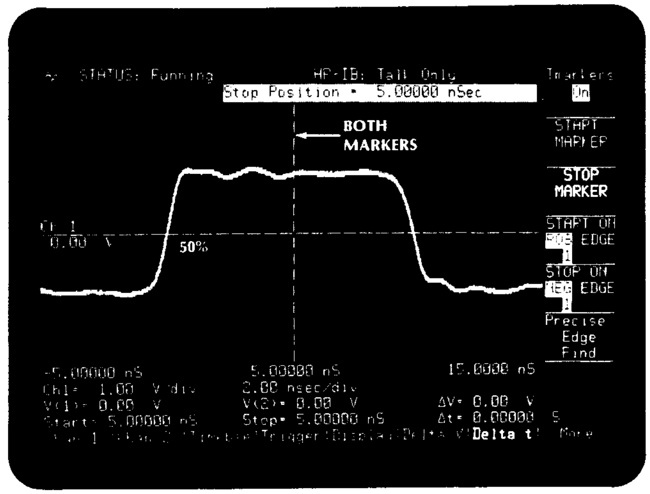


Press **STOP MARKER** and position it to intersect with the delta V markers at the trailing edge of the pulse.



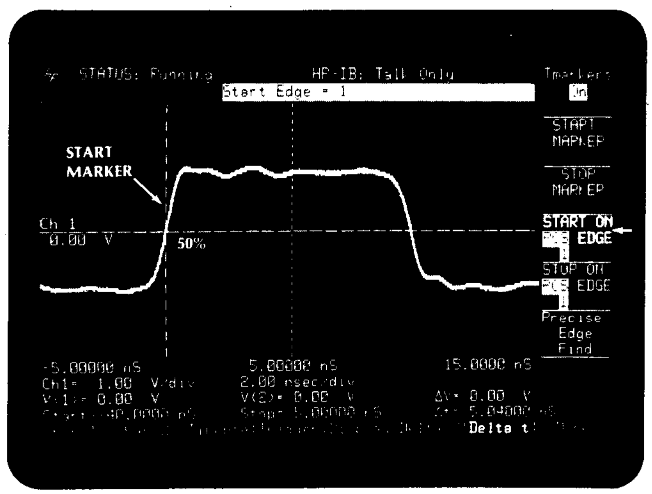
The delta t reading at the bottom of the screen is the pulse width.

Move both delta t markers to center screen.

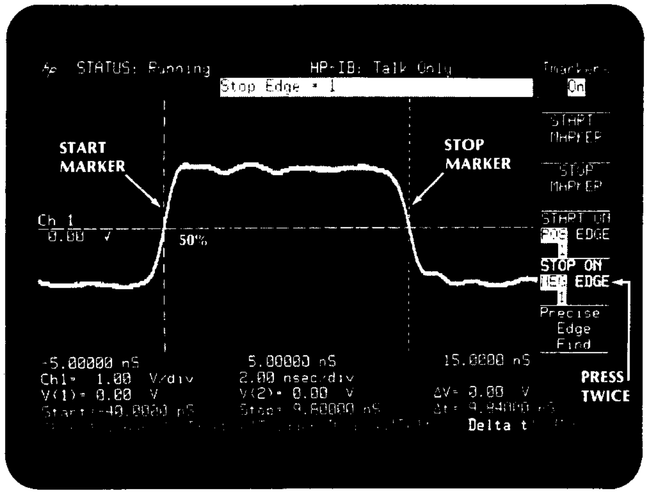


Alternative #2

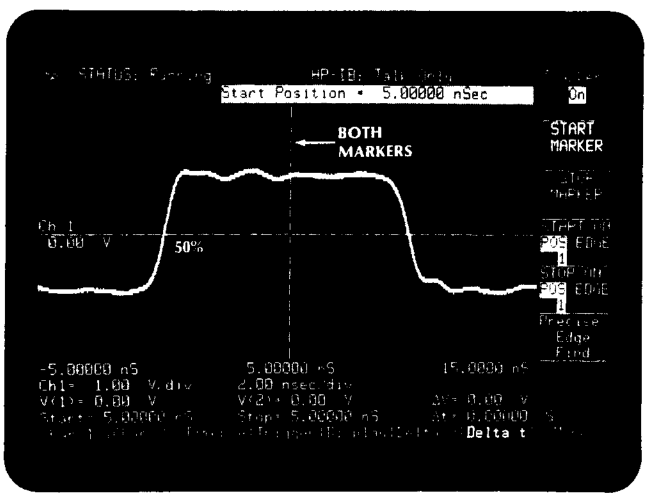
Press **START ON POS EDGE 1** and note the marker jumps to the leading edge.



Press **STOP ON POS EDGE 1** twice. On the second keystroke, the key changes to **NEG** and the stop marker jumps to the trailing edge.

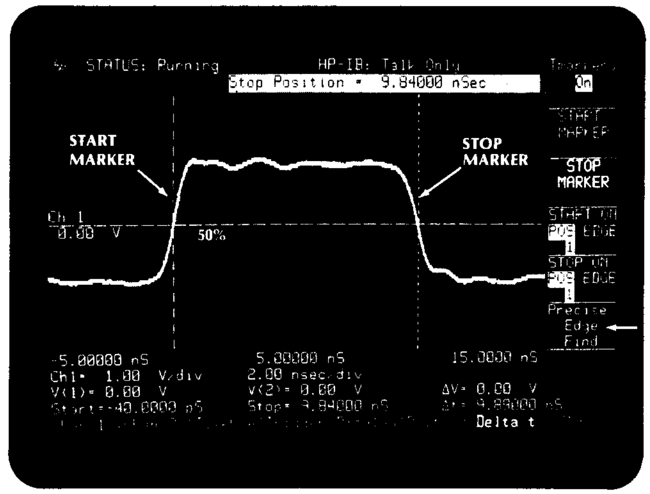


As in the rise-time measurement, the operator is not required to position the markers. Using **START MARKER, STOP MARKER**, and the control knob, return the two delta t markers to center screen.

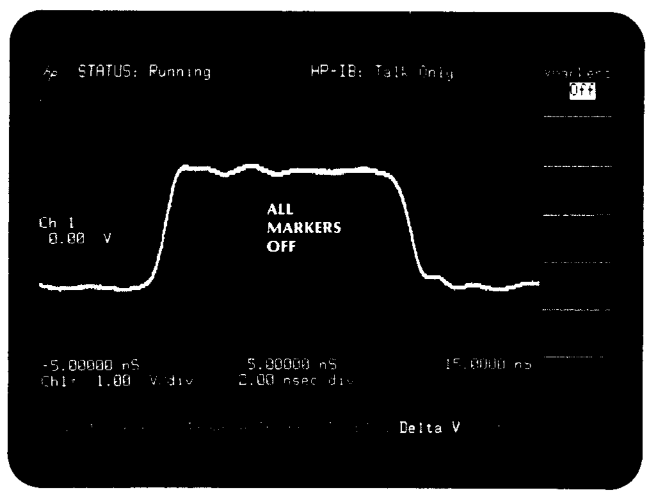


Alternative #3

Press **PRECISE EDGE FIND** and again both delta t markers jump to their pre-assigned edges. During this mode, the sweep speed automatically rescales for better resolution of the edges. Press **PRECISE EDGE FIND** again and watch the rescaling. This better resolution also increased the accuracy for rise-time measurement alternative number three. The **PRECISE EDGE FIND** alternative takes longer than the alternative #2 method because it takes time to rescale the waveform.

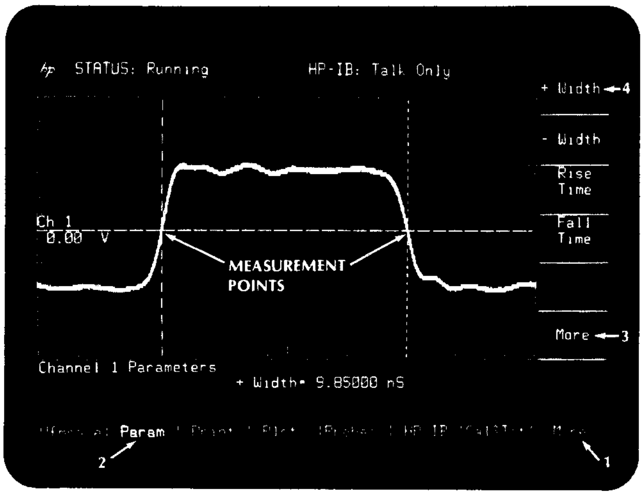


Return the delta t markers back to center screen, and turn them off. Press delta V and turn those markers off, also.



Alternative #4

As we did while making the automatic rise time measurement, press **MORE, PARAM**, the side **MORE** key, and then the + **WIDTH** key.

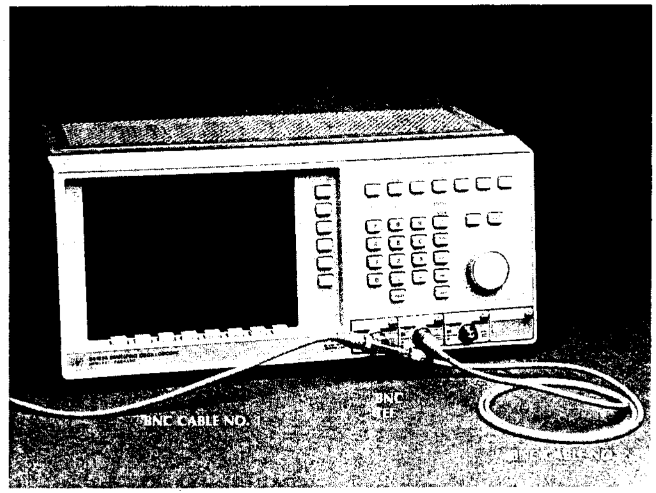


Once again, as with the automatic rise-time measurement, all four markers automatically found their respective positions. Note that the markers were turned back on so we would know where the references were located. Also, notice that the 50% level was chosen as a reference point. If another level is desired, alternatives 1, 2, or 3 would be more appropriate. Press **AUTO-SCALE**, return to the **PARAM** menu, and use the other parameter keys. There are three levels of parameter softkey menus in all. In each case, notice that the markers tell us the reference points of the measurement.

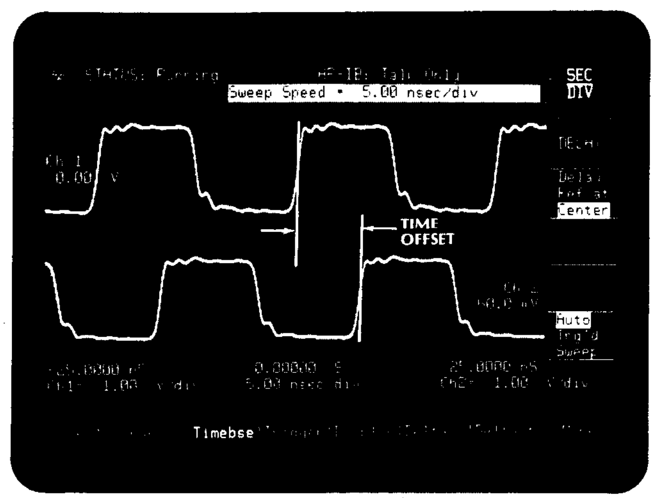
Two-channel Delta Time Measurement

While the **HP 54100A/D** does not have a **PARAM** softkey to perform a two-channel measurement, we can use any of the other three alternatives just learned. In this example, we are going to make a propagation-delay measurement. Digital circuit designers are concerned with propagation delays whenever they lay out a printed circuit board or run cables between modules. Their concern is with timing—that is, making sure all of the information processed by the different components, data, address, and control lines gets to the right place at the right time. The problem they encounter with propagation delay is that it takes time for an electrical signal to pass through a conductor. In this respect, we can think of cables as having an electrical length.

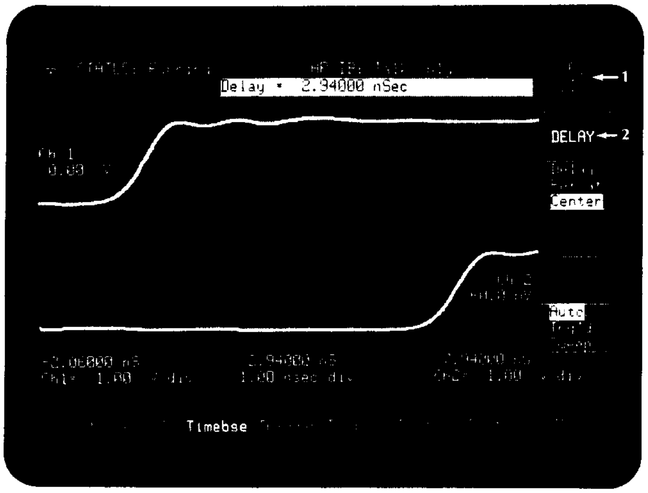
In this measurement, we are going to measure the electrical length of a BNC cable. Begin by connecting the cables as shown below.



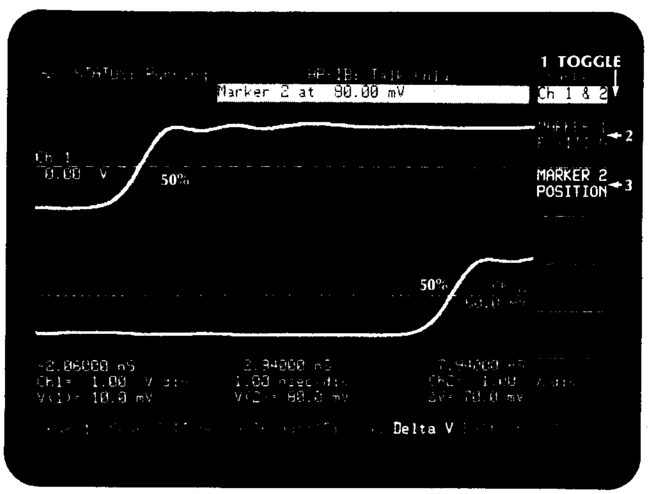
Press the **AUTO-SCALE** key. The result should be a split-screen view of two traces with channel 2 slightly offset in positive time from channel 1. This offset is the propagation delay we are going to measure.



Adjust **SEC/DIV** and **DELAY** for better resolution of leading edges on each screen.

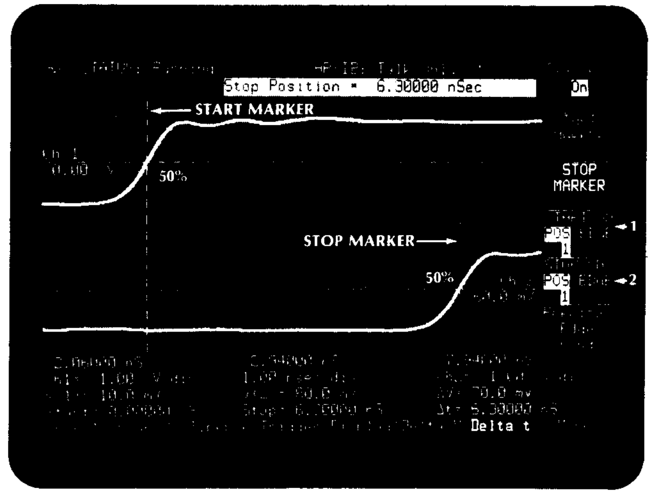


Next, we need to set the delta V markers. We will position them at the 50% points as we did while making the pulse-width measurement. Press **DELTA V** and toggle the **V MARKER** key until it reads **CH 1 & 2**. With the **MARKER 1 POSITION** turned on, position the marker at the 50% level of the leading edge on channel 1. Press **MARKER 2 POSITION** and set that marker to the corresponding point of the edge on channel 2.



Unfortunately, the **AUTO TOP-BASE** softkey is not available for two-channel measurements.

Press **DELTA t**, turn the markers on, and press **START ON POS EDGE 1** and **STOP ON POS EDGE 1**.

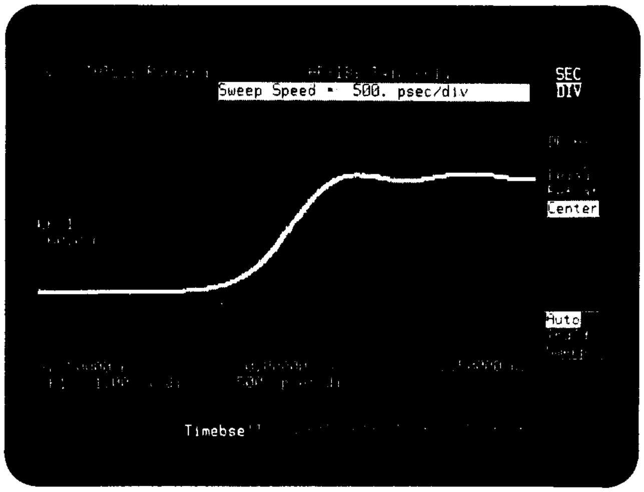


The delta time reading is the extra amount of time required for the signal to travel from channel 1 to channel 2 through the extra length of cable. The time is the electrical length of the second cable.

Jitter Measurements

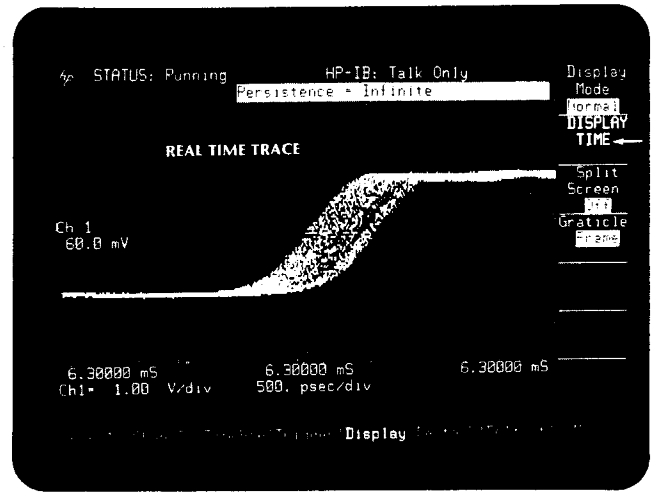
Jitter of an electrical signal is the result of shifting frequency. Even the most stable frequency sources exhibit jitter when we trigger on one edge and view an edge that occurs a million cycles later. Making a jitter measurement with the **HP 54100A/D** provides the opportunity to use two more of its features—variable persistence and waveform storage.

With only one signal connected to the scope, press **AUTO-SCALE**, and adjust the **SEC/DIV** to display one edge on screen.

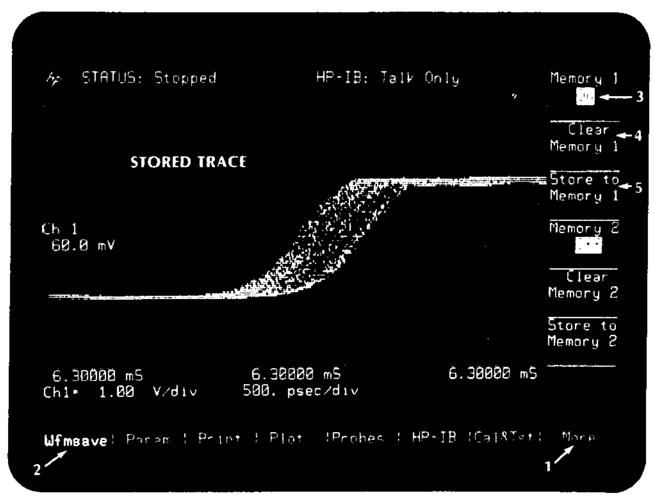


Press **DELAY** and increase the delay to several milliseconds downstream (with a delay of 20 ms, the one millionth cycle of a 20 ns period is displayed). Notice that with this much delay, the reduced sample point density, combined with the points quickly fading away, make an accurate jitter measurement impossible. This problem is encountered when using a conventional scope in this mode. It is the result of the delay-to-sweep-speed ratio. The time between sweeps is longer than the CRT's persistence, so the first trace fades away before the second one comes by.

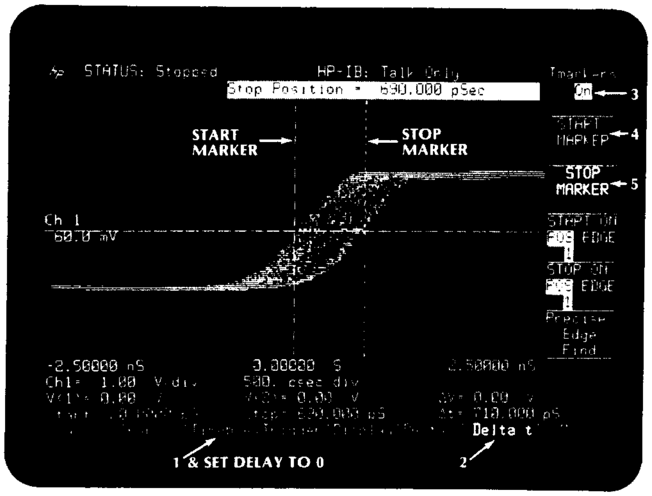
This problem is easily overcome with the **HP 54100A/D's** variable persistence mode. While in this mode, each sample point taken can be left on screen indefinitely. Press **DISPLAY**. While in **DISPLAY MODE NORMAL**, the controls are automatically assigned to **DISPLAY TIME** (note its value above the display). **DISPLAY TIME** can be set from 200 ms up to 10 seconds; selecting a value of 11 seconds or greater sets it to **INFINITE**. Set **DISPLAY TIME** to **INFINITE**, and watch as the scope builds up a display of the total jitter. By having the persistence set at infinite, we can make a worst-case measurement. If necessary, go back to the **TIMEBSE** menu and adjust **DELAY** to center the edge on screen.



The delay-to-sweep-speed ratio is also going to cause a problem when we try to use the delta t markers. While they are designed to move in increments as small as parts-per-million, that becomes a big jump when we have this much delay. With a sweep speed of 2 ns/div and a delay time of 20 ms, one part-per-million equals one screen diameter. This problem is easily overcome by making the measurements on a stored version of the trace. Press the bottom **MORE** key and then select **WFMSAVE**. Turn **MEMORY 1 ON**, press **CLEAR MEMORY 1**, and then press **STORE TO MEM 1**. Press the **STOP/SINGLE** and the **CLEAR DISPLAY** keys. Now, the display on screen is a stored version of our jittering pulse.

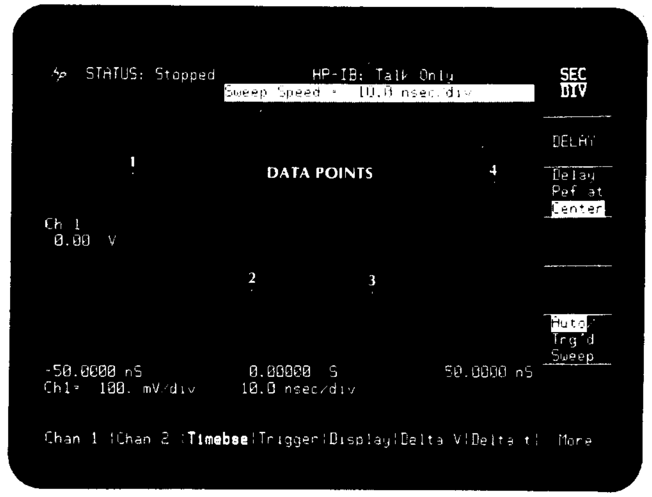


Go back to the **TIMEBSE** menu and set **DELAY= 0.000000**. Press **DELTA t** and turn the markers on. Position the **START MARKER** on the worst-case data point to the left, and the **STOP MARKER** on the worst-case data point to the right. The delta time reading is the amount our pulse was jittering.

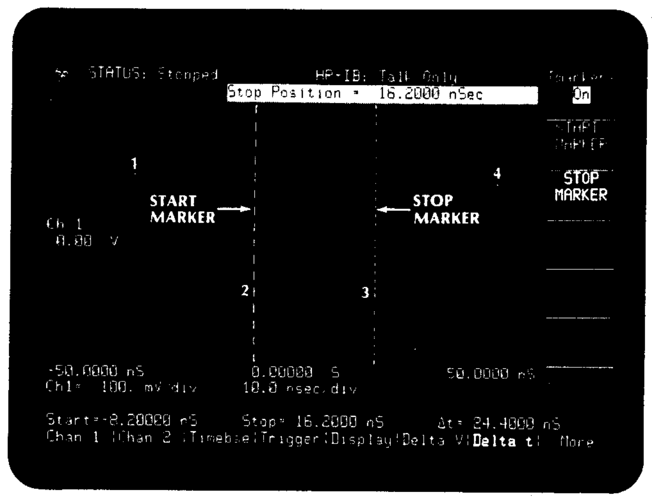


Random-Repetitive Sampling

The **HP 54100A/D** uses a technique referred to as random-repetitive sampling to capture a waveform. Through this technique, new data points are taken during each sweep. The new data points are offset from those taken on previous sweeps. To demonstrate this, connect a 50 MHz signal (20 ns period) to channel 1 and press **AUTO-SCALE**. Bring up the **TIMEBSE** menu, set time per division to 10 ns, and select the **TRG'D SWEEP** mode. Press **STOP/SINGLE** and note the **STATUS:STOPPED** in the upper left corner of the display. Clear the display and press **STOP/SINGLE** once. There should be at least four points on the display.

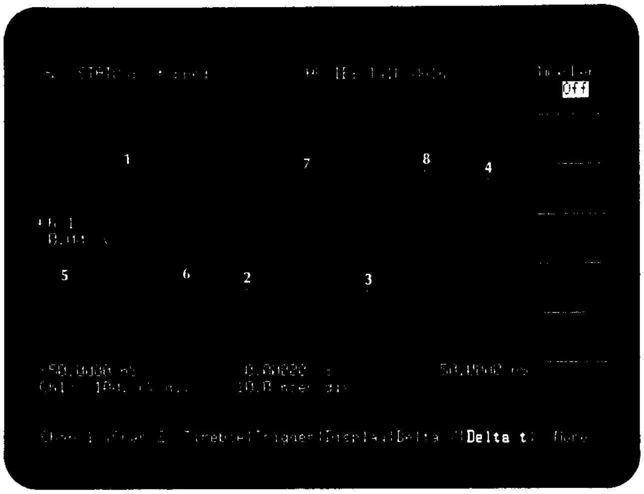


Press **DELTA t**, and place the markers on two adjacent points. The delta time reading should be approximately 24.6 ns. This is the digitizing sample rate of the **HP 54100A/D**.

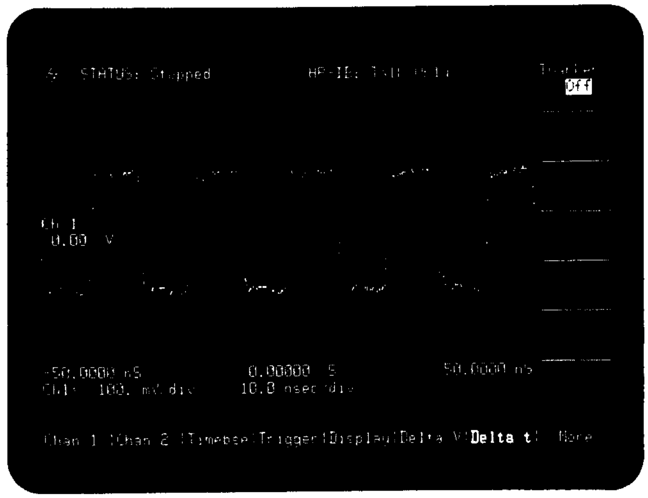


Random-Repetitive Sampling

Turn the delta t markers off and press **STOP/SINGLE** once more. Note the new set of data points are offset in time from the first set.



Press **STOP/SINGLE** several times and watch the display as the 50 MHz signal is built up.



Press **RUN** to return to the repetitive sweep mode. Random-repetitive sampling can reconstruct a waveform with a frequency that is far greater than its sample rate—that is, if the waveform is repetitive. Single-shot event capture is limited by the sample rate and is typically specified as one-fourth of the sample rate.

II. Application Measurements

This section illustrates some typical applications for the HP 54100A/D. It assumes a certain degree of familiarity with the operation of the HP 54100A/D, instructions being provided in Section I.

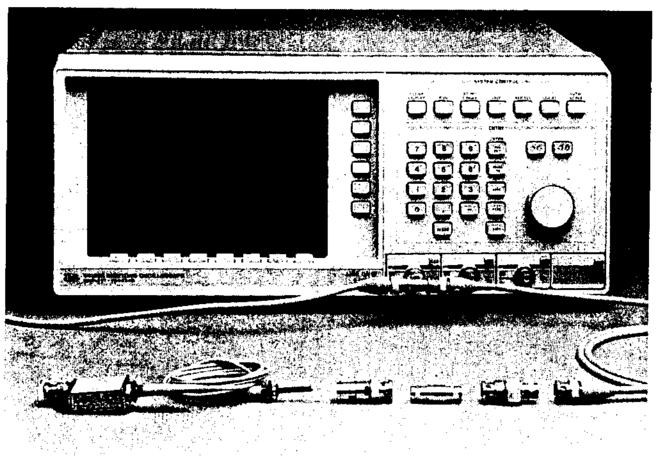
Demo 1—Measuring Reflections

Equipment Required:

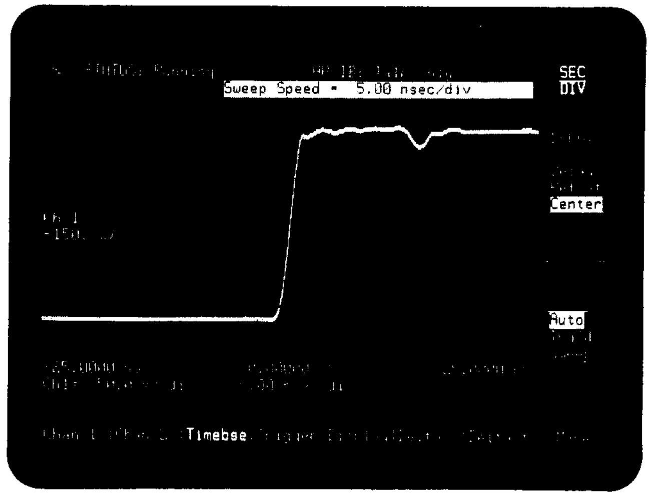
- HP 54100A/D oscilloscope
- Pulse generator with less than 2.5 ns transition times (**HP 8082A, HP 8161A, HP 10326A**, or the **HP 54100A/D** Cal signal)
- 2 BNC-BNC cables
- 1 BNC Tee (HP 1250-0781)
- 1 50 ohm termination (HP 10100C)
- 1 BNC feed-thru (HP 1250-0080)
- 1 BNC-to-probe adaptor (HP 1250-1454)
- 1 megohm probe (HP 10017A or equivalent)

Connections And Initial Settings

Connect the equipment as shown below.



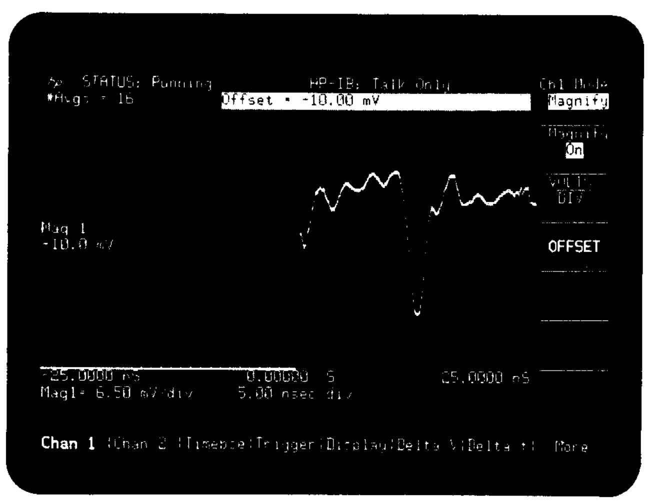
Press AUTO-SCALE and adjust VOLTS/DIV and TIME/DIV to get good resolution of one edge on screen.



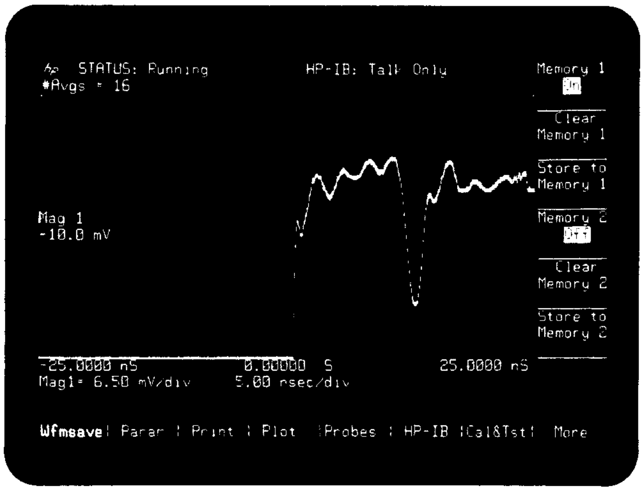
Measuring Reflections

Note the small reflections from the probe at the far end of the cable. If you're not sure where the reflections are, remove the probe from the probe adaptor and note the change in the reflections.

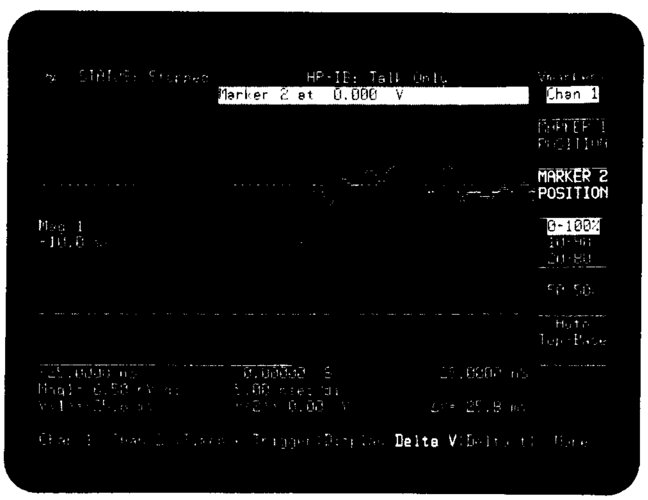
To view the reflections in more detail, switch **CHAN 1** from **NORMAL** to **MAGNIFY**. Adjust **WINDOW SIZE** and **POSITION** so the window markers just bound the reflection. Turn the channel 1 **MAGNIFY ON**. Switch the display mode to **DISPLAY MODE AVERAGED**, if it wasn't there already. Set the **NUMBER OF AVERAGES** to 16. The display should look something like this.



Go to the **WFMSAVE** menu and store the trace. The sequence of keys is as follows: **CLEAR MEMORY 1, STORE TO MEMORY 1, MEMORY 1 ON.**



Starting with the probe, remove each of the components up to—but not including—the 50 ohm termination at the end of the cable, restoring the trace after each step. The display should look like the figure. Using the delta V and delta t markers, measure the width and level of the reflection.



What Does This Measurement Demonstrate?

This measurement is typical of the measurements that system designers working with high-speed logic have to make. Reflections due to improperly terminated lines, edge connectors, sockets, etc., can easily become large enough to disrupt proper circuit operation by crossing through logic threshold and causing glitches.

Even a small reflection, if it coincides with an edge, can disturb operations in a couple of ways. If it occurs near a logic threshold, it may cause the input of a gate to pass through threshold twice, resulting in a glitch at the output. Or it may shift the threshold-crossing time sufficiently enough to violate timing rules.

This measurement demonstrates the use of magnification and averaging to extend the vertical resolution of the **HP 54100A/D** to 10-11 bits. This makes it very useful for measuring small features on a waveform that constitute a small fraction of the amplitude of the waveform.

Note: **this is the recommended way to measure small details. It is not advisable to overdrive the input beyond the screen limits in the non-magnified mode.**

Demo 2—Measuring Low Rep-rate Narrow Pulses

Equipment Required:

- **HP 54100A** or **HP 54100D** oscilloscope
- Pulse generator
- **HP 54002A** 50 ohm pod for **HP 54100A/D**
- BNC-BNC cable

Connections And Initial Settings

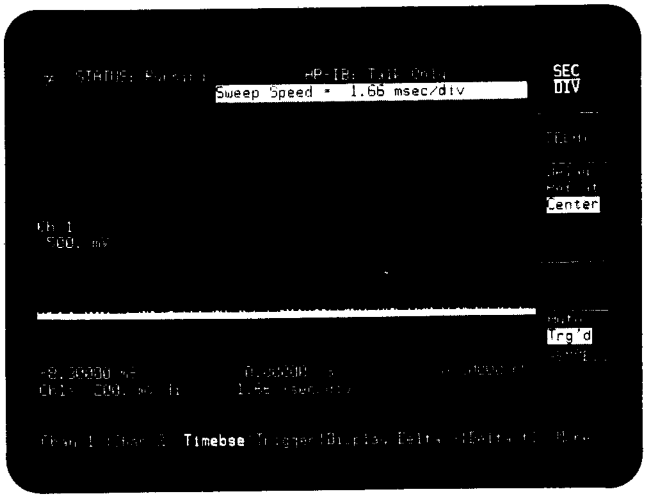
Adjust the pulse generator for the following output characteristics:

- High level: approx. +1 V
- Low level: 0 V
- Width: 100 ns
- Frequency: 60 Hz
- Polarity: positive

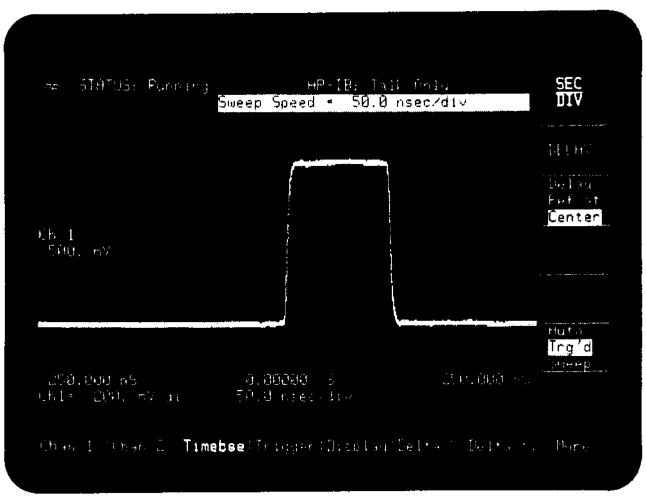
Connect the pulse generator output to the **HP 54100A/D** channel 1 input. Set the **HP 54100A/D** up as follows:

- **CHAN 1, VOLTS/DIV:** 200 mV/div
- **CHAN 1, OFFSET:** 500 mV
- **CHAN 1 DISPLAY ON**
- **CHAN 2 DISPLAY OFF**
- **SEC/DIV:** 1.66 ms/div (enter through keypad)
- **DELAY:** 0 sec
- **AUTO/TRG'D SWEEP:** triggered
- **TRIG SRC CHAN 1**
- **TRIG LEVEL:** 500 mV
- **DISPLAY MODE NORMAL**
- **DISPLAY TIME:** Infinite; the easiest way to get infinite persistence is to enter a value of 11 seconds from the keypad.
- **GRATICULE:** frame

Let the scope run for a few minutes. You should begin to see the pulse appear as a narrow column of dots at center screen.



Now, expand the TIME/DIV to 50 ns/div to examine the pulse in detail.



Decrease the **DISPLAY TIME** to 200 ms. Note the very high throughput, resulting in an easy-to-view, dynamic display. Change the pulse height and note the display changes instantly.

What Does This Demo Show?

This demonstrates the value of infinite persistence in displaying very low rep-rate, narrow pulses. This is a measurement that must be done, for instance, on a disc drive when checking an erased track for residual pulses. The combination of 100 ns pulse width and 60 Hz rep rate were chosen because they are typical of a single pulse on a high-capacity, hard disc track.

Viewing low rep-rate, fast events is tough with any oscilloscope, either at low sweep speeds (searching for an event) or at high sweep speeds (analyzing the event). With most digitizing oscilloscopes, you will not see the pulse on the slow sweep speed, because the oscilloscope will only display one voltage value for each time slot. They may sample the input during the pulse, but the sample will only be displayed momentarily, and will be replaced on the next acquisition. At the high sweep speed, the throughput will be limited by (1) the sampling rate, and (2) the processing cycle time for samples. The **HP 54100A/D's** sampling rate is 40 MHz. The 68000 microprocessor—and the efficient time measurement and display code—measure and display the samples quickly.

Demo 3—Measuring Cyclical Groups Of Events

Equipment Required:

- **HP 54100A** or **HP 54100D** oscilloscope
- Pulse generator with burst capability (**HP 8116A**)
- 50 ohm input pod for **HP 54100A/D** (**HP 54002A**)
- BNC-BNC cable

Connections And Initial Settings

Adjust the pulse generator for the following output characteristics:

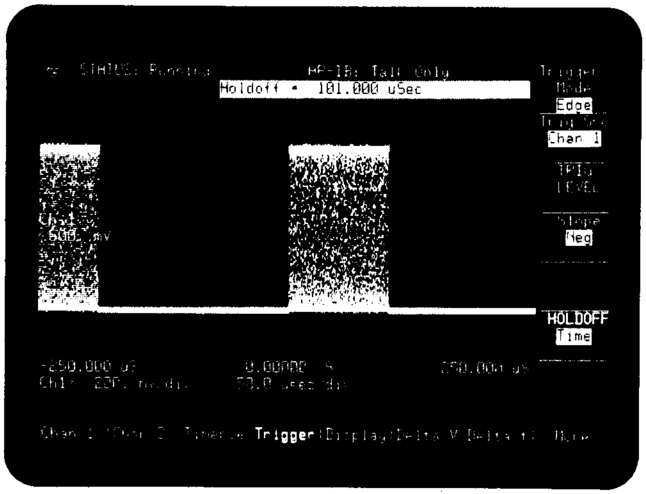
- High level: approx. +1 V
- Low level: 0 V
- Mode: internal burst
- Number of pulses in burst: 1000
- Burst repetition period: 300 μs
- Frequency: 10 MHz
- Duty cycle: 50% (pulse width approx. 50 ns).

Connect the pulse generator output to the **HP 54100A/D** channel 1 input.
Press **AUTO-SCALE.**

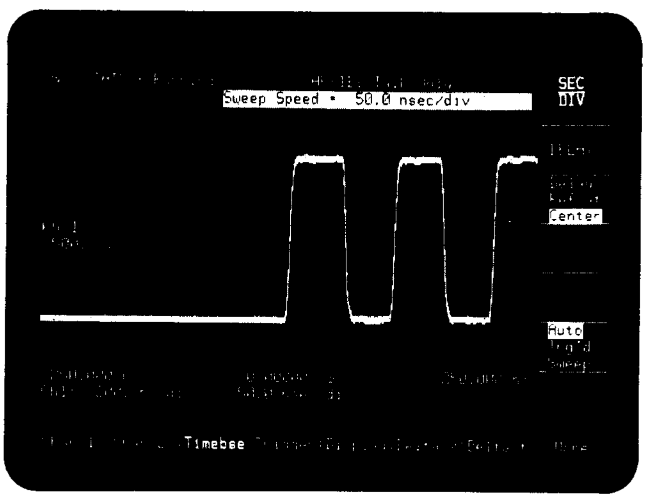
Using Holdoff

Set the **SEC/DIV** to 50 μs/div. Check the trigger to make sure it's on channel 1, positive slope, and the trigger level is approximately centered on the signal. Note that the display is asynchronous to the pulse bursts; the scope triggers on any positive edge in the burst. Press the **HOLDOFF** key twice; it should now read **HOLDOFF EVENTS.** Enter 999 for the number of events from the keypad (you must press any of the **ENTER** units keys to enter the number after pressing the number keys). The waveform should be displayed as stable. However, the start of the burst may not be at center screen.

Measure the width of the burst by using the delta t markers. Press the **HOLDOFF** key again to return to the **HOLDOFF TIME** mode. Enter a value of holdoff time that is slightly larger than the burst duration (which should be approximately 100 µs). The burst should now start at center screen.



Expand the **TIME/DIV** to 50 ns/div to see the first few pulses in the burst.



What Does This Demo Show?

Trying to sync on cyclical groups of events is a frequent problem, especially in digital systems. It is not sufficient to synchronize on the signal at the micro-time level; you need some way to synchronize the oscilloscope at the macro level, to the higher level of periodicity in the signal. For example, in a serial digital data stream, the pattern may be 16 or 32 clock cycles long; in this situation, the oscilloscope could be triggered on the clock, and the holdoff-by-events could be set to the number of clock cycles in the pattern. Another example occurs in measuring a composite video/sync signal. If you know the total number of sync pulses and equalizer pulses in a complete frame, you can set holdoff to N-1, where N is the total number of times the signal passes below black level, including equalizer pulses. Note: if you set the holdoff to the total number of pulses in a field minus 1—instead of a frame—the scope will trigger on alternating fields, and will be unsynchronized to the overall signal.

In some situations, time—not number of events—is important in determining cycles in a signal. For instance, consider a very noisy signal, but one that has a periodic, stable-frequency, dominant component that you want to view. If you know the exact period, you can use holdoff-by-time set to just less than the period. This will keep the scope from re-triggering on noise in the signal, only allowing it to trigger on the same point in each successive cycle of the signal. This is especially important if you want to use the averaging feature to eliminate uncorrelated noise from the signal. If the scope is not precisely synchronized to the signal, then successive averages cannot be correctly time-correlated, so the averaged signal will have amplitude errors introduced by time jitter or drift of the signal relative to the time base.

Demo 4—Measuring Multiple Cyclical Groups of Events

Equipment Required:

- HP 54100A/D oscilloscope
- Two pulse generators with burst mode (**HP 8116A**)
- 50 ohm input pod for **HP 54100A/D** (**HP 54002A**)
- 2 BNC-BNC cables

Connections And Initial Settings

Adjust the first pulse generator as follows:

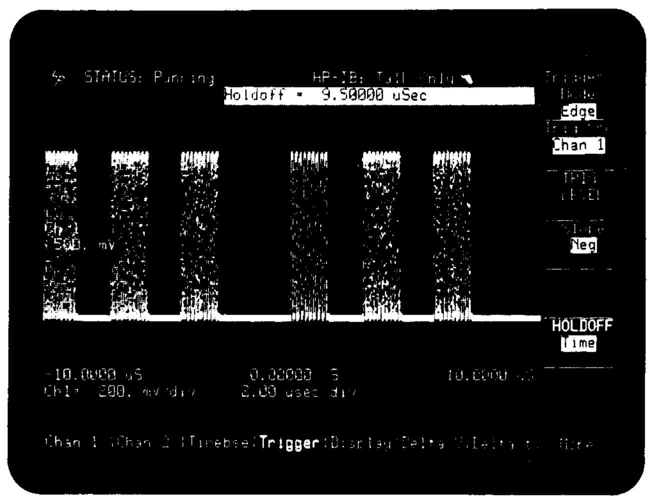
- Mode: internal burst
- Burst repetition rate: 10 μs
- Burst width: 3 pulses
- Frequency: 350 kHz
- Duty cycle: 50%
- High level: +2 V
- Low level: −2 V
- Function: square wave

Connect the output of the second pulse generato to the input of the **HP 54100A/D.**

Measuring the Time From the First Pulse in the First Burst to the First Pulse in the Last Burst

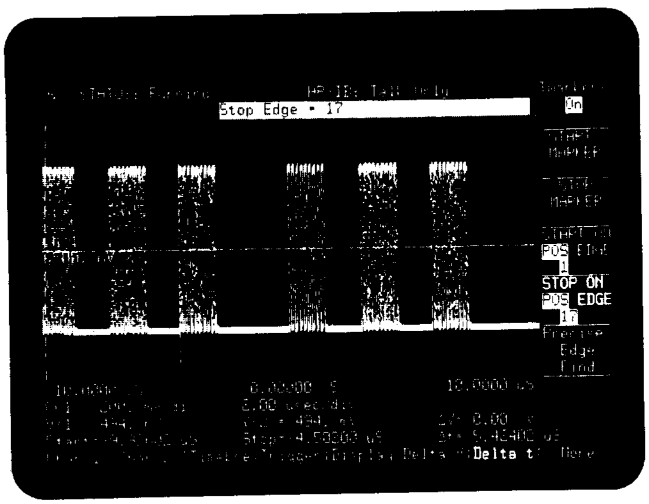
Here, we have a similar situation to that in demo 3: we can use the holdoff advantage to trigger on a complex waveform. However, the challenge is greater: we don't have a simple repeating burst of pulses, but a repeating group of bursts. This is getting a little closer to the kind of complex periodicity seen in real-world digital circuits. There are three periods in this signal: the pulses repeat themselves in each burst, the bursts repeat in groups of three, and the groups repeat. Also, note that the difference in timing between the groups of bursts (T1) is not greatly different from the separation of the bursts within each group (T2). Therefore, it is more important to set the trigger holdoff within a narrow range.

Set up the **HP 54100A/D**; press **AUTO-SCALE**. This should get the vertical sensitivity and offset approximately right, and the trigger onto the right channel. Now set the sweep time to 2 μs/div. Notice that the display is unsynchronized. Set the holdoff to 9.5 μs. The display should now trigger on the leading edge of the first pulse in the first burst, as in the figure. Try varying the holdoff time with the control knob. Note the range through which the display remains triggered on the first pulse in the first burst.



Now we're ready to make a time-interval measurement. First, press **DELTA V**, then toggle the menu to **V MARKERS CHAN 1**. Press **AUTO TOP-BASE**, then **50-50%**. This positions both voltage markers at the 50% level of the waveform.

Now press **DELTA 1** and toggle **T MARKERS ON**. Use the **START ON--** and **STOP ON--** keys to place the start marker on the leading edge of the first pulse in the first burst, and the stop marker on the leading edge of the first burst in the third burst. Note: the easiest way to do this is to first press the **START ON POS EDGE XX** or **STOP ON POS EDGE XX** key, then use the control knob to vary the edge count until the marker is on the desired edge. Now press **PRECISE EDGE FIND**. Note the difference in the delta t indication at the bottom of the screen.



What Does This Demo Show?

This demo combines the power of precise, explicitly adjustable trigger holdoff and the automatic precision time-interval measurement capability of the **HP 54100A/D** to make a simple task of measurement that would be very time-consuming on other oscilloscopes. Note that we did not have to search for the edges desired on the delayed sweep as we would have had to do on a conventional oscilloscope. The firmware in the **HP 54100A/D** scales and optimally offsets the time base to find and measure each edge. With other oscilloscopes that have variable holdoff, you could have adjusted the holdoff by trial-and-error to stabilize the signal, but it might have taken awhile, and then you might not have been certain that it was not going to slip out of sync when you were off measuring edges by using delayed sweep.

Another problem with most other scopes is the limited range of holdoff adjustment available. Try the same demo again, but slow the pulse generators down by a factor of 1000 (rescale all the frequencies and burst repetition rates in the setup instructions to be three orders of magnitude slower). Now you'll have to use a holdoff of 9.9 ms. Few, if any, other scopes have that much holdoff range.

You may have noticed that the precision edge finder algorithm didn't work very quickly this time. There are two reasons for this. First, the rise time of the pulse is now many orders of magnitude faster than the repetition rate, so the **HP 54100A/D** will pick a fairly fast sweep speed, relative to the repetition rate. This means it takes an inordinate amount of time to gather sufficient data for the edge time measurement. Still, by itself, this would not affect the accuracy of the measurement. Second, the jitter in the pulse generator will be very large—compared to the rise time—for the second edge. To see this, use **DELAY** to center the second edge on screen and set the sweep time to 200 ns/div.

Note: **the delay adjustment is an easy way to bring the second edge on screen. Just note the reading of the second marker position, and enter the amount for delay from the keypad. Try that on any other oscilloscope! This jitter will prevent the automatic precision edge finder from getting a valid reading. This is a good demo in itself, because it shows where not to use the automatic features in the HP 54100A/D.**

III. Front Panel Controls

This section is a detailed description of each of the softkey menus and the front panel controls.

Getting Started with the Front Panel

This section will describe the front panel layout and discusses its three functional areas. These areas include system control, entry, and menu selection. These three groups of keys give the operator complete local control of the instrument.

System Controls

The system control keys are located on the top right-hand side of the front panel. These keys provide control of acquisition, the dynamic display, the **SAVE/RECALL** registers, and automatic display scaling.

Clear Display

The **CLEAR DISPLAY** key erases the dynamic display. This key will not erase a waveform in memory that is being displayed. When **CLEAR DISPLAY** is pressed, the instrument will stop acquiring data for a moment. If **STOP/SINGLE** has been pressed previously, **CLEAR DISPLAY** will erase the displayed waveform and acquisition will not resume unless **RUN** is pressed. If a single acquisition is desired, **STOP/SINGLE** can be pressed for a second time.

Run and Stop/Single

RUN causes the **HP 54100A/D** to resume acquiring data after acquisition has been stopped by **STOP/SINGLE**. When **STOP/SINGLE** is pressed, the instrument will stop acquiring data and display the last data acquired until **RUN** is pressed. Each subsequent **STOP/SINGLE** key press causes the instrument to make a single acquisition that will be started by the next trigger event. To return to the previous operating mode, press **RUN**.

Save/recall

The **HP 54100A/D** allows you to save and recall up to 10 different front panel setups in nonvolatile memory. To save the current front panel setup in one of the ten **SAVE/RECALL** registers, press **SAVE**, then press the number (0-9) of the register desired. All front panel functions, modes, and Cal factors of menu selection and input-device assignments are saved.

To recall a previously-saved front panel setup, press **RECALL**, then press the number of the desired register.

To return to the condition prior to the last **AUTO-SCALE**, press **RECALL**, then press **AUTO-SCALE**. This feature allows you to recover conditions if **AUTO-SCALE** is accidentally pressed.

Local

When **LOCAL** is pressed, an RTL (return to local) message is sent to the HP-IB interface and the unit will return to local (front panel) control if it had previously been in remote operation and if the HP-IB controller had not invoked a local lockout. **LOCAL** is the only active front panel key when the unit is in REMS (remote state).

Auto-scale

When **AUTO-SCALE** is pressed, the instrument will autorange the vertical sensitivity, determine the trigger level, and select a sweep speed for an appropriate display of the input signal. If input signals are present at both vertical inputs, the sweep will be triggered on channel 1 and the display will go to the split-screen mode and scale the vertical sensitivity for each channel.

When the **AUTO-SCALE** cycle is complete, **TIMEBSE** will be selected and the entry controls will be assigned to **SEC/DIV**.

Entry Controls

Under the system-control keys is an area labelled **ENTRY**. Located in this portion of the front panel is a number pad, a vertical column of five keys, the knob, and two arrow keys. These three items are referred to as the entry devices throughout this section. The entry controls are used to change the value of any of the items in the menus that are written in uppercase letters. The menus are on the right side of the CRT. Two examples of variable functions would be **VOLTS/DIV** and **SEC/DIV**. The value of the selected variable function is displayed in inverse video at the top of the CRT.

Menu Descriptions

Menu Selection

Softkeys provide front panel control of the **HP 54100A/D**. This instrument has two sets of softkeys. The first set is located at the bottom of the CRT, and the second set is right of the CRT. The keys at the bottom of the CRT are referred to as the menu-selection keys, as they are used to choose a desired function menu. As you press the different selection keys, the menus along the right side of the CRT will change. Pressing **MORE** at the bottom right-hand corner of the CRT provides an additional seven menus. If **MORE** is pressed again, the original menu will return.

After you have selected a menu, notice that some of the softkey labels have text shown in inverse video. If the adjacent softkey is pressed, the text that is in inverse video will change (e.g., to turn a function on or off). When a softkey with an uppercase label is pressed, the text will intensify and the entry controls will be slaved to that function.

In the last case, the label for a softkey function will have the first letter of each word in uppercase and there will be no inverse-video text field associated with the label. When a key with this type of label is pressed, the function will execute. This type of label is used primarily in the **PARAM** (e.g., peak-to-peak voltage and frequency) and **CAL & TEST** menus.

Familiarize Yourself With The Menus

Connect one of the Cal signals from the rear panel to the channel 1 input. The most convenient method of scaling the vertical and horizontal is to press **AUTO-SCALE**. This causes the **HP 54100A/D** to evaluate the vertical inputs and scale the vertical and timebase for a triggered display.

When **AUTO-SCALE** is pressed, **DELAY** will be set to 0 and referenced to center screen. The instrument will be left in the **TIMEBSE** menu with **SEC/DIV** as the assigned function for the entry controls. Rotate the control knob and notice the sweep-speed change. Enter 1 from the keypad and press the μsec entry key. The sweep speed will go to 1 μs/div. Next, alternately press the arrow keys. The sweep speed will either sweep faster or slower, depending on which key is pressed.

If no signal is detected on the inputs, an inverse-video error message on the display will state **NO SIGNAL FOUND**. If there is a signal present at the inputs of both channels, the **HP 54100A/D** will go to the split-screen function (i.e., channel 1 will be displayed in the top half of the display and channel 2 will be displayed in the bottom half of the display). Channel 1 is the trigger reference for a two-channel **AUTO-SCALE**.

Chan 1 and Chan 2

When **CHAN 1** or **CHAN 2** is selected, one of two function menus will appear on the right side of the display: one is for the **NORMAL** mode and one for the **MAGNIFY** mode. If you wish to change from one mode to the other, press the channel mode key.

Normal

NORMAL should be selected when the entire vertical magnitude of the input signal needs to be observed. When operating in this mode, you should not adjust **VOLTS/DIV** or **OFFSET** so the signal will be off-scale vertically, because your results may be erroneous.

Push **DISPLAY ON/OFF** and notice that the **CHAN 1** signal disappears and reappears. This function key turns off the display for a particular channel. It does not stop that channel from acquiring data.

VOLTS/DIV allows the vertical sensitivity to be changed in a 1-2-5 sequence—a 1-2-4 sequence is used when you are in the split-screen mode. The sensitivity may be changed in three ways.

1. Vertical sensitivity can be changed by using the number pad on the entry portion of the front panel. After a number on the keypad has been pressed, the appropriate unit key must be pressed to complete the operation. The unit keys are located just right of the keypad.
2. The control knob may be used to change the vertical sensitivity.
3. The arrow keys, located just above the control knob, may be used to increment or decrement the vertical sensitivity.

These three entry controls may be used on any item that is written in uppercase letters.

OFFSET allows the trace to be moved up or down by using the number pad, the control knob, or the arrow keys. This function works in the same way as a conventional position control. The **OFFSET** voltage is shown in inverse video at the top of the display.

The next function key is **PRESET**. This key provides three choices: **ECL**, **TTL**, or neither. When **ECL** or **TTL** is chosen, the instrument automatically chooses the correct **OFFSET**, **VOLTS/DIV**, and **TRIG LEVEL** for the selected logic family. These selections will be highlighted. When neither preset is desired, press the preset key until neither **ECL** or **TTL** is highlighted. When this is done, the **OFFSET**, **VOLTS/DIV**, and **TRIG LEVEL** will return to their previous settings.

Magnify

When MAGNIFY is selected, it can be turned on or off by pressing the key. When off is selected, there will be two variable functions on the horizontal-function menu: WINDOW SIZE and POSITION, and WINDOW SIZE. The horizontal lines that define the window can be moved closer together or further apart by using the entry controls (i.e., arrow keys, control knob, or number pad). The window defines the range that will become full-scale when MAGNIFY ON is selected. When POSITION is selected, you can move the window on the vertical axis by using the input controls.

MAGNIFY is easy to demonstrate: input the Cal signal to channel 1 and press AUTO-SCALE. Select MODE=MAGNIFY and MAGNIFY=OFF. Alternately select and adjust WINDOW SIZE and POSITION so the window is positioned at the pulse top. When MAGNIFY is on, the display will show the portion of the signal that was defined by the window. The vertical sensitivity for the magnified portion is shown in inverse video at the top of the display. The vertical sensitivity (i.e., VOLTS/DIV) and OFFSET can be adjusted in the magnify mode by selecting the appropriate function key and using one of the entry controls.

The magnify mode allows higher vertical resolution—up to 16X magnification when in the average mode—and is useful only in the averaged mode.

Timebse

After AUTO-SCALE is pressed, notice that the instrument has established itself in TIMEBSE and SEC/DIV. TIMEBSE contains two variable functions. The SEC/DIV function allows the time reference on the X axis to be varied from 1 sec/div to 100 ps/div in a 1-2-5 sequence by using the entry controls. Inputs from the number pad are not limited to values in the 1-2-5 sequence. As SEC/DIV is varied, the sampling rate is changed to provide an appropriate display on the CRT.

DELAY controls the pre- and post-trigger delay and can be varied by using the entry controls. The adjustment resolution for DELAY time is equivalent to .2% of the time interval represented by 10 horizontal divisions, but not less than 2 ps. DELAY has an effect similar to a horizontal position-control on a conventional oscilloscope.

DELAY REF allows the user to reference the delay to the right or left graticule edge, or to center screen, depending on which one was chosen as the trigger point. When DELAY is selected, delay time is displayed in inverse video at the top of the display. Maximum pre- and post-trigger time intervals vary with sweep speed and the delay-ref location. Negative DELAY values are time before the trigger, and positive DELAY values are time after trigger.

The last key on the TIMEBSE menu is AUTO/TRG'D. When the auto-sweep function is chosen, the unit will provide a base line on the display without a trigger when a signal is not present. If the unit is in triggered sweep and a signal is not present, the unit will not sweep. Always use the triggered-sweep function when the trigger rep-rate goes below 20 Hz—it prevents the auto-sweep circuitry from generating the base line.

Trigger

TRIGGER allows you to select trigger mode, trigger source, slope, and holdoff. This menu also allows the use of the HP 54100A/D's combinational triggering capability (i.e., logic-pattern triggering).

Edge

When previewing the trigger menu, notice the two trigger modes: EDGE mode and PATTERN mode. EDGE mode allows you to select one of three different trigger sources for the HP 54100A and four sources for the HP 54100D. Adjust TRIG LEVEL, determine the slope of the input signal being used to define the trigger event (POS/NEG), or define the HOLDOFF in time or events.

TRIG SRC permits the selection of one of three possible sources for the trigger input: CHAN 1, CHAN 2, or the external trigger (Trig 3). The HP 54100D has a second external trigger (Trig 4) for a total of four trigger sources. If CHAN 1 or CHAN 2 is selected as the trigger source, a horizontal trace will appear on the display showing the TRIG LEVEL with respect to the displayed signal.

SLOPE selects the negative or positive slope of the input signal being used as the trigger. The trigger slope can be set independently for each channel. This allows you to have each channel trigger on an opposite slope.

The HOLDOFF circuitry allows you to define the trigger-circuit disable period. The HP 54100A/D allows HOLDOFF to be defined by events or by time. An event is defined as a change in the input that satisfies the trigger conditions. The time range used to define HOLDOFF is from 70 ns to 670 ms. If number of events is used to define HOLDOFF, the range is from 2 events to 6.7 × 10E7 events.

HOLDOFF can be used to vary the minimum time between accepting triggers and giving a stable display of a complex waveform. This means you can view waveforms with varying periods and still maintain a stable display. **HOLDOFF TIME** can be used any time you need to eliminate multiple triggering on a complex waveform where the fundamental period is sufficiently stable (i.e., not jittering). **HOLDOFF EVENTS** is used to view a cyclic event that does not occur after each trigger event, as in the case of a pulse pattern that repeats after a given number of clock pulses.

HOLDOFF can be varied by using any of the entry controls, and, when selected, is displayed in inverse video at the top of the display.

Pattern

Press the **TRIGGER** mode key to access the **PATTERN** mode. In the **PATTERN** mode, you have 3-bit pattern recognition capability (the **HP 54100D** has 4-bit capability), and the instrument can be triggered either when entering or exiting the pattern. **HOLDOFF** can be defined as events or time.

The label for **TRIG ON PATTERN** includes three characters in inverse-video text. When **TRIG ON PATTERN** is pressed, one of these characters will be highlighted. By using the entry controls, you can change this character to one of three letters: **X**, **L**, or **H**. The inverse-video text on the **HP 54100D** includes four characters. **X** indicates a don't care condition, **L** indicates a requirement for a low condition or a logic 0, and **H** indicates a requirement for a high condition or a logic 1. The three characters in this text field determine whether the voltage levels at each of the three inputs (i.e., **CHAN 1**, **CHAN 2** and Trig 3—the **HP 54100D** has Trig 4) are required to be above or below **TRIG LEVEL** or are not used as a trigger qualifier—that is, if these characters read **L H X**, **CHAN 1** would have to be below **TRIG LEVEL** and **CHAN 2** would have to be above **TRIG LEVEL** before a trigger event would occur. In this example for the **HP 54100A**, Trig 3 is not used as a trigger qualifier because it is in the don't care condition. Set the **TRIG LEVEL** for each trigger source while you are in the **EDGE** mode. These trigger levels must be set before going to the **PATTERN** mode for proper pattern triggering.

The next key is **WHEN ENTERED/EXITED**. When this is pressed, the inverse-video text next to the key will change from **ENTERED** to **EXITED**. If **WHEN ENTERED** is selected, the unit will generate a trigger on the last transition that makes **TRIG ON PATTERN** true. If **WHEN EXITED** is selected, the unit will generate a trigger on the first transition on any of the inputs that cause **TRIG ON PATTERN** to be false. When you are in the **PATTERN** mode and you have pressed **TRIG ON PATTERN**, the inverse-video text field at the top of the CRT will list what condition a particular input must be in to satisfy the pattern requirements (e.g., **CH 1 Trigger=Low, Trig 4=High**, etc).

The triggering capabilities that have been discussed to this point are shared by the **HP 54100A** and **HP 54100D**, except where specifically stated otherwise. The remainder of this section deals exclusively with the additional triggering capabilities of the the **HP 54100D**.

The **HP 54100D** had two additional functions on the pattern trigger menu: **WHEN PRESENT >** and **WHEN PRESENT <**. These functions can be accessed by pressing **WHEN**. These two functions allow time to be used as an additional trigger-qualifier.

If **WHEN PRESENT >** is selected, a trigger event will occur if the trigger pattern is true for a minimum time-period. This period is listed in the label for the time key and can be varied from 10 ns to 5 sec by using the entry controls. When the trigger-pattern requirements remain satisfied for the required period of time, a trigger will occur when any of the inputs transition to a false state. If the pattern becomes true and then goes false before the specified time, the exit edge will be ignored.

If **WHEN PRESENT <** is selected, a trigger will occur only if the trigger pattern is satisfied and one of the inputs transitions to a false state before a given time-period. The period is listed on the key label and can be varied from 10 ns to 5 sec by the entry devices.

Press the trigger-mode key. The label will change to **STATE. In the STATE** mode, one of the inputs is selected as a simple edge source, the other three inputs define a bit pattern. A trigger will occur on the edge when the pattern is true and **IS PRESENT** is selected. A trigger will also occur on the edge when the pattern is false and **IS NOT PRESENT** is selected. The polarity of the edge that is used for trigger qualification is selectable and and the threshold is set by **TRIG LEVEL**. Press the **TRIGGER** mode key and the label will read **TIME DLY**. This menu allows you to select a signal edge on any input, wait for a period of time, and then trigger on an edge from the selected input. The edge polarities, the inputs that are used to acquire the edges, and the delay time are all defined by the user.

The second and third function keys allow you to select the polarity and source of the starting edge.

The fourth key allows you to define a waiting period between the edge that is used as a trigger qualifier and the edge that is used as a trigger event.

The fifth and sixth function keys allow you to select the polarity and source of the edge that is used as the trigger event.

The last trigger mode is **EVNT-DLY**. This menu allows you to define an edge as a trigger qualifier. Once this edge is detected, the unit will trigger on a defined occurrence of a second edge.

The second and third keys on the menu allow you to select the polarity and source of the first edge or trigger qualifier.

The fourth key allows you to determine the number of edge occurrences that take place before the trigger event.

The fifth and sixth keys allow you to determine the polarity and source of the second edge or trigger event.

Display

When **DISPLAY** is chosen, two modes are available: **NORMAL** and **AVERAGED**. In the normal mode, each data point is displayed for a period of time defined by the user. You can vary the display time from 200 ms to infinite.

In infinite persistence, the data points will remain on the display until **CLEAR DISPLAY** is pressed or the display is moved with an instrument control (e.g., sweep speed, vertical sensitivity, or trigger level). The persistence time is shown in inverse video at the top of the display.

If variable persistence (i.e., persistence other than infinite) is selected, you have a flexible display that changes with variations in the input signal but stores the signal indefinitely on the display if the trigger is lost and the unit is in **TRG'D SWEEP**.

A minimum-persistence setting is useful when the input signal is changing and the user needs immediate feedback, as when rapidly probing from point to point, or setting up the amplitude or frequency of a signal source. More persistence is useful when observing the relative distribution of waveform changes. At fast sweep speeds and low trigger rep-rate conditions, more persistence is needed to gain an adequate number of data points on the display. Infinite persistence is useful for worst-case characterization of signal noise, jitter, drift, timing, etc.

There is a limit to the number of data points that can be displayed on the screen at any one time in the variable persistence mode. The display time is temporarily reduced whenever the number of points exceeds 5,500. This reduces the number of data points on the display. If averaged mode is selected, the last acquired data points are averaged with previously-acquired data before they are displayed. The number of data points that are averaged is variable from 1 to 2048 in powers of 2. Vertical resolution can be extended and displayed noise can be significantly reduced by using the averaged mode. As the number of averages is increased, the display becomes less responsive to changes in the input signal(s). By selecting the appropriate number of averages, the throughput for the automatic pulse-parameters or the time-interval measurements can be controlled. Since these automatic measurements use averaging, the user can trade off the speed of the measurements against the repeatability of the measured results.

Next is **SPLIT SCREEN**. When **SPLIT SCREEN** is on, channel 1 will be presented in the upper half of the display and channel 2 in the lower half. Scaling accuracy is maintained as this function is turned off and on. When the split-screen function is off, channels 1 and 2 can be overlaid on the display area. Three different graticules are available in the display menu. Press the graticule key and cycle through them to see how they appear.

Delta V

When **DELTA V** is enabled, two markers are displayed. These markers can be used to make absolute-voltage measurements on the signal under evaluation. You could also use them for reference markers when adjusting a signal to a given amplitude. Once **DELTA V** is selected, the markers cannot be activated unless the display for channel 1 or channel 2 is turned on. After you have chosen the channel you would like to evaluate and have enabled the V markers, observe the next two functions on the delta V menu:
MARKER 1 POSITION and **MARKER 2 POSITION**. These will allow you to position the markers on the vertical axis. The voltage shown in inverse video at the top of the display indicates the voltage level of the V marker that has been selected.

The next three keys on the delta V menu automatically position the V markers on the display. The **0-100%,10-90%,20-80%** key causes the instrument to perform some calculations and position the V markers for you. When the V markers are positioned manually, the inverse-video field will change to **0-100%**. If the key showing **0-100%** is pressed, the label will change to **10-90%** and the markers will move to the 10% and 90%

points of their previous levels. If the key is pressed again, the label will change to **20-80%** and the markers will move to the 20% and 80% points of their original levels. If either of the V markers are manually repositioned while the function switch is in **10-90%**, **20-80%** or **50-50%**, the original reference and label for the key will change to **0-100%**. The **50-50%** key moves both markers to the 50% point of the 0-100% levels.

AUTO TOP-BASE automatically locates the top and base of the displayed waveform. This is done by evaluating a histogram of the displayed signal. **AUTO TOP-BASE** and the **0-100%,10-90%,20-80%,50-50%** function key are disabled when V markers are selected for **CH 1 & 2**.

Connect the Cal signal from the rear panel to channel 1 and press **AUTO-SCALE**. Next, select **DELTA V** and key on the V markers. Now establish the top-base reference by pressing **AUTO TOP-BASE**. To demonstrate the action of the **0-100%,10-90%,20-80%** key, press it several times. Notice how it cycles through the three selections and how the V markers move. Press **50-50%**: this establishes the V markers at the 50% point of the signal.

In the lower portion of the display are display factors. These factors include the delta V value—delta V is the voltage difference between the two V markers. This measurement capability simplifies waveform measurements.

Delta t

DELTA t provides control for two time markers that can be used to make measurements in the time domain (i.e., X axis). The display factors include **DELTA t**, which is the time interval between the two t markers, and **START=** and **STOP=**, which are the time intervals between the two t markers and the delay reference. After the t markers have been enabled, each t marker can be moved by selecting **START MARKER** or **STOP MARKER**. The inverse-video text at the top of the CRT lists the time between the selected marker and the delay reference.

The delta t menu is extended when the delta V markers are turned on. **START ON EDGE**, **STOP ON EDGE**, and **PRECISE EDGE FIND** are available on the **DELTA t** menu when the delta V markers are on. To demonstrate this, let's do a short exercise.

Input the Cal signal to channel 1 and press **AUTO-SCALE**. Select **DELTA t** and turn the t markers on. Manually move **START MARKER** that it coincides with the first positive leading-edge of the Cal signal. Next, move **STOP MARKER** to the second positive leading-edge of the Cal signal. You have just made a time-interval measurement. In the display factors, the **START MARKER** is approximately 2 μs ahead (−2.0 μs) of the delay ref which was established at center screen when you used **AUTO-SCALE**. **STOP MARKER** is located at approximate-center screen (0.0 μs) and the delta **t** interval between the t markers is approximately 2 μs.

Select **DELTA V** and turn the V markers on. Press **AUTO TOP-BASE**, then press **50-50%**. For this measurement, the significant thing is to make sure that the V markers intersect the rising and falling edges of the signal. Return to **DELTA t**. Press **START ON EDGE** several times. Notice that the positive/negative indicator alternates and **START MARKER** moves from the front edge to the trailing edge of the first pulse. If you need to move the **START EDGE** to another pulse, use the entry controls. **STOP EDGE** can be changed in this fashion, also. **START ON EDGE** and **STOP ON EDGE** are coarse edge-locators—in as much as data already collected on screen is used to locate the edges. New data is acquired automatically only if the the unit is in the normal mode.

To demonstrate **PRECISE EDGE FIND**, return to **DELTA V** and press **AUTO TOP-BASE**. Then select **10-90%**. Return to **DELTA t** and press **PRECISE EDGE FIND**. **DELTA t** in the text field will represent the rise time of the pulse—in this case, approximately 2 ns.

PRECISE EDGE FIND initiates an automatic time-interval measurement. The **HP 54100A/D** will acquire the data, make the measurement, and have the delta t and delta V markers visible on the display so that you can see where the automated measurements were made. When you use **PRECISE EDGE FIND**, the unit will expand the selected edge using **START ON EDGE**, **STOP ON EDGE**, and, if necessary, rescale the timebase until a suitable slope is acquired. This expansion is accomplished with newly-acquired data. By expanding the edge in this fashion, the horizontal resolution is increased. The speed and repeatability of this measurement is influenced by the number of averages (i.e., the more averages, the slower and more repeatable the measurement will be). Other items that will influence measurement speed and repeatability are input-signal edge speed, rep rate, and signal jitter.

More

Press **MORE**, located in the lower right-hand corner of the display. This key allows you to access seven additional function menus. Pressing **MORE** again allows you to return to the original set of menu keys.

Wfmsave

The HP 54100A/D has two volatile pixel memories. These are in addition to the dynamic memory that is used for the active display. These memories have a resolution of 501 pixels horizontally and 256 pixels vertically. When you select WFMSAVE, you have full control of these two pixel memories. The contents of each memory can be viewed or removed from the display by selecting either memory and keying it on or off. To store a signal in one of the static memories, press STORE TO MEMORY 1 or MEMORY 2. Multiple waveforms may be stored in these memories and kept for future viewing and comparisons. To purge a memory, press CLEAR MEMORY 1 or MEMORY 2. Any stored waveforms will remain available for viewing until the instrument power is removed or the appropriate CLEAR MEMORY key is pressed.

When a waveform is stored in memory, only the waveform is maintained. The scaling factors (i.e., volts/div and sec/div) are not stored.

Param

Press PARAM. You now have access to three menus that can be accessed by pressing MORE on the function menu. If neither channel is activated, MEASURE will default to CHAN 1 and—if a measurement is made—the unit will automatically activate the CHAN 1 display. PARAM uses the measurement capabilities of DELTA t and DELTA V to make automatic pulse measurements. These measurements can be made whether a channel's display is on or off.

The first menu presented when PARAM is pressed is MEASURE. This key selects the channel to be measured.

The next function key is ALL. When ALL is pressed, the HP 54100A/D automatically makes the measurements and lists the results in the factors area.

Print

PRINT allows display and memory data to be output over HP-IB to a graphic printer that is compatible with Hewlett-Packard raster-scan standard. The HP 54100A/D must be in the talk-only mode and the printer must be in the listen-only mode. The HP 54100A/D can be set to talk-only when in the HP-IB menu.

The PRINT menu offers you four print options, an automatic form-feed option, and a start-print key.

The four print options allow the selection of data to go to the graphics printer. Any or all data sources can be put out at the same time—any combination of the factors, MEMORY 1, MEMORY 2, and the display data can be sent to the printer for a hardcopy. If you want automatic form-feed after a hardcopy, key this function on. After the data has been selected for copying, press START PRINT to initiate the hardcopy.

Plot

When the plot menu is selected, the HP-IB output from the HP 54100A is formatted in HP-GL. The HP 54100A/D must be in talk only, and the HP-GL plotter must be in listen only.

The first option on the plot menu is AUTO PEN. When this function is on, a new pen will be selected when a different function is chosen to be plotted—if the plotter has multi-pen capability.

The next PLOT option is PEN SPEED. You may choose FAST or SLOW if your plotter has this feature. SLOW is normally chosen when you are making overheads or transparencies.

When PLOT GRATICLUE is selected, the displayed graticule—including display factors—will go to the plotter. When PLOT DISPLAY is selected, all on-screen waveforms will go to the plotter. When PLOT MEMORY 1 or PLOT MEMORY 2 is selected, whatever information is in that memory will go to the plotter.

If the display menu is in the AVERAGED mode, the output from the HP 54100A/D will cause the plotter to draw a continuous line plot of the displayed waveform. There is one case where this is not true: if you are in the MAGNIFY mode and you have two waveforms on screen that overlap, the HP 54100A/D will put out dot-formatted information to the plotter. If the display menu is in the NORMAL mode, or if you are plotting from one of the memories, the output from the HP 54100A/D is formatted so the plotter will plot the waveform in a pixel format.

Probes

When PROBES is selected, you can input any desired attenuation ratio (from 1 to 1000) for any of the inputs. When a probe attenuation ratio is defined, the actual sensitivity at the input of the HP 54100A/D does not change. The data base used to develop the automatic voltage-measurements or input voltage levels (i.e., peak-to-peak voltage, trigger level, etc.) is actually being changed.

HP-IB

When you want to connect the **54100A/D** digitizing oscilloscope to other **HP-IB** devices, you must select **HP-IB**. This menu allows you to establish the device as an **HP-IB** talker, listener, or both. The **EOI** instruction can be sent by the controller when under program control, or when accomplishing such applications as binary control. When the **HP 54100A/D** is in the talk/listen mode, the **HP-IB** address can be changed by using the entry controls.

Cal & Test

When **CAL & TEST** is selected, you are offered three selections: **CAL** menu, **TEST** menu, and CRT setup. These menus are discussed in the **HP 54100A/D** service manual.