Basic Techniques of Waveform Measurement Using an Oscilloscope

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Text, image compilation, and document re-assembly By Perry Sandeen 3/2016

HP Editor's Note: This article is based on a three-part videotape series (HP pin 90741D) originally developed to train customer technicians on the use and operation of an oscilloscope. While most of the references to controls are based on an HP 1740A Dual-Trace Oscilloscope, the information presented is basic and applies to the operation of other manufacturers' oscilloscopes as well.

Generally speaking, a technician becoming familiar with a piece of test equipment is concerned about three things: .
. Knowing where and how to connect the test instrument,
. Knowing how to adjust the controls,
. And knowing how to interpret the data.

This article addresses these three basic concerns as they apply to the oscilloscope. Why the oscilloscope? Because it is probably one of the most versatile troubleshooting instruments you have on the bench. You can use it to measure voltage levels (from dc to microwave), phase differences, sigma presence (or absence), logic highs or lows, frequency response, distortion, and complex waveform analysis (wave shape, overshoot, etc.) to name a few. We obviously can't show you how to use the scope in all these endeavors. We can, however, give you the basics to cover the three original concerns ¬how to connect it, adjust it, and read it.

Once these concepts are mastered, the only remaining hurdle for you is to locate the controls on the scope's front panel. Most manufacturers try to help you by grouping similar controls together and separating the different groups by color or lines on the front panel

GETI'ING BACK TO THE BASICS

The oscilloscope presents a voltage vs. time display of a waveform on a cathode ray tube (CRT). Inside the CRT, an electron beam draws the waveform on a phosphor-coated screen. This screen presents three types of information: voltage information on the vertical or Y axis, time information on the horizontal or X axis, and intensity information on the Z axis. All oscilloscopes have controls to adjust the voltage, time and intensity information in order to present a meaningful picture on the CRT.

The Vertical Input

As shown in Figure 1, the input signal is connected to the vertical input amplifier. The vertical amplifier either attenuates or amplifies the signal for convenient viewing.

The next block the incoming signal encounters is the delay line. The delay line allows the sweep generator circuitry time to start a sweep before the signal reaches the CRT vertical deflection plates. This coordination of vertical and horizontal timing by the delay line enables viewing of the leading edge of the signal. This will be explained in greater detail later on. The vertical output amplifier provides additional amplification that is required by the CRT vertical deflection plates.

The Time Axis

Although precise horizontal deflection rates are not required in many general purpose applications, the more sophisticated scope applications require precise control of the sweep timing with respect to the signal under test. This precise control increases time interval measurement accuracy and ensures horizontal stability of the trace. Lack of this stability is seen as "jitter."

Intensity

Intensity information is provided in the form of bias control to the grid controlling the density of the electron beam. If the negative bias is sufficient, the CRT is cut off eliminating the trace.

Now let's look at the front panel of an HP oscilloscope in Figure 2 and see how the controls that operate these circuits are identified and grouped on this particular model.

VERTICAL INPUT CONTROLS

The vertical input controls generally consist of an input coupling switch, calibrated attenuator, and position control. A dual-trace scope will also have switches to select single channel, dual channel, or various combinations.

The Input Coupling Switch

The Input Coupling Switch on our example 1740A Scope has four positions: AC, GND, DC and 50il. The AC and DC positions are designated high impedance which is typically one Mil shunted by about 20 pF. This high input impedance, together with a standard 10 to 1 divider probe, increases the input impedance to 10 MΩ allowing you to measure waveforms with minimum circuit loading. Some scopes also allow you to select 50Ω input impedance, which is ideal for monitoring pulse and signal generators or other low impedance sources.

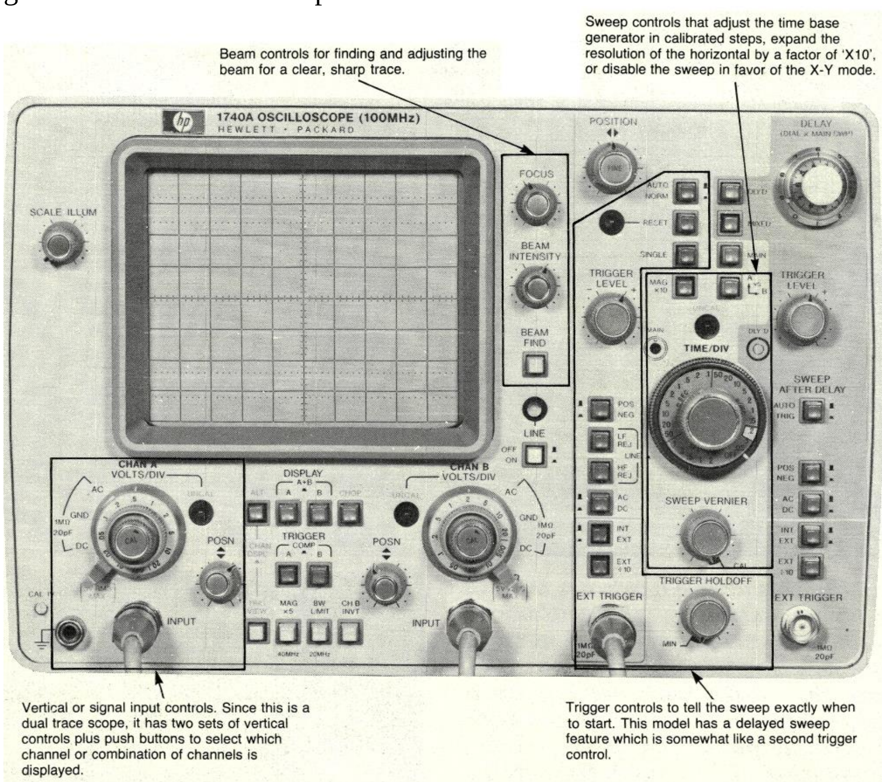


Figure 2. Front panel controls on HP 1740A Oscilloscope

AC Position - The AC position couples the input signal through a dc blocking capacitor, allowing only the ac component to be viewed.

AC coupling can be very useful when you want to measure a small ac signal superimposed on a large dc voltage. For example, to measure the small ac ripple voltage from a power supply, ac couple the signal to block the large dc component.

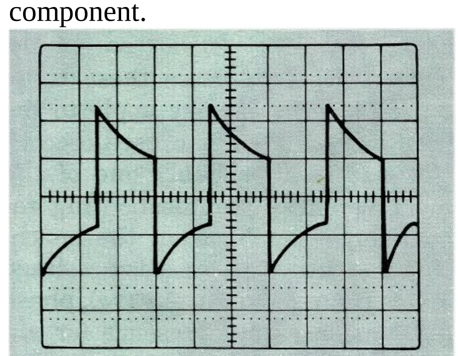


Figure 3. Distorted display as a result of trying to measure a low-frequency digital signal thru the input dc blocking capacitor (input switch in the AC position).

Do not use the AC position to measure low frequency digital-type signals. The internal dc blocking capacitor will distort the waveform as shown in Figure 3.

GND Position - The ground (GND) position is useful when you want to set a ground or zero volts reference level on the CRT screen without disturbing the input signal connection. The input signal is internally disconnected and the vertical amplifier's input is grounded. This means that you can leave the input signal connected to your scope. You won't short it out when you switch to the ground position.

NOTE
High frequency signals can create special problems for switches in scopes as well as other instruments. Therefore, when measuring HF signals, it is probably safer to go ahead and disconnect the input before presetting the controls.

DC Position - The DC position allows you to view both dc and ac components of the input signal. For example, if you have set the 0 volts reference level at the center of the screen (using the GND position) and then switch to DC, the waveform will appear showing the ac component, if any, and the signal will offset either up or down depending on whether the dc component is positive or negative. DC coupling is also used when you are measuring digital-type signals or square waves.

50Ω Position - The 50Ω position is a dc input (no blocking capacitor) with the Xc of the input amplifier very large compared to 50 ohms. The 500 input is used to measure high speed pulses and square waves from 50 ohm sources with minimum distortion and VSWR reflections. Most oscilloscopes with a built-in 50Ω input have internal compensation that makes it a better match than an external load.

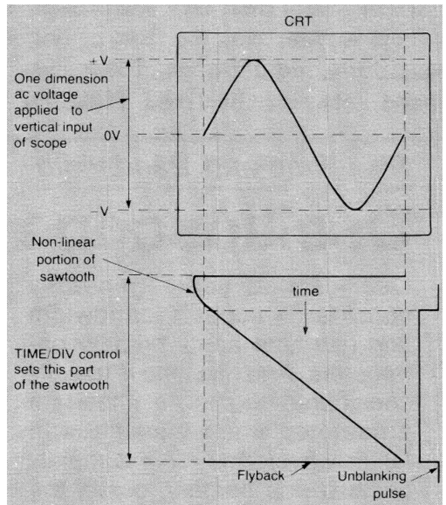
The Input Attenuator Control
Most modern scopes use a combination of variable attenuation and adjustable vertical amplifier gain to control input signal levels. High level signals will require more attenuation/less gain so that the trace is not deflected off the screen, and low level signals will need less attenuation/more gain. The VOLTS/DIV control allows you to change the vertical sensitivity in calibrated fixed steps, from 20 volts per division to 5 millivolts per division on the 17 40A. The vernier portion of the input attenuator provides continuous sensitivity control between the calibrated volts-per-division ranges. Whenever you move the vernier out of its detent position, the UNCAL light will be on, letting you know that the steps marked on the VOLTS/DIV dial are not calibrated.

Some scopes also have a vertical magnification control. MAG X 5 on the 1740A will allow you to increase the vertical sensitivity 5 times, from 5 m V to 1 m V per division, but with a reduction in bandwidth from 100 to 40 MHz. The vertical magnifier is useful when you're trying to measure low-level signals such as power supply ripple.

HORIZONTAL INPUT CONTROLS

The sweep generator, sometimes called the time-base generator, produces the sawtooth waveform which controls the rate the beam is drawn horizontally across the face of the CRT. The generator's most imp or-tan.t function is to ensure linear beam movement, meaning the beam moves at the same rate from start to finish. Without this precise rate, accurate time measurements are not possible. Another factor of accuracy depends on the delay line. Its function is to delay the vertical input signal just enough so that the trace being displayed is the signal that started the sweep (see Figure 4).

Another function of the sweep generator is CRT unblanking. An unblanking pulse is a positive square wave that turns the trace on in relation to the rising portion of the sawtooth. What this means is that the trace is turned on during its left-to-right movement across the screen and then turned off during retrace (sometimes called flyback), which is when the beam resets from right-to-Ieft. If the beam was not turned off in this manner, you would see the retrace lines with every sweep



Note that there is a non-linear part to the sawtooth sweep. Also, at the end of deflection, the sweep tends to drive the horizontal power amplifier into saturation. The unblanking pulse is timed to eliminate both of these non-linear portions of the sawtooth to provide the best time interval measurement accuracy.

Figure 4. Development of a sinewave pattern on the CRT.

Sweep Speed Control

The sweep generator's sawtooth waveform is controlled by a front panel control called TIME/DIV or SECIDIV. This calibrated control lets the operator select many different sweep speeds in order to view waveforms that vary from a few Hertz up to the bandwidth limit of the scope. The control is usually divided into steps in a 1-2-5 sequence covering the ranges of seconds, milliseconds, microseconds, and nanoseconds.

These ranges correlate to how fast the beam is drawn across the CRT. The faster the beam is drawn across the CRT, the faster the time reference (Le., the shorter the scale). For example, if the TIMEIDIV control is set for 0.5 seconds-per-division, the time reference over the full 10 major divisions (vertical graticule on the CRT face) is 5 seconds.

If it's set at 5 milliseconds-per-division, the full scale time reference is 50 milli-seconds. Figure 4 shows how the sawtooth waveform produced by the sweep circuit develops a sinewave pattern on the CRT.

Part of the TIME/DIV control is a sweep vernier control that provides continuous adjustment of the sweep speed between the fixed TIME/DIV steps. Whenever you move the vernier out of its detent CAL position, the UNCAL light will be on letting you know that the steps marked on the TIMEIDIV dial are not calibrated.

Another control that interacts with the sweep speed control is the horizontal magnifier. This control ex-pands the sweep time by whatever factor the magnifier is labeled. For example, if your scope has a 10 division time axis (10 squares on the horizontal axis) and the magnifier has a factor of ' X 10', you would have an effective 100-division wide signal and a 10-division window. This also means the signal has 10 times the horizontal resolution as before.

Rise Time and Bandwidth: Oscilloscope Amplifier Considerations

Oscilloscope users generally consider a scope's bandwidth and rise time as its primary parameters. And rise time is usually considered the more important parameter when working with faster waveforms. This is mainly because the primary axis of the scope's display is the horizontal or time axis, and it offers the greatest. resolution - less than 2% for timing measurements.

Why is the horizontal or time axis considered the major axis? Consider that the vertical axis has an 8cm window, whereas the horizontal axis has a 10cm window. 10cm provides more resolution than 8cm. Also, the range of the vertical axis (the HP 1740 for example) is 2,000 to 1 or from 1 mv/cm to 20 v/cm. The time axis has a range of 40,000,000 to 1 from 2 sec/cm to 50 ns/cm. This is 20,000 times greater than the vertical axis offers.

Signal bandwidth is of course defined as the frequency range in which signals are handled with less than a 3dB loss compared to mid-band performance. However, the vertical system of an oscilloscope is not flat like that of a voltmeter - it is Gaussian.

What does Gaussian response mean? It means that the vertical system of the scope alters the input signal and delays it in such a way that it produces a linear phase response. The linear phase response has a constant group delay so all the frequency components will reach the deflection plates at the same time. This results in minimum distortion of complex waveforms. Note that this Gaussian response is always falling in gain, therefore, accurate voltage measurements can only be made at dc. The frequency response will be down 1.5dB at 20% of the 3dB bandwidth, so 3% accurate amplitude measurements of sinewaves can't be made for frequencies greater than 20 MHz on a 100 MHz oscilloscope. However, the amplitude of a pulse is dc so accurate pulse amplitude measurements can be made up to the full bandwidth of the scope.

Constraints make bandwidth and rise time numerically related in well designed general purpose oscilloscopes. Bandwidth in megahertz multiplied by rise time in nanoseconds is approximately 0.35. Therefore, if your oscilloscope needs are defined in terms of one factor, for example rise time, dividing it into 0.35 will produce bandwidth.

In terms of rise time, scopes ideally should have a vertical system capable of responding at least three to five times as fast as the fastest applied step signal. In such a case, the rise time of the signal indicated on the scope will be in error by less than 2%. For example, if you are going to accurately measure 'X' micro-second pulses, the minimal requirements for scope bandwidth using the 5 times faster and 0.35 factors together can be estimated using the following rule of thumb:

$$\text{Bandwidth (minimal)} = \frac{1.70}{\text{Fastest Rise Time}}$$

Fastest Rise Time But remember, very accurate absolute rise time measurements are not always important. *When simply comparing the rise times of two signals, scopes with a rise time equal to the rise time of the signals applied are usually considered adequate.*

In conclusion, it can be said that the modern oscilloscope with its Gaussian response is designed for pulse parameter analysis but not sinewave analysis. The characteristics of a sinewave can be better measured with instruments other than the oscilloscope. For true RMS, a voltmeter can give better amplitude measurements, a counter better frequency measurements, and a spectrum analyzer better distortion measurements. However, for a complex waveform such as a pulse, the oscilloscope is clearly the best choice. The voltmeter can't respond fast enough to make this measurement. The trigger uncertainties of a counter mask its accuracy for pulse measurements, and nothing but a scope can measure parameters such as overshoot, droop, and ringing.

Measuring Rise Time

High-speed, precisely timed sweeps provide data of fundamental importance in waveform analysis. For example, one of the basic characteristics of a square wave or pulse is its rise time as shown in Figure 5.

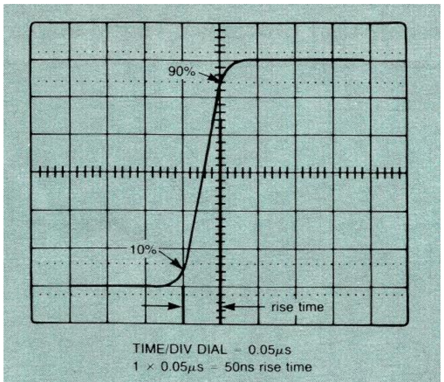


Figure 5. Rise time measurement.

Rise and fall times are usually measured between the 10% and 90% amplitude points on the leading or , trailing edge of the pulse. These two points are generally accepted as industry standards for waveform measurement. To make rise time measurements easier, the HP 1740A scope has 10% and 90% dotted lines engraved on the faceplate for pulse amplitudes of both 6 and 8 divisions.

The first step in measuring rise time is to adjust the vertical controls so that pulse height is six divisions.

Then use the TIME/DIV and horizontal position controls to expand the sweep speed and position the leading edge of the pulse to intersect the bottom 10% amplitude point with a convenient vertical graticule line (see Figure 5). Read the rise time by measuring the time between the 10% and 90% points. The example shown in Figure 5 is one division times 0.05 microseconds which equals a rise time of 50 nanoseconds.

How accurate is this measurement? Always remember when measuring rise time that the vertical amplifier of your scope has its limits. Many times a new technician will make the mistake of trying to measure the rise time of a 10kHz pulse train with a 500 kHz scope (sounds reasonable), without realizing that the actual rise time of the pulse is faster than the vertical amplifier can respond to.

Refer to your operating manual for rise time specifications. If you don't have a manual use the following rule of thumb: **Bandwidth x Rise Time = .35**

Therefore, if you have a 500 kHz scope, don't try and measure rise times faster than 7μs. In fact, the vertical system of your scope should be two to five times faster than the rise time of the applied signal. In such a case, the rise time of the signal indicated on the scope will be in error by less than two percent.

Measuring Pulse Width

Measuring the pulse width of a digital signal is accomplished by using the TIME/DIV control and other sweep circuit controls as necessary to make the pulse as high and wide as possible to take advantage of the full scale accuracy of the instrument.

The first step in measuring pulse width is to adjust the vertical controls so that pulse height is six divisions (i.e., enough height to easily see the 50% point). Then use the TIME/DIV control to expand the sweep speed so that one pulse is in the center of the screen. Do not move the vernier control out of its CAL position.

Pulse width is measured at the 50% amplitude points. Use the vertical and horizontal position controls to center the pulse around the center horizontal graticule line with the pulse's leading edge over a convenient vertical graticule. Count the number of divisions between the 50% points and multiply that times the main sweep speed read from the TIME/DIV dial. The example shown in Figure 6 is eight divisions times 0.5 microseconds which equals a pulse width of 4 microseconds (8 div. x 0.5µs = 4.0 µs). To determine the accuracy of this measurement, look up the main time base accuracy specification of your scope and multiply it by the final full scale setting.

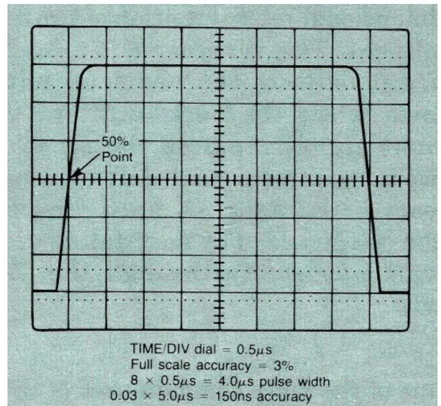


Figure 6. Pulse width measurement of a square wave.

For example, an accuracy figure from the manual of 3% full scale would be 0.03 times full scale on our scope. Full scale is determined by multiplying the TIMEIDIV dial setting times full scale on the CRT (0.5 µs per div. x 10 div. = 5.0 µS). So 5.0 microseconds times 0.03 accuracy equals 150 nanoseconds (0.03 µS x 5 µs = 150 ns). The pulse shown in Figure 6 then is 4.0 µs ± 150 ns.

Frequency Measurements

Frequency is the reciprocal of the time period for one cycle. For example, the time period of the signal shown in Figure 7 is obtained by counting the number of horizontal divisions covered by one cycle (five) and multiplying that times the setting of the TIME/DIV control (0.2 ms). Then take the reciprocal.

$$F = \frac{1}{T} = \frac{1}{5 \times .02ms} = \frac{1}{10-3} = 1.0 \text{ kHz}$$

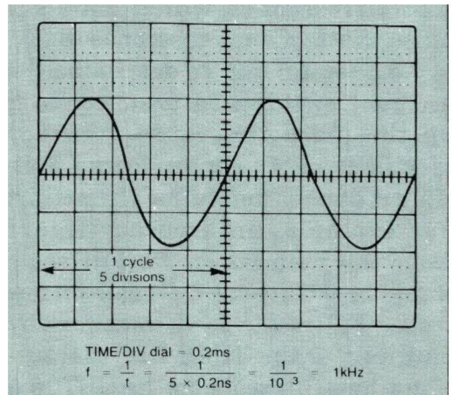


Figure 7. Frequency (time period) measurement of a sinewave.

X - Y Operation

The X-V mode of operation is a two dimensional representation of two ac voltages. The vertical or 'V' input signal deflects the beam up and down while the horizontal or 'X' input signal replaces the scope's sweep generator and deflects the beam horizontally. A third dimension can be added by modulating the beam's intensity through the 'Z' axis.

One of the more common uses of the X-V mode is to generate Lissajous patterns to check phase.

For example, the transistor checker discussed in the Sept.-Oct. and Nov.-Dec. 1974 issues of Bench Briefs provides a Lissajous pattern that indicates the voltage-to-current characteristic of a diode junction.

Another more sophisticated use is in the area of circuit frequency response where you tum your scope into a simple network analyzer.

Figure 8 shows some of the various Lissajous patterns you can expect using the X-V mode. Note that Figure 8f shows what is commonly called a "bow-tie" pattern and is the result of the deflection voltages having a 1:2 frequency ratio. To obtain the ratio of vertical and horizontal deflection frequencies from any Lissajous pattern, count the number of horizontal tangent points, and divide this number by the number of vertical tangent points. If you use this method, always make certain that the trace contains visible crossovers, that they are not masked by trace coincidence; that is, the horizontal tangent points don't fall together.

Figure 9 represents a frequency response curve and is obtained by connecting a sweep generator to both the input of the circuit under test and the 'X' axis. The output of the circuit is connected to the 'V' axis. The oscilloscope becomes a simple network analyzer that is a swept receiver that provides a visual display.

It shows how energy is distributed as a function of frequency.

NOTE

X- Y operation is limited by horizontal amplifier frequency response and phase difference between the horizontal and vertical amplifiers. Refer to your operating manual for specifications.

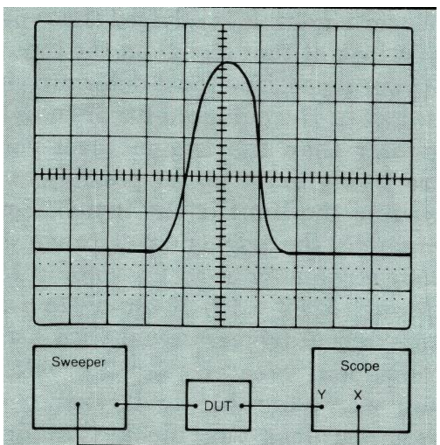


Figure 9. X-Y mode of operation showing a simple network analyzer-type pattern of a frequency response curve

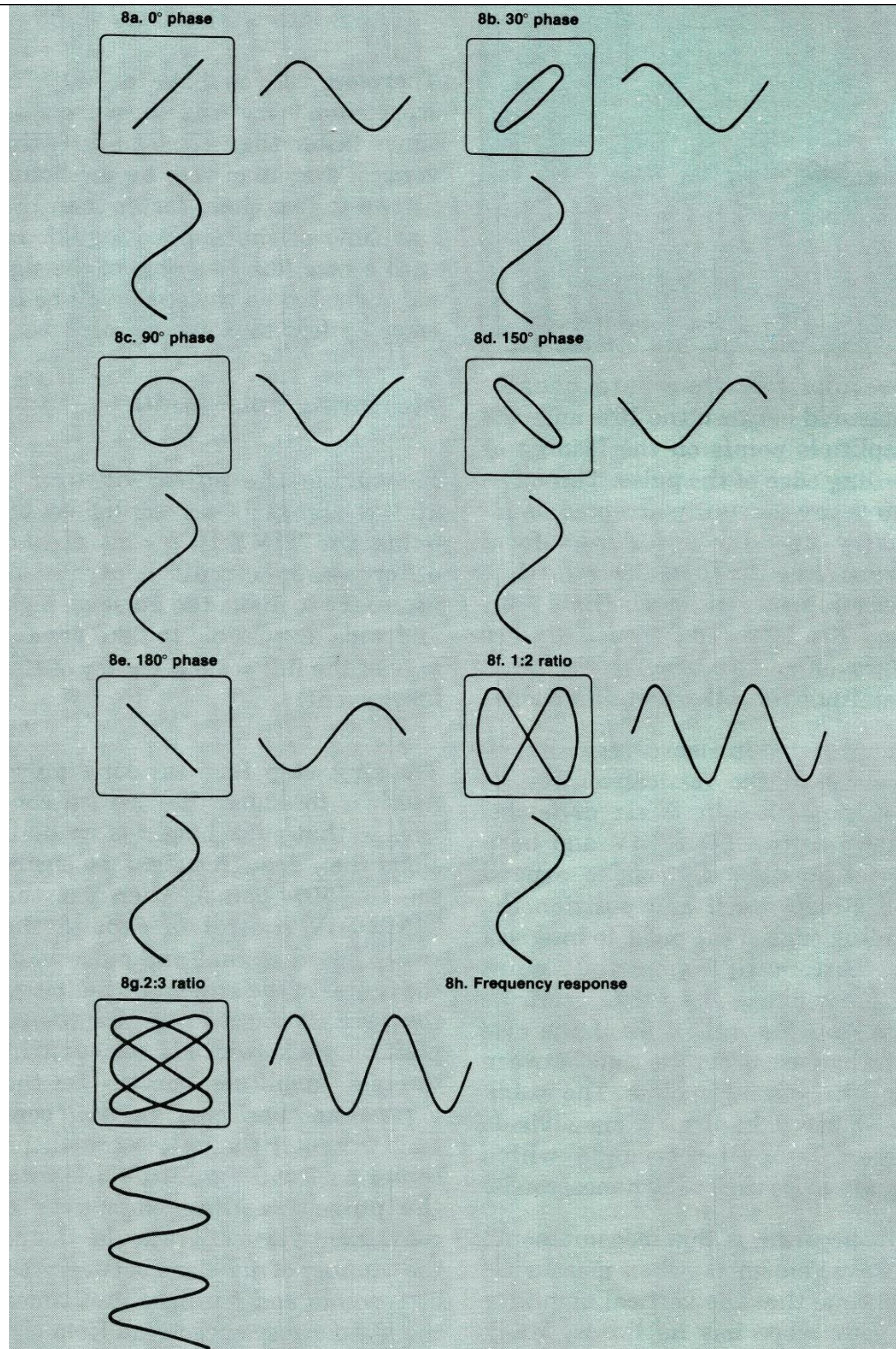


Figure 8. X-Y mode of operation showing typical examples of Lissajous patterns.

TRIGGER CONTROLS

The purpose of the trigger circuit is to produce a stable display. This is accomplished by synchronizing the sweep signal discussed earlier so that each trace is written right on top of the previous one. You see one single trace, but it is actually being refreshed on each sweep.

Several controls allow you' to select the source, positive or negative mode, and level of the synchronizing trigger signal as shown in the simplified diagram Figure 1. The' following table is an abbreviated description of the basic controls and their functions.

Auto/Normal

This switch is probably the greatest source of "pilot error" in oscilloscope operation. In simple terms, Normal mode requires a trigger signal to generate a sweep - Auto does not.

Auto Mode - The Auto mode selects an internal oscillator or multi-vibrator that is used to trigger the sweep generator in order to produce a reference baseline - if there is no other trigger source. As soon as you select one of the three trigger sources (internal, external, or line) that trigger source is used to start the sweep generator. If the trigger source frequency is below approximately 40 Hertz, you must switch to the Normal mode to obtain stable triggering.

Stated another way, the Auto mode is used to obtain a reference baseline when you are adjusting the controls for focus, intensity, position, and de reference. It also keeps the baseline on the CRT if you remove the input signal.

BASIC TRIGGERING CONTROLS		
Typical Name	Positions	Functions
Mode	AUTO	Connects sweep to multi-vibrator so sweep free-runs in absence of adequate trigger signal.
	NORMAL	Connects trigger circuit to one of three sources: input signal, external signal, or line.
	INT	Uses sample of input signal to start sweep.
	SINGLE	Sweep will start only upon the occurrence of the trigger signal that meets the conditions of level and slope after the button is pushed
Source	EXT	Uses sample of some external signal to start sweep. External signal is usually related to input signal.
	EXT ± 10	Same as EXT except attenuates external signal by a factor of 10.
	LINE	Uses sample of power source. Useful for viewing events related to power line frequency.
Trigger level	VARIABLE -1.5v to + 1.5v (EXT) -15v to +15v (EXT ± 10)	Permits selection of triggering at any point (level) on the positive- or negative- going edge of the displayed waveform.
Slope	POS (+) NEG (-)	Sets up the triggering circuit so that the displayed signal is triggered on the positive- or negative-going edge.

Normal Mode - The Normal mode requires a trigger signal from one of the three sources (internal, external, or line) in order to generate a reference baseline or sweep. The "pilot error" mentioned earlier usually occurs when you have set the scope up for internal triggering and the mode switch is in the normal position. If you don't have a signal connected to the vertical input of the scope, you won't have a trigger signal - hence no trace.

This loss of trace with loss of input can be a valuable troubleshooting aid. Say, for example, you are probing a circuit looking only for presence or absence of a signal. If you adjust the trigger level control for an optimum level, and then probe a point in the circuit that has no signal present, there will be nothing to trigger the display and the screen will be blank. Figure 1 shows a simplified representation of how the trigger controls are interlocked.

Trigger Level and Slope

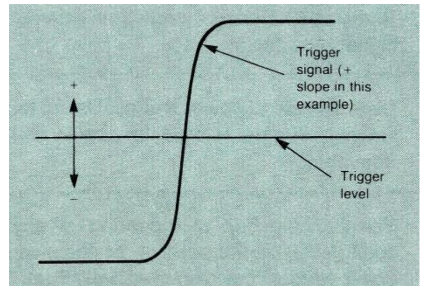


Figure 10. Trigger level control varies the voltage level to the trigger circuit. This figure shows that positive slope has been selected.

Trigger Level and Slope controls allow you to select any point on the positive or negative edge of the displayed waveform to trigger the sweep circuit (see Figure 10).

Usually, when the scope is in the Internal Trigger mode, the level control will select any point on the vertical waveform displayed. With external trigger signals, the control has a voltage limit (refer to the operating manual).

Internal Trigger

When the switch is set for Internal Triggering, it means that a portion of the input signal is tapped off, as shown in Figure 1, and sent to the trigger circuit. The CRT will display a *portion* of the input signal related to the first occurrence of a positive or negative slope of the input signal (depending on how you have set the Slope and Level controls).**This allows you to view a time event related to the input signal.** If you are using a dual-channel scope, you must know which input channel will trigger the sweep circuit and use that channel for your input.

If you are using the internal trigger mode for troubleshooting, you may have to re-adjust the trigger level control to maintain a trace as you probe different points in the circuit under test. The reason this occurs is because the trigger circuit has been initially adjusted (by you) to trigger the sweep at some positive or negative voltage level. Therefore, as you move the probe from point-to-point monitoring different signal levels, the voltage level to the trigger circuit is also constantly changing. To eliminate this inconvenience, use the External Trigger mode and connect the external trigger to a low rep rate timing signal from the circuit under test. In a digital circuit, use a sub-multiple of the clock pulse rate. External Trigger

When the switch is set for External Triggering, you must provide a signal to a connector on the scope marked EXT TRIGGER. If the signal voltage exceeds the input voltage limit (refer to your manual), then use the EXT 1/10 trigger input. A good rule-of-thumb is use a 10:1 probe on EXT and no probe on EXT - 1/10. This will help prevent saturation of the trigger comparitor. The External Trigger signal is usually derived from a low rep-rate timing signal related to the input signal. The CRT will display the input signal on each occurrence of the trigger signal. **This allows you to view an event time-related to the trigger source**. The Trigger Level and Slope controls work the same for an external triggered signal as an internal triggered signal.

One method of viewing the time relationship between the input signal and external trigger signal is with a dual-channel scope. Use one input to look at the signal and one input to look at the trigger. You must know which input channel will trigger the sweep circuit and use that channel for the trigger input. Then set the source switch for INT.

If you are going to use an external trigger signal, it is advised that you first look at that signal on the input of your scope. You must determine if it has a de component or noise greater than the trigger level you are trying to set up (or possibly exceeding the limit of the input). For example, the trigger level range of your scope may be ± 1.5 volts (± 15 through EXT 1/10). If you try to use an external trigger signal with a de component greater than 1.5 volts, you won't be able to trigger the sweep unless you block that de. Some scopes have ac coupling (selectable) built in - other do not. At any rate, you *must* use de coupling for trigger signals below about 20 Hz.

Your external trigger signal may also have power line pick-up or possibly RF noise. In either case, you need to filter out the unwanted portion in order to obtain a stable display. Some scopes have built-in filters while others do not. The point is, if you use external triggering, make certain the signal is clean.

Line Trigger

In the Line mode, the display is triggered by a sample of the power line which is usually 50 or 60 Hertz. Line triggering is often used when you want to determine if there's any relationship between the displayed signal and the line frequency (often called power line hum).

Trigger Holdoff

Some oscilloscopes may have this specialized variable control that is used in conjunction with the Trigger Level control. Trigger Holdoff increases the time between sweeps and helps stabilize the display when internally triggering off a complex digital signal or RF signal.

PUTTING IT ALL TOGETHER

Now that you have an idea of what all the basic controls are for, let's put them all together in step-by-step order to actually set up your scope.

1. Turn-On and Preset (before the signal is connected)

. Turn on the power and allow approximately 30 seconds for warm up.

. Preset the trigger mode switch to Auto and turn the intensity control up.

. If there's still no display, use the beam finder together with the horizontal and vertical position controls to bring the trace to center screen.

. Adjust the intensity control to a comfortable viewing level. Adjust the focus control for sharpest trace.

. Adjust the input attenuator control to its highest setting. This will prevent the trace from being deflected off screen if the signal has a large dc component or is a very large ac signal.

. Set the input coupling switch according to the following criteria: 50Ω if the source is a pulse or signal generator, DC if the source is a low frequency digital signal (square wave), AC if the source has a large DC component that needs blocking or for general purpose probing.

. Connect the input signal and adjust the input attenuator control to obtain a reasonable display.

. Adjust the sweep speed control until you get a display you can recognize.

2. Fine Tuning

The following steps are contingent on the type of oscilloscope that you have. A lot of brands won't have all of the controls that we have been discussing, and some brands may have more. The point is, the theory is the same regardless of what the control is called or even if you have one.

NOTE
The following axioms apply when you are using an external trigger signal.

Axiom # 1: The trigger signal must be clean and free of noise. If your scope has built-in filters, use them.

Axiom #2: If the trigger signal has a large dc component, it must be blocked by a capacitor (e.g., 0.1 µF). If your scope has ac/dc selection built into the trigger input controls, use the ac position to block the unwanted dc component.

. Select the trigger source. You can trigger the sweep from an external, internal or line frequency signal.

. If the frequency of the trigger signal is less than approximately 40 Hertz, change the mode switch to Normal.

. If you have selected external trigger, select either ac or dc trigger coupling. Use ac if the trigger signal contains a large dc component. Use dc if the trigger signal frequency is less than 20 Hertz.

. Always use the EXT -:- 10 input if you are not using a divider probe to connect the external trigger signal to the scope.

Authors Notes: I don't have a divide-by symbol on my computer so I used 1/10. Also I don't have parts two and three of this article.