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Basic Techniques of Waveform Measurement Using an Oscilloscope — Part 2

Editor's Note: Part 1 of this series described most of the fundamental controls of an oscilloscope and how to set them up to make basic measurements. Part 2 concludes the series by matching probe to measurement, then setting up a dual-trace oscilloscope to make typical period, pulse rise time, width, propagation delay, and time-delay phase measurements. As in Part 1, Part 2 will base most control references on an HP 1740A Dual Trace Oscilloscope as shown in Figure 1. Most modern dual trace oscilloscopes have the same controls. The controls may operate in a different manner between scopes, but the basic theory is the same.

Signal Source Loading

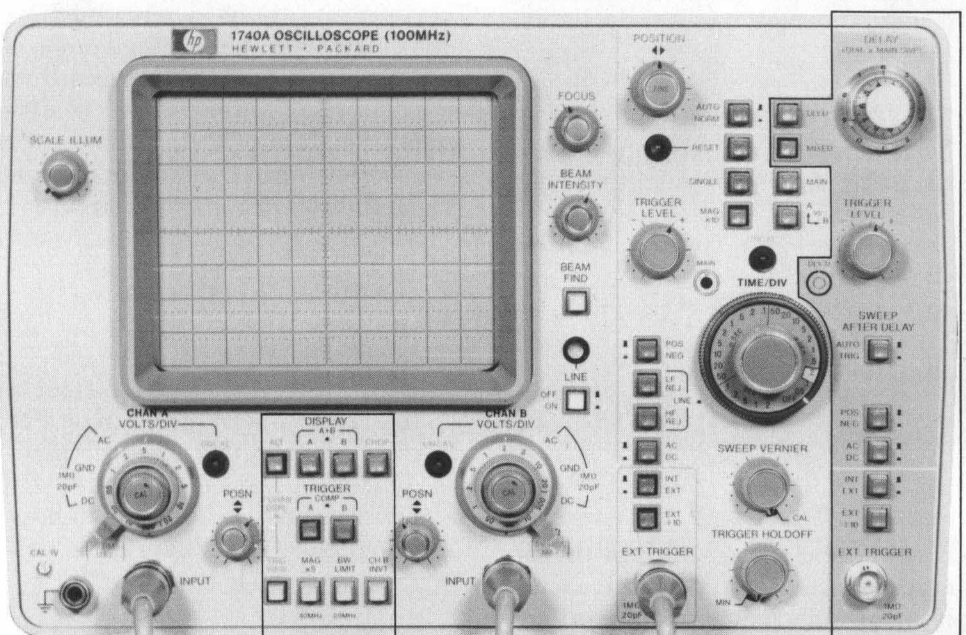
As we stated in Part 1, oscilloscopes are versatile instruments that can measure voltage levels, phase differences, signal presence (or absence), logic highs or lows, frequency response, distortion, and complex waveforms. However, the oscilloscope is a useful measurement tool only if the signal to be measured can be accurately coupled to the scope's input amplifiers. This means measuring a circuit point with a minimum of loading.

Oscilloscope Input Impedance

Typical oscilloscope inputs are 1MΩ shunted by 20pF. Any type of cable you hang on the input increases its capacitance. This capacitance causes measurement errors that are frequency variable. The input capacitance of an oscilloscope requires careful attention to probe selection and point of measurement (source impedance) if these errors are to be minimized. Some problems that become increasingly evident as the input shunt capacitance increases are:

- CW amplitude attenuation
- CW phase shift
- Induced pulse perturbations
- Inaccurate pulse rise time measurements
- Inaccurate propagation delay measurements
- Excessive source loading
- Abnormal circuit operation

At high frequencies, the oscilloscope input behaves like a low pass filter which shunts the high frequency information to ground and significantly reduces the oscilloscope input impedance. For example, at 30 MHz the Xc for 20pF is 265 ohms, while at 100 MHz it drops to 80 ohms. As will be explained later, many measurements, especially phase shift and pulse rise time, are more adversely affected by input capacitance than by resistive loading. Always remember that the capacitive reactance of an oscilloscope input varies as a function of frequency.



Main display and trigger controls. These pushbuttons determine which channel will be displayed, A, B, or both; Alternate or Chop mode, and which input will trigger the sweep.

Delayed sweep and trigger controls. The outer ring of the TIME/DIV control sets the sweep rate of the delayed time base. The DELAY control sets the delay time. Refer to Figure 5.

Figure 1. Front panel controls on an HP 1740A Oscilloscope.

Circuit Test Point Impedance

Knowing the source impedance at the point of measurement is critical. If the source impedance is low, rise time and amplitude measurements are generally no problem. For example, batteries and power supplies have source impedances of milliohms. Signal generators are 25, 50 or 600 ohms. The problem occurs when the source impedance is high. TTL has a source impedance of ~2.5kΩ so even at very low frequencies (single shot), measuring fast transition times is difficult at best.

Basic Probe Considerations

If the scope is being used as a monitoring device, the connection between the signal source and scope is usually a direct 50Ω cable. However, if the scope is being used for signal tracing or circuit analysis, then some type of an isolating device must be used to prevent the scope from loading the circuit and attenuating the signal. Today's modern oscilloscopes use a probe for this isolation.

The frequency of the signal you are measuring and source impedance at the point of measurement influences which probe to use. What you want to measure — rise time or amplitude — is also a weighing factor. In general, there are four types of probes available for common circuit analysis.

— High resistance probes
— Miniature passive divider
— Active (FET)
— Current probes

Any voltage probe will load the circuit you are attempting to measure. If amplitude measurements at low frequencies are all you are interested in, then a passive one-to-one 1MΩ non-attenuating probe may be all you need. A good rule-of-thumb to remember is, "To keep resistive loading errors below 1%, select a probe/scope combination that has an Rin that is at least 100 times greater than the source impedance."

But as frequencies rise, or pulse rise time becomes very fast, scope input capacitance becomes more and more important, forcing use of an miniature passive divider probe to reduce that input capacitance.

And at the highest frequencies, if both amplitude and rise time are important in high source impedance circuits, an active FET input probe should be used.

If the ultimate in rise time is needed, a 50Ω divider probe may be used. However, you must be careful of DC loading. A 50Ω divider probe with an input Xc of 500Ω will attenuate the amplitude of a signal, or upset the bias of the circuit if you probe the wrong point (e.g., collector of a transistor), or burn up the probe if you draw too much current.

A current probe is useful in those certain situations where touching the circuit with any voltage probe at all, even one with the smallest capacitance, changes the circuit's operation. It may be the collector of a transistor where an inductor and capacitance form a tuned circuit.

Probe Rules for Making Amplitude Measurements

1. If you have a choice, select a minimum impedance source. For example: emitter-to-base impedance of a transistor is generally lower than the collector-to-base impedance (this implies a balanced input measurement).

2. Select a probe with the highest possible Zin at the frequency of interest. When measuring pulse amplitude, capacitance is not as important as Rin being high relative to the source impedance. While probe capacitance distorts pulse shape, the flat portion of the pulse top (maximum amplitude) can be used to make an accurate amplitude measurement since it contains low frequency information. Conversely, if the pulse width is small compared to the measurement system rise time, input capacitance can introduce errors since the source cannot fully charge the input capacitance during its on time. This problem becomes worse with increasing source impedance.

3. When source impedance is unknown, the probe with the highest Zin usually yields the greatest accuracy. However, for frequencies above 10 MHz, high probe capacitance can reduce accuracy more than high probe resistance can help.

4. If the source voltage is totally unknown, it is wise to start with a 100:1 divider probe to reduce the possibility of damaging the probe. This will also indicate whether or not there is enough signal available to capitalize on the relatively low capacitance of a 100:1 divider probe. However, in real-life situations, you probably don't have a 100:1 divider probe. If this is the case use your standard 10:1 divider probe.

Probe Rules for Making Rise Time Measurements

1. Always try to probe the lowest impedance point that contains the waveform of interest. For example: emitter-to-base impedance of a transistor is generally lower than the collector-to-base impedance (this implies a balanced input measurement).

2. The fastest input system will generally have the lowest Rin and Cin. (This rule is limited only by the maximum resistive loading that the source can tolerate.)

3. At high frequencies, the 50Ω divider probe (500Ω at 1pf) is the best bet for accurate rise time measurements. However, you must be careful of DC loading. The 500Ω input Xc will attenuate the amplitude of a signal, or upset the bias of the circuit if you probe the wrong point (e.g., collector of a transistor), or burn up the probe if you draw too much current.

How To Get Free Advice on Signal Source Loading and Probes

Application Note 152, titled "Probing In Perspective," is available free of charge from Hewlett-Packard (write to the address at the rear of this issue). AN152 describes in detail all aspects of signal source loading and probes. There are graphs, formulas, and lots of good information — much more than can be briefly described here.

Probe Compensation and Calibrating Your Scope

After you have gone through the rigors of selecting the right probe, you're ready to make some measurements.

Let's begin by making sure your scope is operating properly. You should check its trace alignment astigmatism and focus adjustments, and finally, if required, probe compensation.

Trace alignment may be needed if your scope is operated near a strong magnetic field. To make this adjustment, ground the input and adjust the TRACE ALIGNMENT control for the best trace alignment with a horizontal graticule line.

The best way to adjust astigmatism and focus is with a dot displayed on the screen. Of course this assumes that your scope has X-Y display capabilities. If it doesn't, select the slowest sweep speed possible. This will present a very slow-moving dot which you can use for adjustments. To adjust astigmatism and focus, set the beam intensity to a low level. Position the spot to center screen and then adjust the focus and astigmatism controls for the smallest round dot.

How many of you are guilty of picking up a divider probe, connecting it to your scope and taking measurements without first checking the probe's compensation?

One of the most common "pilot errors" is using an un-compensated probe to make measurements. An un-compensated probe will cause errors in the display which will be undetected unless some kind of a standard waveform is checked. To be safe, you should always check probe compensation:

— at the beginning of each work day
— whenever you re-connect a probe to a different input connector
— whenever you change probes

To compensate the probe, connect it to the calibrator squarewave signal, select DC coupling, and adjust the scope's controls for a stable display. Select the lowest VOLTS/DIV setting possible and center the top portion of the squarewave on the screen. This provides a more precise adjustment method (if your scope is adjusted properly). Adjust the probe until you get a flat-topped square wave with no rounding or overshoot of the signal's corners. Refer to Figure 2.

After probe compensation, check the scope's vertical accuracy against the internal calibrator square wave. With the vernier in the CAL position, set the VOLTS/DIV control to obtain a display that is nearly full scale. The displayed square wave should match the p-p value of the calibrator output. If not, the scope should be recalibrated using the main vertical amplifier gain adjustment (check your scope's service manual for the proper procedure).

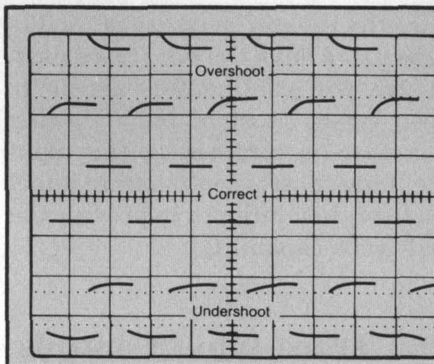


Figure 2. Probe compensation adjustments. Overshoot means the compensating capacitance is too large and the high frequencies are not attenuated enough. Undershoot means the capacitance is too small and the high frequencies are attenuated too much.

With the scope checked and the probe compensated, you are now ready to make some measurements.

Observing Two Signals at the Same Time

There are two techniques oscilloscope manufacturers use to display more than one signal at a time; dual beam and dual trace. The dual beam scope has two independent deflection systems within its CRT; hence two beams are displayed simultaneously. The dual trace scope incorporates electronic switching to alternately connect two input signals to a single deflection system; hence two traces are displayed alternately by a single beam. The switching rate is usually in the 250-500 kHz range.

Most dual beam scopes are used in applications where two events that occur simultaneously would not be displayed correctly on a dual trace scope as it is switching between signals.

Since the greater majority of oscilloscope users have the dual trace models, we will confine this article to those types. Most of the following discussion is confined to the input switching controls on the front panel and how they interact to provide the dual trace capability.

Dual Trace Input Controls

There are many various ways to manipulate two signals through two separate vertical input amplifiers and apply them to a single deflection system CRT. Front panel controls allow you to view the two inputs at what appears to be the same time in either the Alternate or Chop modes. And you can add or subtract the channels so that you can view the algebraic sum or difference between the two signals. Some oscilloscopes allow you to switch a channel to the horizontal axis so you can view Channel A on the "Y" axis plotted against Channel B on the "X" axis. This was discussed in detail in Part 1.

Alternate Mode

In the Alternate mode, the A and B channels are alternately displayed, one channel per sweep. At fast sweep speeds, the alternate traces will appear to be displayed at the same time. However, as the sweep speed is slowed, the traces will begin to flicker showing the alternating pattern.

Chop Mode

In the Chop mode, both A and B channels are alternately displayed by switching between channels at a fixed high-speed rate (250-500 kHz). Even at slow sweep speeds, both channels seem to be displayed at the same time. Some oscilloscopes have the Chop mode connected to the sweep control so the scope automatically switches into the Chop mode at the lower sweep rates. If your oscilloscope does not have this automatic feature, the general rule is to use the Alternate mode for fast sweep speeds and the Chop mode for slow sweep speeds. On some occasions, fast sweeps might require the Chop mode if the signal rep-rate is low, or even single-shot.

Algebraic Sum

When both channels A and B are selected (or added), you're in the A plus B mode. The CRT screen will display the algebraic sum of the two input signals.

One use of the A plus B mode is the dual channel display of single-shot events. Another use is checking balanced or push-pull type amplifiers. Balanced signals should have equal amplitude and be 180 degree out of phase. Since the sum of these signals is zero volts, you would expect to see a straight line. If the signals do not have equal amplitude or are not 180

The 50-Ohm Input Versus

Editor's Note: The following information about 50-ohm and HF inputs is a small segment edited from one of HP's application notes. For more information about probes, signal source loading, rise time measurements, and phase measurement rules, send for Probing in Perspective, Application Note 152. Use the address on the last page of 'Bench Briefs'.

In recent years, there has been a lot of discussion over the merits and demerits of these two types of oscilloscope inputs. The key issue in making a comparison is input impedance versus frequency. The "high impedance" input is only high impedance for frequencies below approximately 1 MHz. Above 1 MHz, the shunt capacitance takes over and there is a fair amount of uncertainty as to what the input impedance actually is. The 50-ohm input starts out with low impedance and has essentially a constant input impedance over the oscilloscope vertical amplifier bandwidth, and virtually eliminates the effects of capacitive loading. These input characteristics dictate the applications for which each input is best suited and the choice of probe to do the job.

Benefits of "High Impedance" Scope Inputs

- Passive probes (refer to Application Note 152) can be used where high input resistance is required. No need for an active probe unless signal levels are small relative to vertical sensitivity.
- Can tolerate much greater input voltages than a 50-ohm input.
- Can be used with high voltage probes.

Problems of "High Impedance" Scope Inputs

- Capacitive loading is much higher than with 50-ohm inputs.
- Input impedance is highly variable with frequency.
- There is a tendency to have confidence that there is no loading because R is high, when in fact capacitive loading is extremely high.
- Does not offer a good termination for fast 50-ohm signal sources. Even when a 50-ohm termination is used to shunt the high input resistance, the VSWR caused by the remaining capacitance is very high.

Benefits of 50-ohm Oscilloscope Input

- Minimizes input capacitance and the problems that it causes.

degrees out of phase, then the signal you see will be a small sine wave.

Algebraic Difference
When both channels A and B are selected and one channel is inverted, you're in the A minus B mode. The CRT screen will display the algebraic difference between the two input signals.

One use of the A minus B mode is to measure the voltage across an ungrounded component without upsetting (or loading the circuit). This is called a balanced or ungrounded input. For example, to measure the voltage across the base-emitter junction of a transistor, set both channels to the same volts-per-division, then connect channel A to the base and channel B to the emitter of the transistor. Connect the ground clips to circuit ground. This allows you to view the small base-emitter voltage on the CRT without upsetting or grounding the circuit.

Trigger Controls for Dual Trace Oscilloscopes

The purpose of the trigger circuit is to produce a stable display on the CRT. This is accomplished by synchronizing the scope's sweep signal with the signal to be viewed. Several controls allow you to select the source, positive or negative mode, and level of the synchronizing trigger signal.

When you're looking at just one signal on a single channel scope, triggering is normally simple and straightforward. However, when dealing with complex digital signals, or RF, or two asynchronous signals, you need all the help you can get in the form of additional trigger controls. You need to be able to tell the scope exactly which signal, and even which portion of the signal, to trigger the sweep on.

As an example, when you're looking at dual trace presentations, you may want to see the correct time relationship between two pulses (i.e., how much a pulse on channel A leads or trails a pulse on channel B). Or, maybe you only want to compare the shape of two signals, but their time separation makes comparison difficult. The ability to select various trigger functions from the front panel enhances the scope's useability. Most modern dual trace oscilloscopes feature controls that allow:

— trigger selection from either input channel (shows time relationship)
— trigger selection from both channels (used for pulse shape comparison)
— delayed triggering (called delayed sweep)
— trigger holdoff
— trigger view (allows you to display the trigger signal)

The "High Impedance" Input

- Presents a better termination for high speed 50-ohm sources. Minimizes pulse shape distortion, VSWR, reflections.
- When an appropriate probe is added to the 50-ohm input, the input impedance can be considerably higher than that of a "high impedance" input scope. The source frequency for which this is true depends on the particular probe selected.

Problems with 50-ohm Input

- Limited maximum input voltage. Typically, the maximum voltage which can be applied directly is less than ±10V.
- Requires a probe to increase the input resistance:
  a) Passive probes can be used to increase the input resistance to 5kΩ if 100X division ratios can be used.
  b) Active probes are generally required to increase the input resistance to the 100kΩ to 10MΩ area. Active probes are expensive but generally offer a more flexible general probing solution.
  c) 50-ohm inputs are not compatible with high voltage probes.
- Does not have ac coupling for signal input.

Summary

To summarize, the 50-ohm input offers superior measurement capability in many situations. However, it cannot be considered to be a general purpose solution because a probe is required to increase the input resistance, and ac coupling is not available without an active probe.

The high impedance oscilloscope input is more general purpose than the 50-ohm input. However, it is generally not as capable for making accurate high speed pulse measurements, phase shift measurements, and high frequency amplitude measurements, even when a probe has been carefully selected.

Most oscilloscope manufacturers offer selectable high impedance and 50-ohm inputs in the same mainframe or plug-in vertical amplifier. The choice of both inputs plus the various probes offered allow the versatility required to make most waveform measurements.

Selectable Triggering

Selectable triggering is a convenience feature. It allows you to look at the display and then select the proper trigger source at the push of a button. Selectable triggering allows you to trigger the display from either one of the input channels.

A typical set-up might be a signal pulse into Channel A and its trigger pulse into Channel B. The correct time relationship between the pulses is obtained when the sweep is triggered by Channel B's signal in the Alternate mode with Internal trigger selected. Figure 3 shows how the time relationship between the two signals changes when the triggering is changed from Channel B to Channel A.

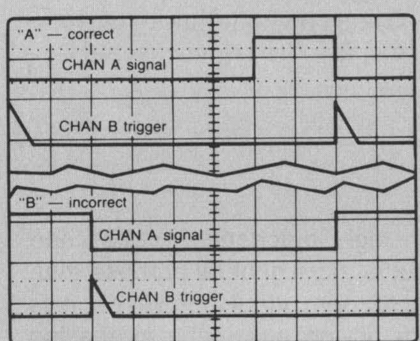


Figure 3. Trigger example showing time relationship between signal connected to CHAN A and its trigger connected to CHAN B.

View 'A' shows the display (sweep) being triggered on the positive-going edge of CHAN B trigger. View 'B' shows the display being triggered on the positive-going edge of CHAN A signal.

**'A' = Internal trigger
Alternate display
Trigger on CHAN B (correct)
Positive slope**

**'B' = Internal trigger
Alternate display
Trigger on CHAN A (incorrect)
Positive slope**

Composite Triggering

Composite triggering is the only way to show two asynchronous signals. It works like this. In the Alternate mode, Channel A sweeps once, then Channel B, etc. The trigger selection controls cause the sweep to be triggered by the displayed signal; therefore when Channel A is being displayed, it is the trigger source and when Channel B is being displayed, it is the trigger source.

A typical set-up might be two asynchronous pulses with nanosecond rise times but separated in time by microseconds. You don't care about the time relationship between the two signals but want to compare the pulse shapes. If a fast sweep is used, only one of the pulses can be displayed at a time.

In this situation, the pulses can be compared by selecting Composite triggering in the Alternate mode. Figure 4 shows how the time relationship between the two pulses is lost when composite triggering is used.

Delayed Triggering

Delayed triggering is directly tied to Delayed Sweep. Delayed Sweep allows easy location and expansion of a small portion of the display, permitting detailed analysis of that portion of the waveform. Delayed Sweep can be triggered after a programmed delay, eliminating any waveform jitter from the expanded display.

How the sweep is triggered in the Delayed Sweep mode will be described in the Delayed Sweep portion of this article. Trying to explain it now may cause some confusion.

Trigger Holdoff

Trigger Holdoff is a variable control used in conjunction with the Trigger Level control. Trigger Holdoff increases the time between sweeps and helps stabilize the display when triggering off complex digital signals. On scopes without this control you would use the Sweep Vernier control as a holdoff, but then your sweep is no longer calibrated.

Trigger View

Some oscilloscopes have a feature called trigger view. Basically it allows you to simultaneously display the external trigger signal on the CRT in addition to the input signals. This can be quite valuable in verifying the time relationship of the trigger signal to the displayed

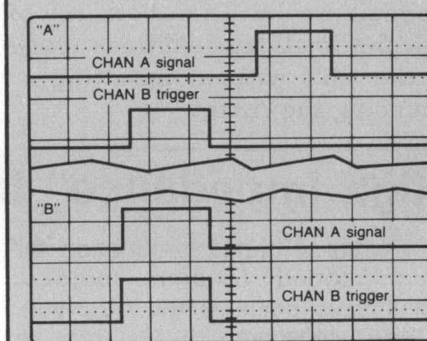


Figure 4. Composite trigger example showing how to compare two asynchronous signals connected to CHAN A and CHAN B.

**"A" = Internal trigger
Alternate display
Trigger on A or B
(correct time relationship)**

**"B" = Internal trigger
Alternate display
Composite Trigger
(incorrect time relationship)**

In Alternate mode and Composite Trigger, each signal is its own trigger source. Effective for signal shape comparison.

waveforms. In Trigger View, the point where the center horizontal graticule line and the trigger waveform intersect is the trigger point. By varying the Trigger Level and Slope controls, you can select any point on the positive or negative edge of the displayed trigger waveform to trigger the sweep circuit, and measure how it affects the input signals.

Bandwidth Limit Control

The bandwidth of some scopes can be reduced to minimize interference in high noise areas such as airports and broadcast stations. On the HP 1740A, the limiter effectively reduces the scope's bandwidth from 100 MHz to 20 MHz.

For example, suppose you are picking up interference from 27 MHz citizens band equipment. If the test signal is less than 20 MHz, use the Bandwidth Limit control to reduce the high frequency interference.

Delayed Sweep

The delayed sweep function found on most high-frequency scopes is probably one of the least understood capabilities of a modern oscilloscope. In basic terms, *the scope with delayed sweep simply has two time bases – main and delayed.*

The controls for the two time bases may be labeled and arranged in various ways and have various capabilities, depending on the manufacturer, but their purpose is basically the same — to expand a selected portion of the displayed signal. To accomplish this, each time base has its own complete set of sweep and trigger controls.

In simple terms, delayed sweep functions as follows. The signal is first triggered by the main sweep at the speed set by the TIME/DIV dial. The delayed sweep speed control is then set to a faster sweep speed than the main sweep (the delayed sweep is triggered after the main). This causes a small part of the main-sweep trace to become intensified or brightened, depending on the setting of the delayed sweep speed control. The slower the setting, the larger the intensified portion becomes. This intensified marker can be moved along the signal by rotating the DELAY control. Then, if we switch the mode to Delayed Sweep, AUTO mode, only the intensified portion will be displayed over the full screen. In other words, we have magnified a portion of the trace.

We can see what really has happened if we consider the signal being displayed by two time bases; first the main sweep followed by the delayed, faster sweep (the intensified portion). What we have done is to set up a delay time from the start of the trace to the beginning of the intensified portion of the trace. When the delayed sweep is automatically triggered, this time is equal to the distance in centimeters from the start of the trace to the intensified trace, multiplied by the sweep time per centimeter (i.e., it's calibrated). The product is the delay time. When we switch to Delayed Sweep (push the DLY'D button on the HP 1740A), we start the main time base with an input trigger, but we do not use it to display the signal. Instead, we use it as a clock that simply marks time until the delay period is over. Then the delayed time base sweeps, displaying the signal. Figure 5 shows how the delay system works in the AUTO mode.

There are two ways to cause the delayed sweep to be initiated after the delay time. The first way (discussed above), is called the AUTO mode. The delayed sweep automatically starts at the end of the delay period with no trigger signal or other external command needed. In the

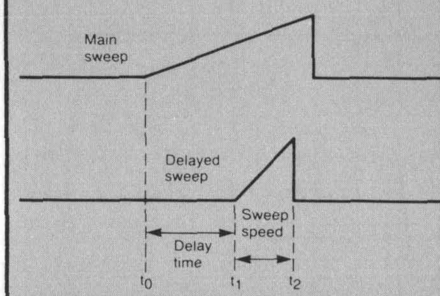


Figure 5. Main sweep and delayed sweep sawtooth waveforms. Delay time (t_0-t_1) is set by DELAY control, and sweep speed (t_1-t_2) is set by DLY'D TIME/DIV control. t_1-t_2 is the intensified part of the waveform. When SWEEP AFTER DELAY control is set to AUTO, sweep is triggered automatically at t_1.

other mode, the delayed sweep is armed at the end of the delay period and requires a trigger signal (either internal or external) to start the delayed sweep. Since there is no way to know when the trigger signal will occur, the delay time is uncalibrated.

Each of these methods has its own advantages. In the AUTO mode, all of the accumulative rate jitter that has occurred since the start of the delay time is displayed on the delayed sweep. If, on the other hand, rate jitter is not desired in the display and a clear picture is needed, then the armed mode should be used. In this mode the delayed sweep is retriggered after the delay time. A new time reference is established, eliminating all of the jitter that has occurred previously, providing a clear picture for accurate measurements on the expanded pulse.

How To Use Delayed Sweep

The delay controls on your oscilloscope usually will be highlighted by color or surrounded by lines on the front panel. The HP 1740A sweep and delay controls are easy to find

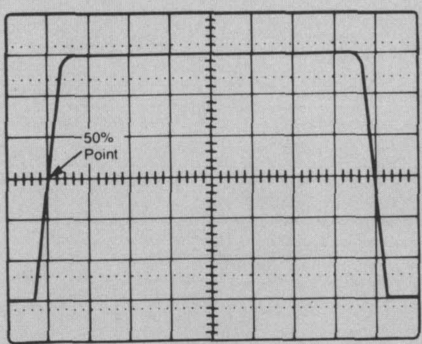


Figure 6. Pulse width measurement using the delayed sweep controls.

DLY'D TIME/DIV dial = 50μs
Full scale accuracy = 3% (of 500μs)
7 × 50μs = 350μs
0.03 × 500μs = 15μs accuracy
pulse width = 350μs ± 15μs

because of the dark grey background. But no matter which scope you have, look for the word DELAY in the control nomenclature.

Suppose you want to measure the width and rise time of the 5th pulse in a pulse train. If you try and expand the signal with the main sweep control, the pulse moves off screen. You could use the horizontal magnifier to expand the sweep time and perform the measurements as described in Part 1. However, you want more accuracy than that method allows. The point about accuracy to remember is that time interval measurements are LEAST accurate using the X10 magnifier, BETTER using direct delayed sweep, and BEST using differential delayed sweep.

NOTE

If you don't have some type of pulse generator for the following experiments, try using the amplitude calibrator output on your scope.

The first step in measuring pulse width and rise time is to adjust the vertical controls so that pulse height is six divisions (i.e., enough height to easily see the 50% point).

Then move the DLY'D TIME/DIV control out of its OFF position. When this is done, a portion of the waveform should become intensified. This intensified marker is used to locate the portion of the waveform to be expanded. Adjust the Delayed Sweep Speed control so the marker is a little wider than the pulse to be measured. Set the SWEEP AFTER DELAY control to the AUTO position.

Next move the intensified marker along the waveform with the DELAY control until it is over the pulse to be measured. Use the horizontal position control to center the intensified pulse. Expand the intensified portion to the full width of the screen by selecting Delayed Sweep (on the HP 1740 push the DLY'D pushbutton). Slightly re-just the DELAY control to make the leading edge 50% point intersect a convenient vertical graticule line. Count the number of divisions between the 50% points and multiply that times the Delayed Sweep Speed control setting. Figure 6 shows an example pulse width measurement using the delay controls.

Differential Delayed Sweep

A more accurate time interval measurement can usually be made using the Differential Delayed Sweep method. To make a differential measurement, select Main Sweep and adjust the TIME/DIV control to expand the sweep speed to make the pulse you want to measure as wide as possible. If the time interval of the pulse is greater than one-half division on the screen, the differential method will be more accurate than the delayed sweep method.

Switch the Delayed TIME/DIV control out of its OFF position. When this is done you should see the intensified marker as in the previous measurement. Adjust the Delayed TIME/DIV control so the marker is a little wider than the pulse to be measured.

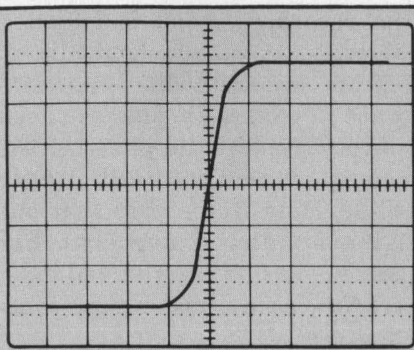
Next move the intensified marker along the waveform with the DELAY control until it is over the pulse to be measured. Expand the intensified portion to the full width of the screen by selecting Delayed Sweep (on the HP 1740A push the DLY'D button).

Adjust the DELAY control to position the 50% amplitude point of the leading edge over the center vertical graticule line. Read and record the DELAY dial setting. Note that some oscilloscopes use an LED readout for this purpose.

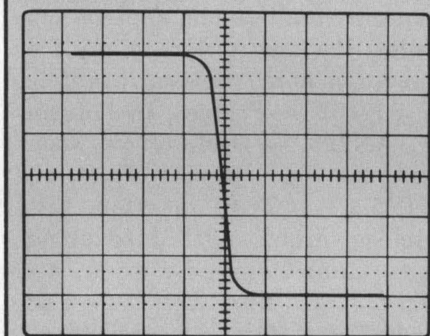
Re-adjust the DELAY control to position the trailing edge 50% amplitude point over the center vertical graticule line. Read and record the DELAY dial setting. The pulse width is the difference between the two readings times the main sweep TIME/DIV setting. Figure 7 shows an example pulse width measurement using the differential method.

A Note on Time Interval Measurement Accuracy

The absolute accuracy of the Differential Delayed Sweep method relies on the principal that the time interval of the pulse to be measured is greater than 1cm of the main sweep. In this case the accuracy is X% of the reading + Y% of full scale. The Y% of full scale will totally mask out the accuracy of the measurement. For the HP 1740A, the accuracy is ±0.5% of the reading ±0.1% of full scale. Therefore, the accuracy of a 10cm (full scale) measurement is ±0.6%. However, as the reading is reduced to smaller and smaller parts of the main display, the accuracy decreases (+ error increases). At one division of main sweep the error is ±1.5% and at 1/2 division of main sweep the error is now about equal to that of the direct-from-CRT measurement.



Use DELAY control to center leading edge of pulse over center horizontal graticule.



Use DELAY control to center trailing edge of pulse over center horizontal graticule.

Figure 7. Pulse width measurement using the differential delayed sweep method. DELAY control is used to center the leading edge and then trailing edge of pulse over center horizontal graticule. Pulse width is difference between the two readings times the main sweep TIME/DIV dial setting.

TIME/DIV dial = 0.2ms

DELAY dial reading = 7.46
−5.70
1.76

1.76 × 0.2ms = 352μs
Accuracy is ±0.5% for the DELAY dial and ±0.1% of full scale

0.005 × 352 = 176μs (dial)
0.001 × 2ms = 2μs (full scale)
pulse width = 352μs ± 4μs

How To Use The Delayed Trigger Method To Eliminate Waveform Jitter

Often, when you expand a signal, waveform jitter becomes more pronounced. This jitter makes it difficult to accurately measure the pulse's rise time or even its width. The scopes we have been discussing usually provide a feature to eliminate this unwanted jitter — it's called Delayed Trigger.

Delayed Trigger controls are much the same as those that control the main sweep. There is a pushbutton that selects either AUTO or TRIG mode (which is similiar to the AUTO-NORM mode). When in the TRIG mode, other controls are enabled that allow you to select the delayed sweep to be triggered "internally" or "externally," divide the external trigger amplitude by 10, AC or DC couple the trigger signal, and adjust the Slope and Trigger Level to start the delayed sweep at any point on the waveform.

Let's use the input signal as the trigger source to see how the delayed sweep is triggered. Refer to Figure 8.

Each input pulse produces a trigger pulse. The main sweep is started by the first trigger pulse. The second trigger pulse doesn't do anything because it's blanked by the delay time set by the DELAY control. The delayed sweep is "armed" at t1 when the delay time ends. The next trigger pulse to arrive after the delay time ends starts the delayed sweep sawtooth which deflects the electron beam across the CRT. Since there is no way to know when the trigger signal will occur, the delay time is uncalibrated.

In effect, you have eliminated all interference by triggering the sweep on only that portion of the waveform you have selected to examine.

Mixed Sweep Mode

There is another mode of delayed-sweep operation found on some oscilloscopes, called mixed sweep. In this mode the main sweep is displayed on the screen for the amount of delayed time desired. Then the sweep increases in speed part way across the screen and finishes up the trace at the faster delayed-sweep rate. The transition point between sweeps is positioned with the DELAY control after the MIXED button is pressed.

Mixed Sweep is convenient for "peeling off" pulses one by one from a long train and examining them individually.

Using the Dual Trace Scope to Read Propagation Delay

Propagation delay in reference to digital circuits is the amount of time it takes for a change at the circuit's input to be noticed at its output. For example, when the input voltage to an AND gate changes from a low to a high, the output will respond at some later finite time. You can use your scope to quickly and easily measure this time and check it against the device's specification.

It would be difficult to specify a test circuit and all the clips and probes required to complete such a test. By now you should already have your scope set-up, probes compensated, and enough background information to complete your own experiment. The necessary scope control settings are as follows:

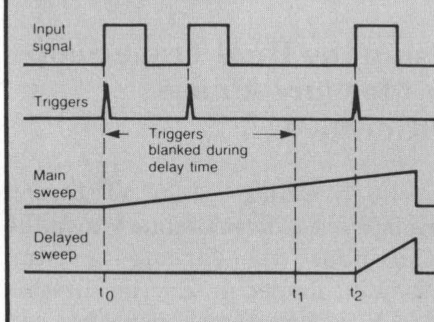


Figure 8. Delayed sweep delayed trigger example. The main sweep is started by the first trigger pulse at t_0. The second trigger pulse "arms" the delayed sweep at t_1. The next trigger pulse to arrive after the delay time ends starts the delayed sweep sawtooth at t_2. The time between t_1 and t_2 is unknown which makes the delayed sweep uncalibrated.

— Always use identical probes (a 50 ohm passive probe is useful in high impedance circuits where maximum rise time accuracy is necessary)
— Set the input coupling switch to AC
— Connect circuit's input signal to CHAN A
— Connect circuit's output signal to CHAN B
— Alternate display
— Internal trigger on CHAN A in AUTO mode
— Adjust vertical controls so signals are centered and approximately six divisions high
— Adjust the sweep control so the pulses look like those used for making rise time measurements

You should see the leading edges of two pulses separated by a measurable distance. Measure the propagation delay at the 50% points (center horizontal graticule line) by counting the number of divisions between the two pulses and multiplying that times the setting of the sweep speed control. If you measure two divisions and the TIME/DIV dial is set at 5 ns, the propagation delay is 10 ns. For greater resolution, use the x10 magnifier or delayed sweep.

Using the Dual Trace Scope to Measure Phase Difference

In the previous issue of Bench Briefs, Part 1 discussed how to make crude phase measurements using Lissajous patterns. Earlier in this article, it was shown how you can use the Algebraic Sum of two channels to make sure the outputs of a push-pull amplifier are 180 degrees out of phase — another type of phase measurement.

A more accurate method of phase measurement uses the time-delay principle. This is the same type measurement discussed previously under the heading, "How To Measure Propagation Delay." It involves looking at two signals simultaneously and observing any phase difference between the two.

One example of using the time-delay method to make accurate phase measurements is checking the output of a stereo tape player. The head alignment, or azimuth, must be precisely set for best high frequency and zero phase response. The necessary scope control settings are as follows:

— Always use identical probes
— Set the input coupling switch to AC
— Connect stereo tape unit's left output to CHAN A
— Connect stereo tape unit's right output to CHAN B
— Select Chop display (for low frequency test signal)
— Internal trigger on CHAN A in AUTO mode
— Adjust vertical controls so signals are centered and approximately six divisions high
— Select CHAN A display only
— Adjust the sweep control so that one cycle covers exactly eight horizontal divisions. Eight divisions divided into 360 degrees equals 45 degrees-per-division.
— Switch back to Chop display

If the recorder's head is adjusted properly, both signals should lie on top of one another which indicates they are in phase, Varying the head azimuth will shift the phase of the signals which you can read directly off the display (remember that one division equals 45 degrees). For greater resolution use the x10 magnifier. Now each division represents 4.5 degrees.

This concludes the Basic Oscilloscope articles. For more information on specific oscilloscope applications, Hewlett-Packard offfers many free application notes. Several examples are: AN152 — Probing in Perspective, AN223 — Oscilloscope Measurements in Digital Systems, AN185-2 — Transmission Line Matching and Length Measurings Using Dual-Delayed Sweep, and AN262 — Eliminating Time Base Errors from Oscilloscope Measurements. Many HP engineers and customers have collaborated on these notes to pass their applications research and experience on to you. Some notes are tutorial in nature, while others describe very specific "how to" procedures. All HP application notes are designed to help you obtain maximum use from your Hewlett-Packard equipment. Please contact your local HP office for more information.

Editor's Note: Parts 1 and 2 of this oscilloscope article have been combined into a training note and published under HP Part No. 5953-3873. For free reprints, please write to Steve Sinn, MARCOM Manager, Hewlett-Packard, PO Box 2197, Colorado Springs, CO 80901.

Hewlett-Packard continually offers training to customers on a worldwide basis to help keep service skills current with HP's extensive product line. Seminars are provided throughout Europe and the United States in an effort to bring our training facilities closer to your area. For registration information please refer to page 20 of *Bench Briefs* and contact your local Hewlett-Packard Office.

8640 AM/FM Signal Generators 8660 Synthesized Signal Generators 435/436 Power Meters or 8672A Synthesized Signal Generator August 25-29, Palo Alto, Ca

COURSE CONTENT

LECTURE

I. Introduction
II. Features and Model Options
III. Front Panel Features
  A. Video Tape
  B. Demonstration
IV. Theory
  A. Block Diagram
  B. Assembly Locations
  C. Schematic

LAB

I. Adjustments
II. Performance Tests
III. Troubleshooting

OPTIONAL
Last day you can choose Lecture/lab between power meters or synthesized signal generators.

PREREQUISITES
Basic knowledge of digital logic circuits and general knowledge of electronics including operational amplifiers and phase lock circuits.

141T, 8552A/B, 8553B, 8554B, 8555A Spectrum Analyzers August 6-8, Santa Rosa, Ca Seminar No. 4544-6932

COURSE CONTENT

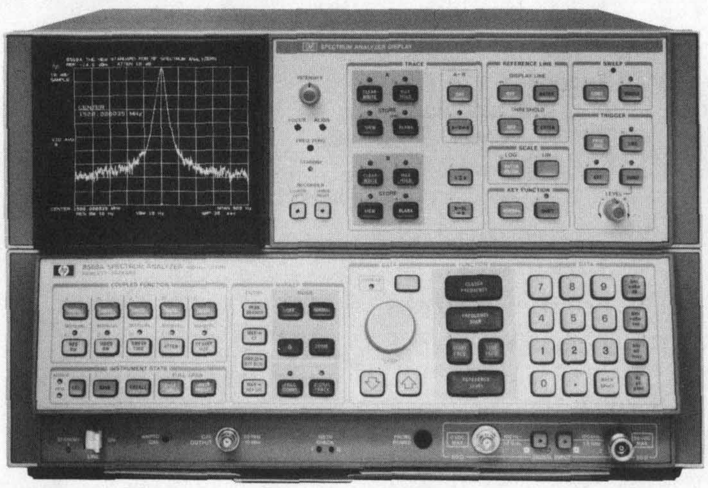
LECTURE

I. Block Diagram Related to Front Panel Controls
II. Overall Block Diagram and System Description
III. Detailed Block Diagram
IV. Circuit Descriptions
  A. Input Circuits
  B. First, Second and Third Mixers and IF Stages
  C. YIG Drive Circuits
  D. 50 MHz Amplifier
  E. Marker Generator
  F. Phase-Lock Circuits
V. Troubleshooting Techniques ("Bugged" Instruments)
VI. Repair Cautions and Mechanical Tuning Adjustments

LAB

I. Front Panel Familiarization
II. Change First Mixer
III. Set Up YIG Frequency
IV. Normal Calibration

8566A/8568A
Programmable Spectrum Analyzers
Same Seminar Given 3 Times,
Contact Factory Coordinator
For Preferred Week
Sept. 15-19
Sept. 22-26
Sept. 29 — Oct. 3
Santa Rosa, Ca
Seminar No. 4544-6934



COURSE CONTENT

LECTURE

I. RF Sections
   A. Block Diagram
   B. Pilot Third Local Oscillator
   C. Derivation of Center Frequency Equation
   D. System Sweep Control
   E. RF Module
   F. Synthesized LO
   G. YTO Loop

II. IF Sections
   A. A3 Digital Storage
   B. Signature Analysis
   C. Diagnostic Functions
   D. System Troubleshooting

LAB

I. Front Panel Familiarization

II. Calculator-Controlled System Test

III. Normal Calibration

PREREQUISITES
Previous experience servicing spectrum analyzers, digital circuit knowledge, and some knowledge of microprocessors is helpful. Knowledge of bus structure as used in computers and digital equipment is very important in understanding the HP 8566A and 8568A Spectrum Analyzers.

DTS-70 PCB Test System
Service Seminar
November 17-21
Loveland, Colorado

COURSE CONTENT

LECTURE AND LAB

I. Product Familiarization

II. RTE Review
   A. FMGR
   B. RTE-IV B
   C. Editor
   D. Disc Organization
   E. Utilities

III. Testaid/Fastrace Overview

IV. System Troubleshooting
   A. System Functional Test Assy.
   B. DTS-70 Hardware
      1. Digital Test Unit
      2. Driver/Comparator Cards
      3. Power Supplies
      4. HP-IB Subsystem
   C. Preventative Maintenance
   D. System Functional Test

V. RTE Installation/Reconfiguration

VI. 91075C DTS-70 Software Installation

VII. Program Development

VIII. Virtual Memory System Overview

IX. System Transfer Files

X. Board Testing With Standard Files

XI. Hardware/Software Integration

XII. Warranty/Support Policies

PREREQUISITES
Some formal HP-1000 Disc-Based RTE course, preferably RTE-IV or RTE-IV B.

3060 Circuit Test System Service Seminar
August 18-29
October 20-31
Loveland, Colorado

COURSE CONTENT

LECTURE AND LAB

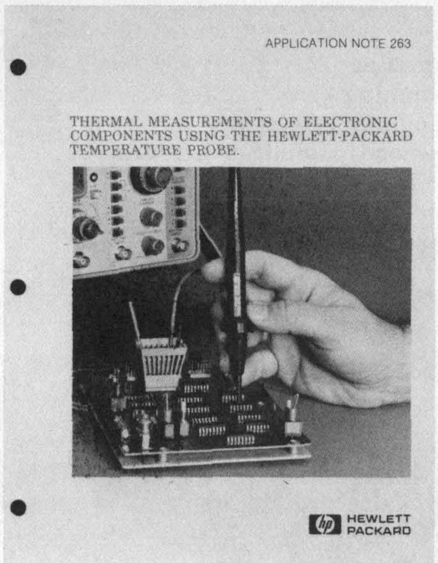
I. Introduction to Course, System, and BTL.
II. Review of HPL and HP-IB
III. System Control Panel
IV. System Multiplexing
V. 3496A Scanner Troubleshooting
VI. 11353A/11453A Diagnostic Fixtures
VII. 34196A Scanner Power Supply
VIII. 11253A System Power Module
IX. Analog In-Circuit Testing
X. Transfer Testing
XI. 3253A Analog Stimulus/Response Unit Theory of Operation
XII. 3253A Analog Stimulus/Response Unit Calibration
XIII. 3253A Analog Stimulus/Response Unit Hardware Familiarization
XIV. 3253A Analog Stimulus/Response Unit Troubleshooting Exercises
XV. 3453A Digital Stimulus/Response Unit Programming
XVI. Static Pattern Testing
XVII D.U.T. Power Supplies
XVIII. D.U.T. Clock
XIX. 3453A Digital Stimulus/Response Unit Troubleshooting
XX. System Troubleshooting

PREREQUISITES
1. 9825A HPL Programming
2. 9885M HPL Programming
3. Knowledge of HP Logic Symbology
4. Knowledge of Operational Amplifier Circuits
5. Knowledge of Basic Logic Circuits

All the above prerequisites are mandatory.

New Application Notes

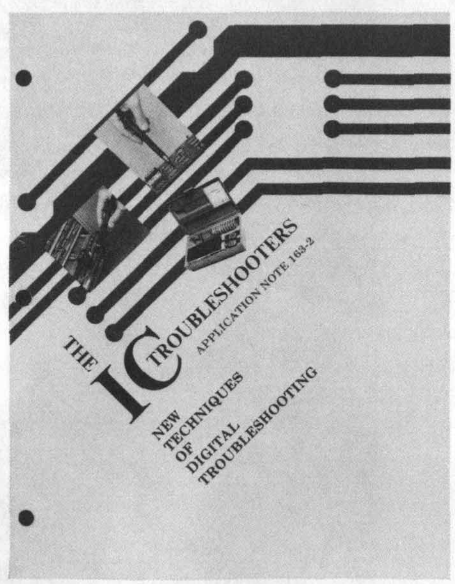
Thermal Measurements of Electronic Components Using The Hewlett-Packard Temperature Probe (Application Note 263). The HP 10023A Temperature Probe provides fast, accurate temperature measurements needed in a wide variety of thermal design, diagnostic, and testing applications. Surface temperature measurements are read directly in degrees Celsius on any general purpose digital multimeter (DMM) having an input impedance of >10 megohms.



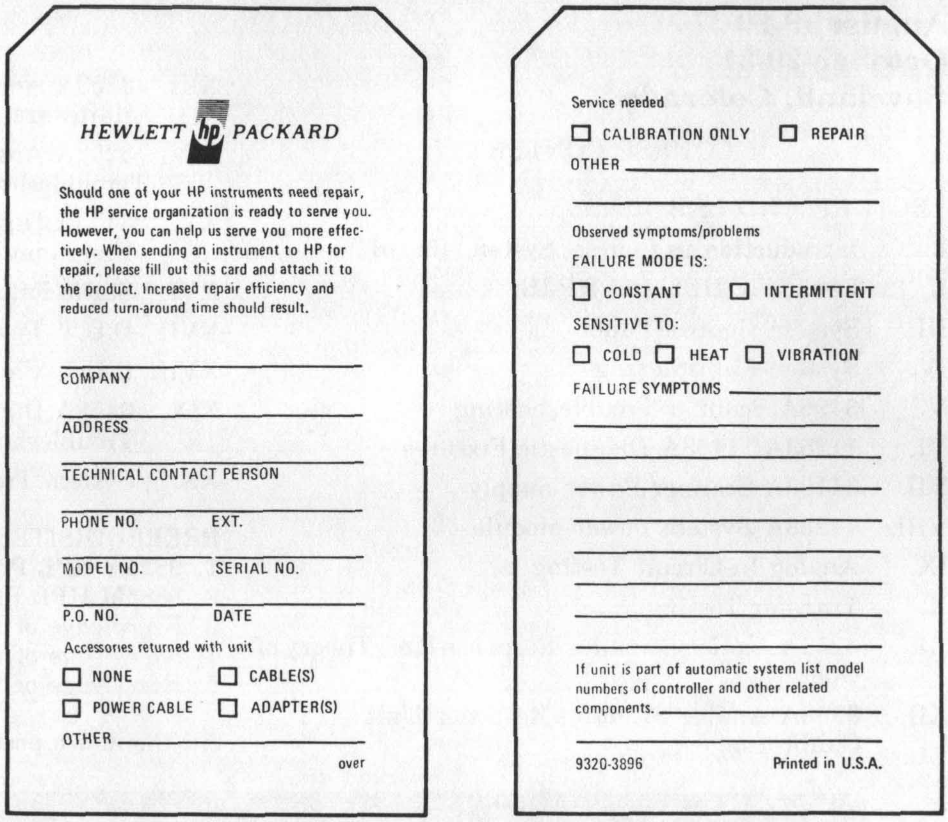
The probe is a self-contained temperature-to-voltage transducer. Integrated circuits permit the entire electronics assembly, including the battery, to be packaged in the probe barrel. A standard dual banana plug output connector provides universal readout through most digital voltmeters including the built-in DMMs on HP's Option 034/035 1700 series oscilloscopes. To make a surface measurement, touch the probe tip to the component of interest, press the readout microswitch, and wait for the voltmeter readout to stabilize.

Applications include spot-checking PC board component temperatures in suspect circuits, and evaluating heatsink performance for power-semiconductor devices by measuring case-to-heat-sink thermal drop. You can also obtain a good estimate of the junction temperature of a transistor by measuring the transistor case temperature.

The IC Troubleshooters (Application Note 163-2) describes new techniques of digital troubleshooting. HP's hand-held IC Troubleshooters are a group of simple digital test and measurement tools. They are intended to be used at the node and gate level to precisely locate some very hard-to-find faults such as Vcc-to-ground shorts, solder bridges, and stuck buses.



Blue Tag Repair


HEWLETT hp PACKARD

Should one of your HP instruments need repair, the HP service organization is ready to serve you. However, you can help us serve you more effectively. When sending an instrument to HP for repair, please fill out this card and attach it to the product. Increased repair efficiency and reduced turn-around time should result.

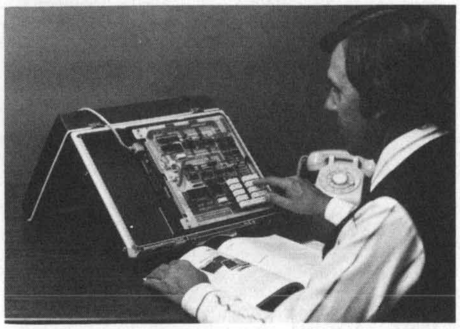
COMPANY
ADDRESS
TECHNICAL CONTACT PERSON
PHONE NO. EXT.
MODEL NO. SERIAL NO.
P.O. NO. DATE
Accessories returned with unit
☐ NONE ☐ CABLE(S)
☐ POWER CABLE ☐ ADAPTER(S)
OTHER
over

Service needed
☐ CALIBRATION ONLY ☐ REPAIR
OTHER
Observed symptoms/problems
FAILURE MODE IS:
☐ CONSTANT ☐ INTERMITTENT
SENSITIVE TO:
☐ COLD ☐ HEAT ☐ VIBRATION
FAILURE SYMPTOMS
If unit is part of automatic system list model numbers of controller and other related components.
9320-3896 Printed in U.S.A.

Should one of your HP instruments need repair, the HP Instrument Repair Organization is always ready to serve you. Toward this end, we are promoting the use of the "Blue Repair Tag."

These tags are available from your HP representative, and are filled out by you and attached to any instrument being sent to HP for repair. Increased repair efficiency and reduced turnaround time are our goals. Please help us help you. Ask your HP representative for some of these cards today.

Attention 5036A Microprocessor Lab Owners



There has been a lot of inquiries about replacing the 5036A Microprocessor Lab's "suitcase". Due to an oversight, the suitcase part number was not included in the Service Manual.

The HP part number is 1540-0537.

If part of the case becomes damaged and must be replaced, it is necessary to purchase the complete case. This is because the cases come pre-matched, lid-to-bottom, from the supplier.

In order to mount the power supply assembly, it is necessary for the customer to drill the mounting holes in the new case to ensure proper alignment. All mounting hardware not included with the new case should be obtained from the replaced case. In case of loss, the hardware part numbers are:

— Plastic Insert Case, HP Part Number 05036-40002.
— Two Metal Clamps, HP Part Number 05036-00003.
— Four Screw Washer Assemblies.
— Three Screw Snap Assemblies.
— Two Handle Screws.

The proper procedure for replacing the lab in the suitcase is:

1. Open the case and fold the circuit board until access is gained to the two screws holding the plastic insert case to the power supply.
2. Remove these two screws completely and retain for replacement.
3. Loosen the four screws at the ends of the case several turns.
4. Lift the plastic insert case free of the main case. Do not unsolder the pc board from the power supply.

For more information order service note 5036A-1 using the form at the rear of *Bench Briefs*.

In general, these tools are used as test sets by field-servicemen on-site, as tools on the production line, and especially around PC board testers as accessories.

It takes circuit knowledge and skill to use simple tools like the IC Troubleshooters in digital troubleshooting. This applications note should enhance your ability to use probes, pulsers, current tracers, logic clips and logic comparators.

Another Puzzle

There is a small repair center that has five different nationality technicians who sit at five differently colored benches and work on five different products. Each technician uses a different method of transportation to get to work and prefers a different choice of drink.

1. The Englishman works at the red bench.
2. The Spaniard walks to work.
3. Coffee is drunk at the green bench.
4. The German drinks tea.
5. The green bench is immediately to the right of the black bench.
6. The technician that works on signal generators rides a bicycle to work.
7. DVM's are worked on at the yellow bench.
8. Milk is drunk at the middle bench.
9. The Frenchman works at the first bench.
10. The technician who works on scopes sits next to the technician that drives a car to work.
11. DVM's are worked on at the bench next to the bench where the technician rides a motorcycle to work.
12. The counter technician drinks orange juice.
13. The Japanese works on distortion analyzers.
14. The Frenchman sits at the bench next to the blue bench.

Answer these questions:
Who drinks water?
Who rides the bus to work?

supplement to BENCH BRIEFS SERVICE NOTE INDEX

Need Any Service Notes?

Here's the latest listing of Service Notes available for Hewlett-Packard products. To obtain information for instruments you own, remove the order form and mail it to the HP distribution center nearest you.

180A/AR OSCILLOSCOPE
180A/AR-12. All Serials. Procedure to reuse the old light mask when replacing a CRT.

180C/D OSCILLOSCOPE
180C/D-4. 180C — serials 1935A02765 and below; 180D — serials 1921A03710 and below. Procedure to reuse the old light mask when replacing a CRT.

180T/TR OSCILLOSCOPE
180T/TR-2. Serials 1944A01140 and below. Procedure to reuse the old light mask when replacing a CRT.

197A OSCILLOSCOPE CAMERA
197A-8. All serials. Modification to improve solenoid reliability.

400E/EL AC VOLTMETER
400E/EL-11. Serials 536-04253 and below. Recommended input attenuator replacement.

1114A TESTMOBILE
1114A-1. All serials. Recommended swivel caster replacements.

1302A-1304A DISPLAY
1302A-2. Serials 1643A and below. Modification to improve reliability.
1304A-2. Serials 1715A and below. Modification to improve reliability.

1311B DISPLAY
1311B-1-S. All serials. Supersedes 1311B-1. X-ray emission hazard when servicing HV power supply board.

1332A DISPLAY
1332A-9A. Serials 1616A08200 through 1945A11350. Improved focus for large Z axis drive level variations.

1336A DISPLAY
1336A-1A. All serials. Instructions for removing and returning a 1336A CRT to HP for warranty credit, and for installing a replacement CRT.

1350A GRAPHICS TRANSLATOR
1350A-6. All 1350A's with 52102A RS-232C (Option 001). Modification to improve performance.

1600A LOGIC STATE ANALYZER
1600A-3. Serials 1714A05004 and below. Modification to prevent incorrect data storage into "B" table.

1610A/B LOGIC ANALYZER
1610A-10. Serials 1940A-01854. Modification to add more "beeps" during 1610A power-up.
1610B-1. Serials 1940A-00446 and below. Modification to add more "beeps" during 1610B power-up.

1640A LOGIC ANALYZER
1640A-4A. Serials 1845A-01199 and below. Modification to eliminate bright spot on CRT after turn off.
1640A-8. Serials 1845A01123 and below. Preferred crystal replacement for increased clock accuracy.

1715A OSCILLOSCOPE
1715A-5. Serials 1823A and below. Modification to improve vertical output amplifier (A5U2) reliability.

1722B OSCILLOSCOPE
1722B-2. Serials 1823A and below. Modification to improve vertical output amplifier (A5U2) reliability.

1725A OSCILLOSCOPE
1725A-4. Serials 1823A and below. Modification to improve vertical output amplifier (A5U2) reliability.

1741A OSCILLOSCOPES
1741A-9. All serials. Cross-reference of interchangeable low voltage power supply printed circuit assemblies.

2804A QUARTZ THERMOMETER
2804A-3. All serials. Instructions for field installation of option 010 (HP-IB).

3045A SPECTRUM ANALYZER
3045A-1. All serials. Instructions on how to sequence commands to prevent sweep problems.

3311 FUNCTION GENERATOR
3311A-2. Serials 1224A00100 to 1224A16201 (approximately). Modification to prevent 20 MHz oscillation when amplitude control is below half-way.

3312A FUNCTION GENERATOR
3312A-3. Serials 1432A05505 and below. Preferred replacement for OP AMP A2-U104/U106.

3325A SYNTHESIZER/ FUNCTION GENERATOR
3325A-3. Serials 1748A01300 and below. Modification to improve status byte operation.
3325A-5. Serials 1748A02350 and below. Modification to improve square wave phase control.
3325A-6. Serials 1748A02300 to 1748A02550. A6 board electrolytic capacitors may be installed incorrectly.

3330A/B SYNTHESIZER
3330A/B-11. Serials 1313A02622 and below. Modification to improve power supply reliability.
3330A/B-12. Serials 1313A02578 and below. Procedure for deleting relay and improving performance.
3330A/B-13. All serials. Notification that the 03330-69579 (A6A Option 004 Digital Input Assembly) will no longer be available on a factory rebuilt program.
3330A/B-14. Serials 1313A01918 and below. Correct termination of HP-IB lines on A34 assembly.

3336A/B/C SYNTHESIZER/LEVEL GENERATOR
3336A/B/C-1. 3336A serials 1930A0018 and below; 3336B serials 1931A00116 and below; 3336C serials 1932A00126 and below. Modification to replace flat cables and connectors with new improved type.

3455A DIGITAL VOLTMETER
3455A-17. All serials. Modifications to reduce AC drift.

3467A LOGGING MULTIMETER
3467A-2. Serials 1821A00270 and below. Modification to prevent spurious blanking of the LED readout.

3551A TRANSMISSION TEST SET
3551A-7A. Serials 1550A01705 and below. Recommended replacement power supply assembly and power transformer.
3551A-11A. Serials 1550A05665 and below. Preferred WECO 310 jack replacements.

3570A NETWORK ANALYZER
3570A-8. Serials 1331A01455 and below. Modification to prevent erroneous phase readings.
3570A-9. Serials 1331A01331 and below. Modification to improve performance during HP-IB operation.

3571A TRACKING SPECTRUM ANALYZER
3571A-2. Serials to 1435A0680. Two modifications to eliminate HP-IB problems.
3571A-3. Serials to 1435A00560. Eliminating 40 MHz oscillations from the +5 VDC supply.
3571A-4. Serials 1435A00620 and below. Preventing oscillations on the A6-U2 mixer lower harmonic and intermodular distortion.

3582A SPECTRUM ANALYZER
3582A-3. All serials. Procedure for troubleshooting the A8 RAM assembly.
3582A-4A. All serials. How to service the Option 001: high transfer function accuracy.
3582A-5. All serials. How to handle digital filters to prevent static damage.
3582A-6. Serials 1747A00100 to 1809A1096 appx. Software update to the ROM assembly.

3585A SPECTRUM ANALYZER
3585A-2. Serials 1750A00466 to 1750A00540. Procedure on changing A1 board relays from 12V DC to 5V DC.

3711A IF/BB RECEIVER
3711A-1. All serials. Preferred replacement for NPN transistor (1854-0071).

3712A IF/BB RECEIVER
3712A-1. Serials 00101 to 00121. Preferred replacement for thin-film amplifier A22E1.
3712A-2. Serials 00101 to 00121. Preferred replacement sub-assembly with a A30K1 relay.
3712A-3. All serials. Preferred replacement for NPN transistor (1854-0071).

3730A IF/BB RECEIVER
3730A-5. All serials. Preferred replacement for NPN transistor (1854-0071).

3737A IF/BB RECEIVER
3737A-2. All serials. Preferred replacement for NPN transistor (1854-0071).

3738A IF/BB RECEIVER
3738A-3. All serials. Preferred replacement for NPN transistor (1854-0071).

3739A IF/BB RECEIVER
3739A-3. All serials. Preferred replacement for NPN transistor (1854-0071).

3744A IF/BB RECEIVER
3744A-1. All serials. Preferred replacement for NPN transistor (1854-0071)

3745A/B SELECTIVE LEVEL MEASURING SET
3745A/B-22B. 3745A serials between 1815U and 1916U; 3745B serials between 1815U and 1908U. Preferred replacement of ROM4 on A109 CPU Memory Assembly.
3745A/B-33. Serials 1812U and below. Preferred replacement of assemblies A108/A109.
3745A/B-34. Serials 1930U and below. Modifications to prevent erroneous level measurements using A301 notch filter.
3745A/B-35. All serials. Instruction on how to select CCITT plans during remote HP-IB operation.
3745A/B-36. Serials 1930U and below. Modification to prevent erroneous level measurements using 2.5kHz filter.

3747A/B SELECTIVE LEVEL MEASURING SET

3747A/B-4A. 3747A serials 1930U and below; 3747B serials 1924U and below. Preferred replacement of ROM4 on A109 CPU Memory Assembly.
3747A/B-13. 3747A serials 1950U and below; 3747B serials 1924U and below. Modification to prevent erroneous level measurements using A301 notch filter.
3747A/B-14. 3747A all serials. Instructions on how to select CCITT plans during remote HP-IB operation.
3747A/B-15. 3747A serials 1950U and below; 3747B serials 1924U and below. Modification to prevent erroneous level measurements using 2.5kHz filter.
3747A/B-16. 3747A serials 1924U-00140 and below; 3747B serials 1924U-00115 and below. Improvement in the suppression of line radiated RFI.

3763A ERROR DETECTOR

3763A-3. Serials 1947U-00326 and below. Modification to improve reliability of power supply switching transistor.

3771A/B DATA LINE ANALYZER

3771A/B-9A. All serials. Table of board link variations with 3771A, 3771B and options.

3771A/B DATA LINE ANALYZER OPTION 005 HP-IB

3771A/B-10. 3771A serials below 1937U-00160; 3771B serials below 1937U-00123. Modification to prevent possible remote mode malfunction.
3771A/B-11. All serials. Retrofitting instructions for Option 002 (Loop Holding).
3771A/B-12. 3771A serials 1937U-00165 and below; 3771B serials 1937U-00123 and below. Preferred replacement of assembly A31 Input Transformer T1.
3771A/B-13. 3771A serials 2002U-00175 and below; 3771B serials 1937U-00123 and below. Modification to prevent loss of DC loop holding path when MEAS/SPEAK switch is set from SPEAK to MEAS.
3771A/B-14. All serials. Preferred replacement of resistors A3R6 and A3R7.
3771A/B-15. 3771A serials 2002U-00180 and below; 3771B serials 1937U-00123 and below. Modification to prevent possible loss of the 2040Hz transmission frequency when frequency shift is selected in the 3771A.
3771A/B-16. 3771A serials 2002U-00175 and below; 3771B serials 1937U-00128 and below. Installation of troubleshooting aid for HP-IB section.

3777A CHANNEL SELECTOR

3777A-1. Serials 1730U-00215 and below. Preferred replacement relays.
3777A-2. Serials 1730U-00215 and below. Preferred replacement for assemblies A4, A5, A6, A7, and A8.

3779A/B PRIMARY MULTIPLEX ANALYZER

3779A-14. Serials 1936U-00185 and below. Preferred replacement for assemblies A1, A8, A9, A31, A35, and A37.
3779A-15. Serials 1919U-00175 and below. Modification to prevent intermittent single channel interface operation while running A-D measurements.
3779A-16. Serials 1919U-00180 and below. Modification to prevent intermittent GvL measurements when running wet line systems.
3779A-17. Serials 1936U-00180 and below. Modification to prevent erroneous result during low level gain measurements.
3779B-14. Serials 1941U-00220 and below. Preferred replacement for assemblies A1, A8, A9, A31, A35, and A37.
3779B-15. Serials 1933U-00206 and below. Modification to prevent intermittent single channel interface operation while running A-D measurements.
3779B-16. Serials 1941U-00216 and below. Modifications to prevent intermittent GvL measurements when running wet line systems.
3779B-17. Serials 1941U-00225 and below. Modifications to prevent erroneous result during low level gain measurements.

3790A IF/BB RECEIVER

3790A-9. All serials. Preferred replacement for NPN transistor (1854-0071).

3791A/B IF/BB RECEIVER

3791A-6. All serials. Preferred replacement for NPN transistor (1854-0071).
3791B-1. All serials. Preferred replacement for NPN transistor (1854-0071).

3792A IF/BB RECEIVER

3792A-5. All serials. Preferred replacement for NPN transistor (1854-0071).

3793A/B IF/BB RECEIVER

3793A-1. All serials. Preferred replacement for NPN transistor (1854-0071).
3793B-1. All serials. Preferred replacement for NPN transistor (1854-0071).

3964A/3968A INSTRUMENTATION TAPE RECORDER

3964A-17/3968A-17. Serials 2009 and above. New type recommended instrumentation recording tape.
3964A-18/3968A-18. All serials. New adjustment procedure for FM data assemblies, 3464A part number 03964-60506, and 3968A part number 03964-60508.

4140A pA METER/ DC VOLTAGE SOURCE

4140A-1. Serials 1917J00195 and below. Modification to improve stability in signature analysis.
4140A-2. All serials. Description of performance test kit for 4140A.

4262A LCR METER

4262A-9. Serials 1739J01650 and below. Description of possible "fail" annunciation display at beginning of self test operation.

4282A DIGITAL HIGH CAPACITANCE METER

4282A-6. All serials. Revised AGC adjustment procedure.

4328A MILLIOHMMETER

4328A-7. Serials 1210 and below. Preferred replacement probes.

4943A TRANSMISSION IMPAIRMENT MEASURING SET

4943A-2. All serials. Instructions for field installation of Option 010 (HP-IB).
4943A-3. Serials 1731A00205 and below. Modification to correct A8 modem duty cycle.
4943A-4. Seials 1731A00254 and below. Modification to improve performance.
4943A-7. Serials 1731A00240 and below. Modification to improve performance and prevent intermittent level dropout.

4944A TRANSMISSION IMPAIRMENT MEASURING SET

4944A-1A. All serials. Instructions for field installation of Option 010 (HP-IB).
4944A-2. Serials 1737A00476 and below. Modification to improve performance.
4944A-3. Serials 1737A00328 and below. Modification to correct A8 modem duty cycle.
4944A-6. Serials 1737A00481 and below. Modification to improve performance and prevent intermittent level dropout.

5036A MICROPROCESSOR LAB

5036A-1. All serials. Suitcase replacement part number is 1540-0537.

5045A DIGITAL IC TESTER

5045A-20. New operational verification test using R-pack checks. Supersedes 5045A-8.

5315A/B UNIVERSAL COUNTER

5315A/B-1. Serials 1832A, 1824A, and 1812A. MRC chip replacement procedure.

5326B/5327B TIMER/COUNTER/DVM

5326B/5327B-10. All serials. Revised in-cabinet performance check.

5328A UNIVERSAL COUNTER

5328A-25B. Serials 1952A13473 or 1948U02430 and below. Modification to improve DAC settling time for Option 041.
5328A-26. Serials 1936A13173 or 1948U02280 and below. Modification to correct interface problem with the HP 9845A controller.

5340A MICROWAVE FREQUENCY COUNTER

5340A-9A. Serials 1644A04200 and below. Line fuse change for improved transformer protection.
5340A-13A. Serials 1936A and below. Recommended replacement for A17 direct count amplifier.

5345A COUNTER

5345A-10A. Serials 1708 and below. Resistor changes on A4 input trigger assembly (05345-60004) to improve performance.

5359A TIME SYNTHESIZER

5359A-1. All serials. Operation verification procedure for the A17 Output Reference board.
5959A-2. All serials. Operation verification procedure for the A18 output assembly.

5363A/B TIME INTERVAL PROBE

5363A-5. All serials. New signature analysis procedures for the 5363A time interval probes.
5363B-1A. Serials 1832A and below. Modification to prevent trigger output oscillations.
5363B-4. All serials. Simple troubleshooting procedure for 5363B calibration errors.
5363B-5. All serials. New signature analysis procedures for the 5363B time interval probes.

5370A TIME INTERVAL COUNTER

5370A-6. Modification to add top cover vinyl and cork strip to help prevent board displacement.

5420A DIGITAL SIGNAL ANALYZER

5420A-21A. Listing of previous service notes that are important to the reliability of the 5420A.
5420A-22. Modification to improve the 5441A display transport assembly.
5420A-23. Recommended replacements for the 5441A. Mother Board (05441-60101), FDB Board (05441-60241), and Servo Board (05441-60271).
5420A-24. Modifications to improve performance.

5427A DIGITAL SIGNAL ANALYZER

5427A-02. Model 5478C A-D Converter. Serials 1928A00230 and below. Modification to improve 5427A self check results.

5500C/5501A/5505A LASER HEAD

5500C-2/5501A-5. All serials. Troubleshooting supplement to the 5500C and 5501A operating and service manuals.
5501A-6. All serials. Notification of new service kits.
5505A-6. All serials. Notification of new service kits.
5505A-7. Serials1948A and above. Measurement capabilities using plane mirror optics.

6140A DIGITAL CURRENT SOURCE

6140A-1. Serials 2004A-00344 and below. Modification to improve reliability of A5Z6.

7010B/7015B X-Y RECORDERS

7010B-1/7015B-1. Safety. Serials 2008 and below. Modification to correct power select switch wiring.

7130/7131 STRIP CHART RECORDER

7130/7131-4. All serials. Options 28, 29, 30, 31 output clutch change for speed reducer options.

7310A PRINTERS

7310A-1. Serials 1941A00101 thru 1942A00125. Recommended replacement of 115-VAC fan motor in the event of failure.

8160A PROGRAMMABLE PULSE GENERATOR
8160A-3. Serials 1804G00181 and below, and serials 1903G00211 and below. Power supply modification to improve performance.

8165A PROGRAMMABLE PULSE GENERATOR
8165A-2A. Serials 1812G00241 to 1812G00281. Modification to correct a power-on problem.
8165A-3A. Serials 1701G00101 to 1812G00281. Modification to improve power dissipation on A10.

8170A LOGIC PATTERN GENERATOR
8170A-3. Serials 1915G00295 and below. Recommended replacement control board 08170-66506, Rev. D.
8170A-4. Serials 1915G00385 and below. Modification to improve external clock synchronization.

8411A HARMONIC FREQUENCY CONVERTER
8411A-4. All serials.Step-by-step procedure for replacing sampler diode.

8566A SPECTRUM ANALYZER
8566A-1A. Serials 1904A and below. Preferred replacement for transistor A6A10Q11.

8568A SPECTRUM ANALYZER
8568A-8A. All serials. New sweep time accuracy performance test.
8568A-22. RF section prefix 1921A and below. Preferred replacement for IC A17U2.
8568A-23. IF section prefix 1922A and above. Notification of new A3A6 system ROM signature analysis to improve performance.
8568A-24. CRT RFI shield cleaning.
8568A-26. RF section serial prefix 2007A and below. Recommended PC board sockets to eliminate intermittent digital operation.
8568A-27. IF section serial prefix 2003A and above. Modification to reduce noise floor.

8620C SWEEP OSCILLATOR
8620C-4. Serials 1933A and below. Option 011 HP-IB installation kit, HP part number 08620-60154.

8662A SYNTHESIZED SIGNAL GENERATOR
8662A-2. Serials 1925A00170 and below. Improved power supply reliability.

11713A ATTENUATOR/SWITCH DRIVER
11713A-1. Serials 1850A and below. Improved HP-IB operation.

59309A HP/IB DIGITAL CLOCK
59309A-5. Modification to allow the use of large HP-IB connector on A2J2.

59403A COMMON CARRIER INTERFACE
59403A-5. Serials 1426A01320 and below. Modification to prevent inadvertent IFC generation.

69423A LOW LEVEL A/D MULTI I CARD
69423A-1. Serials 1837A-00312 and below. Modification to improve performance.

Safety-Related Service Notes

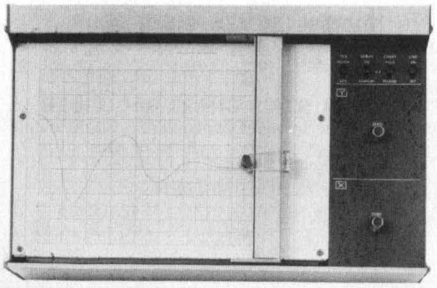
Service Notes from HP relating to personal safety and possible equipment damage are of vital importance to our customers. To make you more aware of these important notes, they are printed on paper with a red border, and the service note number has a "-S" suffix. In order to make you immediately aware of any potential safety problems, we are highlighting safety-related service notes here with a brief description of each problem. Also, in order to draw your attention to safety-related service notes on the service note order form at the back of *Bench Briefs* each appropriate number is highlighted by being printed in color.

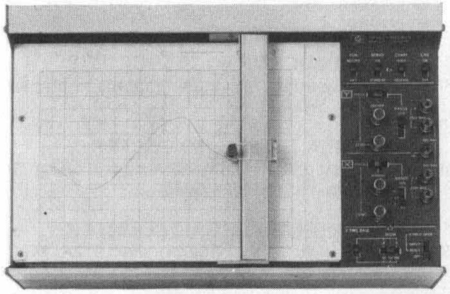
7010B and 7015B X-Y Recorders

On recorders with serial number prefixs below 2008, the 110ACV — 220ACV input power select switch has been miswired in the 220V position. If the recorder is connected to 220V, the secondary ±16 volt supply rises above ±18 volts causing U1 on power board A4 to fail. In addition to the failure of U1, the power transformer becomes overheated with possible imminent failure.

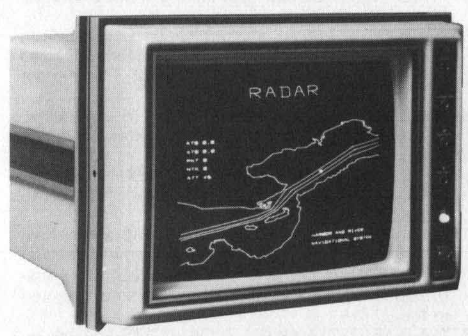
The miswire is corrected by replacing a jumper on the voltage select switches as illustrated in the Safety Service Note 7010B-1/7015B-1.

For complete detailed instructions, please order the note with the order form at the back of *Bench Briefs*.





1311B Large Screen Display



This Safety Service Note provides a warning to service personnel of the possibility of excessive CRT X-ray emissions should the high voltage power supply board be replaced or repaired.

Should any maintenance be performed, the high voltage power supply and intensity limit adjustment procedures in the HP 1311B Operating and Service manual (Section V), or the procedures accompanying each replacement high voltage power supply board must be strictly followed. Failure to do so could result in an excessive level of CRT X-ray emission.

Service Note Order Form

Instructions

If you want service notes, please check the appropriate boxes below and return this form separately to one of the following addresses.

For European customers (ONLY)

Hewlett-Packard
Central Mailing Dept.
P. O. Box 529
Van Hueven Goedhartlaan 121
AMSTELVEEN—1134
Netherlands

All Others

Hewlett-Packard
1820 Embarcadero Road
Palo Alto, California 94303

NAME ______________________________

COMPANY NAME ______________________________

ADDRESS ______________________________

CITY ______________________________

STATE ______________________________ ZIP __________

- ☐ 180A/AR-12
- ☐ 180C/D-4
- ☐ 180T/TR-2
- ☐ 197A-8
- ☐ 400E/EL-11
- ☐ 1114A-1
- ☐ 1302A-2
- ☐ 1304A-2
- ☐ 1311B-1-S
- ☐ 1332A-9A
- ☐ 1336A-1A
- ☐ 1350A-6
- ☐ 1600A-3
- ☐ 1610A-10
- ☐ 1610B-1
- ☐ 1640A-4A
- ☐ 1640A-8
- ☐ 1715A-5
- ☐ 1722B-2
- ☐ 1725A-4
- ☐ 1741A-9
- ☐ 2804A-3
- ☐ 3045A-1
- ☐ 3311A-2
- ☐ 3312A-3
- ☐ 3325A-3
- ☐ 3325A-5
- ☐ 3325A-6
- ☐ 3330A/B-11
- ☐ 3330A/B-12
- ☐ 3330A/B-13
- ☐ 3330A/B-14
- ☐ 3336A/B/C-1
- ☐ 3455A-17
- ☐ 3467A-2
- ☐ 3551A-7A
- ☐ 3551A-11A
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- ☐ 3779A-17
- ☐ 3779B-14
- ☐ 3779B-15
- ☐ 3779B-16
- ☐ 3779B-17
- ☐ 3790A-9
- ☐ 3791A-6
- ☐ 3791B-1
- ☐ 3792A-5
- ☐ 3793A-1
- ☐ 3793B-1
- ☐ 3964A-17/3968A-17
- ☐ 3964A-18/3968A-18
- ☐ 4140A-1
- ☐ 4140A-2
- ☐ 4262A-9
- ☐ 4282A-6
- ☐ 4328A-7
- ☐ 4943A-2
- ☐ 4943A-3
- ☐ 4943A-4
- ☐ 4943A-7
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- ☐ 4944A-3
- ☐ 4944A-6
- ☐ 5036A-1
- ☐ 5045A-20
- ☐ 5315A/B-1
- ☐ 5326B/5327B-10
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- ☐ 5328A-26
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- ☐ 5345A-10A
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- ☐ 5363B-5
- ☐ 5370A-6
- ☐ 5420A-21A
- ☐ 5420A-22
- ☐ 5420A-23
- ☐ 5420A-24
- ☐ 5427A-02
- ☐ 5500C-2/5501A-5
- ☐ 5501A-6
- ☐ 5505A-6
- ☐ 5505A-7
- ☐ 6140A-1
- ☐ 7010B-1/ 7015B-1 (SAFETY)
- ☐ 7130/7131-4
- ☐ 7310A-1
- ☐ 8160A-3
- ☐ 8165A-2A
- ☐ 8165A-3A
- ☐ 8170A-3
- ☐ 8170A-4
- ☐ 8411A-4
- ☐ 8566A-1A
- ☐ 8568A-8A
- ☐ 8568A-22
- ☐ 8568A-23
- ☐ 8568A-24
- ☐ 8568A-26
- ☐ 8568A-27
- ☐ 8620C-4
- ☐ 8662A-2
- ☐ 11713A-1
- ☐ 59309A-5
- ☐ 59403A-5
- ☐ 69423A-1

U.S. Seminar Information Form

	COURSE	DATE	COST	COORDINATOR/ LOCATION
□	141 — 8552 — 8553 — 8554 — 8555 —	Aug. 6-8	$300/Student	Jim Boyer 1400 Fountain Grove Parkway Santa Rosa, CA 95404 (707) 525-1400
□	8566A — 8568A —	Sept. 15-19 Sept. 22-26 Sept. 29-Oct. 3	$400/Student	
□	3060 —	Aug. 18-29 Oct. 20-31	$2,100/Student	Sandy Selleck P.O. Box 301 Loveland, CO 80537 (303) 667-5000
□	DTS-70 —	Nov. 17-21	$1,000/Student	
□	8640 8660 —	Aug. 25-29	$400/Student	Steve Thomas 1501 Page Mill Road Palo Alto, CA 94304

Registration Instructions

To enroll in any of the seminars, contact your local HP office and specify the course desired. Please note that the 8566A/8568A Spectrum Analyzer seminar is being repeated three consecutive weeks. Contact the factory coordinator to specify which week you desire.

Upon receipt of your registration, we will confirm your enrollment by returning all necessary prestudy material along with a list of nearby motel accommodations and reservation forms. Attendees are responsible for their own transportation, accommodations, and meals.

HEWLETT-PACKARD COMPANY
1820 Embarcadero Road
Palo Alto, California 94303

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