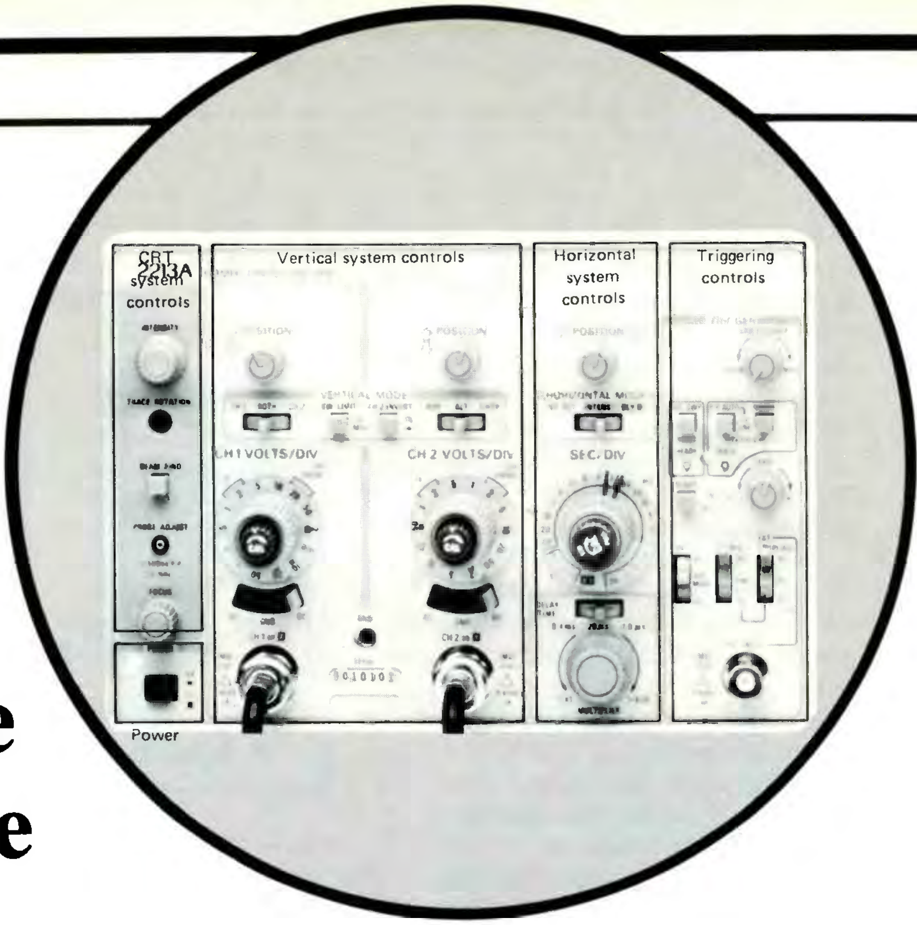

Oscilloscope User's Guide

Part 2 (Conclusion)

A close-up look at the high-performance general-purpose oscilloscope and how to use it for making tests and measurements

By Vaughn D. Martin

Last month, in Part 1 of this article, we introduced you to the high-performance, general-purpose oscilloscope and began telling you how to use it to make various types of measurements. In this concluding part, we continue with our discussion of how to use the scope in time-saving ways.

Differential Measurements

The ADD vertical mode and the channel 2 INVERT button on the 2200 Series scopes let you make differential measurements. Often differential measurements eliminate undesirable components from a signal being measured (Fig. 8). If you have a signal that is very similar to the unwanted noise, the setup is simple: Feed the signal with the spurious information into channel 1; feed the signal that is like unwanted components into channel 2; set both input coupling switches to DC (use AC if the dc components of the signal are too large); and select the alternate vertical mode by moving the VERTICAL MODE switches to BOTH and ALT.

Now set the VOLTS/DIV switches so that the two signals are about equal in amplitude. Then set the right-hand VERTICAL MODE switch to ADD and press the INVERT button so that the common-mode signals have opposite polarities.

If you use the channel 2 VOLTS/DIV switch and CAL control for maximum cancellation of the common signal, the signal that remains will contain only the desired part of the channel 1 input signal. The two common-mode signals will have canceled out, leaving only the difference signal.

Using The Z Axis

The scope's CRT has three axes: horizontal (X), vertical (Y), and intensity of the electron beam (Z). The input for the Z axis is usually located on the rear of the instrument. This input lets you modulate the intensity of the displayed signal on the screen, using an external signal. The Z-axis input will usually accept a signal of up to 30 volts peak-to-peak over a usable frequency range of dc to 5 MHz. Positive voltages decrease and negative voltages increase brightness, with 5 volts causing a noticeable change in intensity.

The Z-axis input is an advantage to users who have their instruments set up for a long series of tests. One example is the testing of high fidelity equipment (Fig. 9).

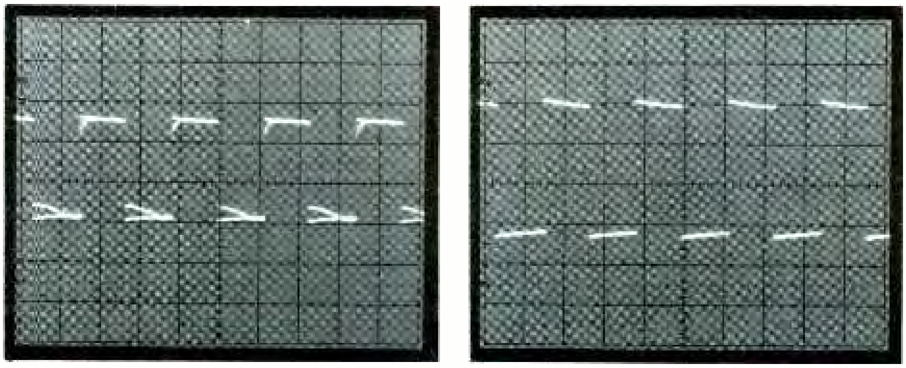

Fig. 8. Differential measurements allow removal of unwanted information from a signal any time there is a signal closely resembling the unwanted components. Once common-mode component is fed to channel 2 and inverted, signals can be added with ADD vertical mode (result shown in photo at right).

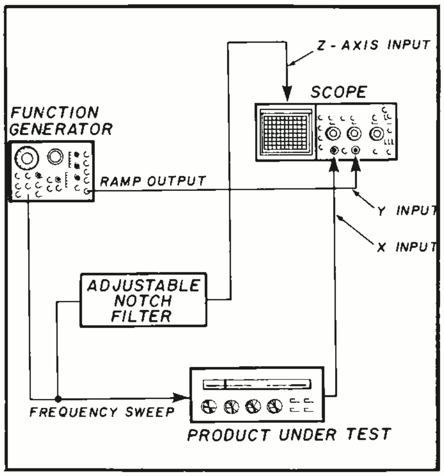

Fig. 9. This setup illustrates how a scope's Z axis, along with a sweep function generator and notch filter, can be used to test hi-fi equipment.

Using TV Triggering

The composite-video waveform consists of two fields, each of which contains 262 lines. Many oscilloscopes offer TV triggering to simplify viewing of video signals. Usually, however, the oscilloscope will trigger only on fields at some sweep speeds and lines at others. The 2200 Series scopes trigger on either lines or fields at any sweep speed.

To view TV fields with a 2200 Series scope, use the TV FIELD mode, which allows the scope to trigger at the field rate of the composite-video signal on either field. Since the trigger system cannot recognize the difference between the two fields, it will trigger alternately on the two and produce a confusing display if you look at one line at a time. To prevent this, add more holdoff time with the variable holdoff control or by switching the vertical operating mode to display both channels. This makes total holdoff time for one channel greater than one field period. Then position the unused vertical channel off-screen to avoid confusion.

It is important to select the trigger slope that corresponds with the edge of the waveform where the sync pulses are located. Selecting a negative slope for pulses at the bottom of the waveform allows you to see as many sync pulses as possible.

When you want to observe the TV line portion of the composite video signal, use the NORM trigger mode and trigger on the horizontal synchronization pulses for a stable display. It is usually best to select the blanking level of the sync waveform so that the vertical field rate will not cause double triggering.

Delayed Sweep Measurements

Delayed sweep is a technique that adds a precise amount of time between the trigger point and the beginning of a scope sweep. Delayed sweep is often used as a convenient way to make a measurement (the risetime measurement is a good example). To make a risetime measurement without delayed sweep, triggering must be on the edge that occurs prior the desired transition. With delayed sweep, you can trigger anywhere along the displayed waveform and use the delay time control to start the sweep exactly where you want.

Sometimes delayed sweep is the only way to make a measurement. Suppose the part of the waveform you want to measure is so far from the only available trigger point that it will not show on the screen. The problem can be solved with delayed sweep by triggering where you have to and using delay out to where you want the sweep to start.

The delayed sweep feature you will probably use most often is intensified sweep, which lets you use the delayed sweep as a positionable magnifier. You trigger in the usual way and then use the scope's intensified horizontal mode. The on-screen signal will now have a brighter zone after the delay time. Run the delay time (and intensified zone) out to the part of the signal that interests you. Then switch to delayed mode and increase sweep speed to magnify the selected waveform portion so that you can examine it in detail.

Single-Timebase Scopes

Very few single-timebase scopes offer delayed sweep measurement. Those that do may have measurement capabilities similar to those of the Tektronix Model 2213, which has three possible horizontal operating

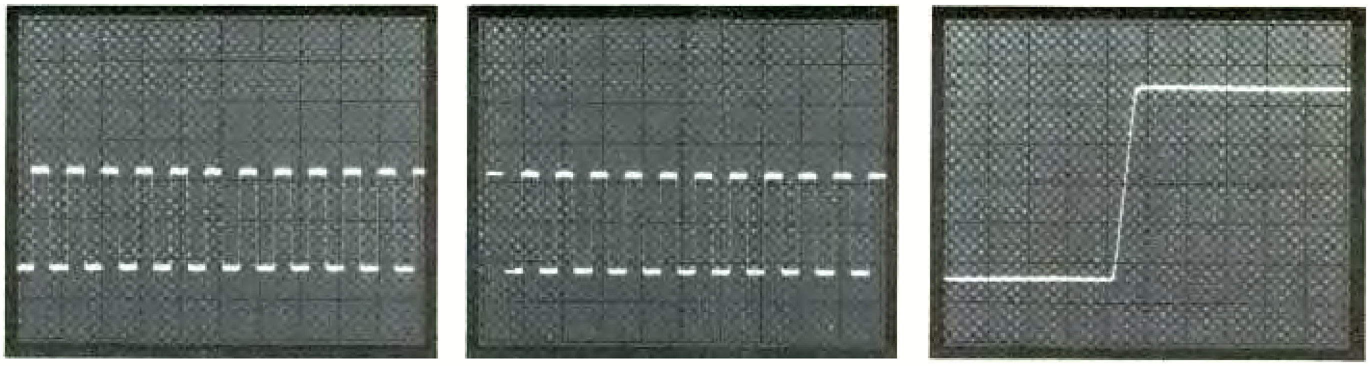

Fig. 10. Delayed sweep adds precise amount of time between trigger point (left) and beginning of sweep (center). By adjusting controls to display one transition of input waveform (right), you can obtain risetime measurement.

modes, labeled on the front panel NO DLY, INTENS and DLY'D.

When you set the HORIZONTAL MODE switch to NO DLY (no delay), only the scope's normal sweep functions. When you choose INTENS (intensified sweep), normal sweep will be displayed with an intensified trace after a delay time. The amount of delay is determined by both the DELAY TIME switch position. You can use 0.5 s, 10 s, or 0.2 ms and the DELAY TIME MULTIPLIER control, which lets you use from 1 to 20 times the switch setting. The DLY'D (delayed) position makes the sweep start after the selected delay. After selecting this position, move the SEC/DIV switch to obtain a faster sweep speed to examine the waveform in greater detail.

This list of horizontal modes should begin to give you an idea of how useful are these delayed sweep features. Start by making the risetime measurement described below. (Note that when making risetime measurements, you must take the risetime of the measuring instrument into account, as in Fig. 10.)

Dual-Timebase Scopes

Delayed sweep is normally found in dual-timebase scopes like the Model 2215, which have two totally separate horizontal sweep generators. In dual-timebase instruments, one sweep is triggered in the normal fashion while the start of the second sweep is delayed. To avoid confusion, we will call the delaying sweep the A sweep and the delayed sweep the B sweep. The length of time between the starts of the A and B sweeps is called the delay time.

Dual-timebase scopes offer all the measurement capabilities of single-timebase instruments, plus convenient comparisons of signals at two different sweep speeds; jitter-free triggering of delayed sweeps; and timing measurement accuracy of 1.5%. Most of this increase in measurement performance is possible because you can separately control the two sweep speeds and use them in three horizontal operating modes. In the Model 2215, these modes are A sweep only, B sweep only, and A intensified by B, as well as B delayed. The HORIZONTAL MODE switch controls the operating mode, and two SEC/DIV switches, concentrically mounted on the Model 2215, control the sweep speeds (Fig. 11).

When you use the ALT (alternate) position of the HORIZONTAL MODE switch, the scope displays the A sweep intensified by the B sweep and the B sweep delayed. As you set faster sweeps with the B SEC/DIV switch, you will see the intensified zone on the A trace diminish in size and the B sweep expanded by the new speed setting. As you move the B DELAY TIME POSITION control to change where the B sweep starts, the intensified zone will move across the trace and the B waveform will change.

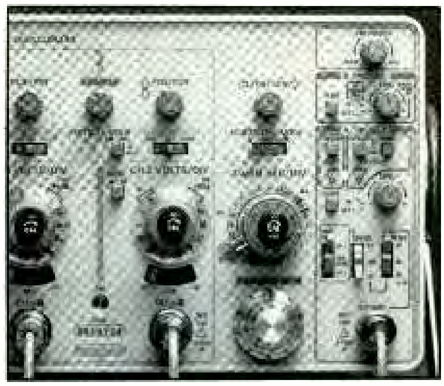

Fig. 11. Close-up of Tektronix's Model 2215 scope shows HORIZONTAL MODE *and two concentrically mounted* SEC/DIV *switches used for controlling sweep speed.*

This sounds more complicated than it really is. As you use the scope, you will find that the procedure, in fact, is very easy. You will always see exactly where the B sweep starts; and you can see the size of the intensified zone to judge which B sweep speed you need to make the measurement you want.

Measurement At Two Sweep Speeds

Examining a signal with two different sweep speeds simplifies making complicated timing measurements.

The A sweep gives a large slice of time on the signal to examine; the intensified zone shows where the B sweep is positioned; and the faster B sweep speeds magnify the smaller portions of the signal in great detail. You will find this capability useful in many measurement applications (Fig. 12).

Because you can use the scope to show A and B sweeps in channels 1 and 2, four traces can be displayed. To prevent overlapping traces, however, most dual-timebase scopes offer an additional position control, like ALT SWP SEP (alternate sweep separation) position on the Model 2215. With this and the two VERTICAL POSITION controls, all four traces can be placed on-screen without confusion.

Separate B Trigger

Jitter can prevent you from making an accurate measurement any time you want to examine a signal that is not perfectly periodic. With two timebases and delayed sweep, you can overcome this with the separate trigger available for the B sweep. Trigger the A sweep as usual and move the intensified zone out to the portion of the waveform you want to measure. Then set up for a triggered B sweep, instead of letting the B sweep simply run after the delay time.

On a Model 2215, the B TRIGGER LEVEL control does double duty. In its fully clockwise position, it selects the run-after-delay mode. In any other position, it is a trigger level control for the B trigger. The B TRIGGER SLOPE control lets you choose positive or negative transitions for the B trigger. These two controls let you set the scope to trigger a stable B sweep even when the A sweep has jitter.

Increased Timing Measurement Accuracy

In addition to letting you examine signals at two different sweep speeds and a jitter-free B sweep, a dual-timebase scope lets you get increased time measurement accuracy. Note that the B DELAY TIME POSITION control is a measuring indicator as well as a positioning device. The numbers in the window at the top of the dial are calibrated for the major divisions of the graticule, while the numbers around the perimeter divide each major division into hundredths.

To make timing measurements accurate to about 1.5% with the B DELAY TIME POSITION control, do the following: 1) use the B runs-after-delay mode; 2) place the intensified zone (or use the B sweep waveform) where the timing measurement begins and note the B DELAY TIME POSITION dial setting; 3) dial back to where the measurement ends and note the reading there; 4) subtract the first reading from the second and multiply by the A sweep SEC/DIV setting. You will find an example of this accurate—and easy—timing measurement in Fig. 12.

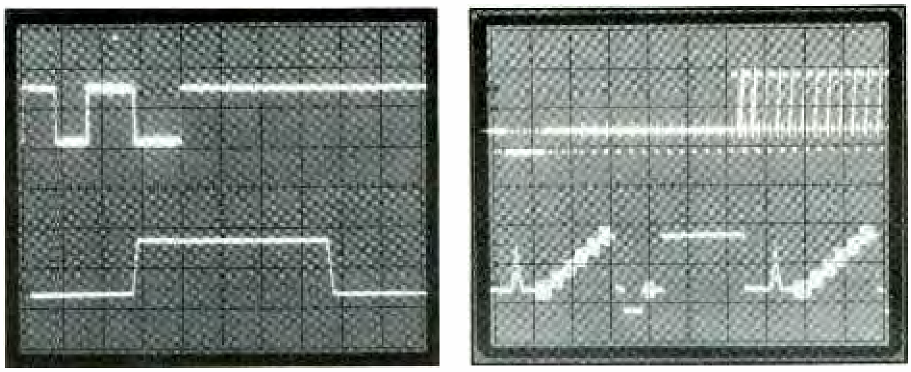

Fig. 12. Alternate delayed-sweep measurements are fast and accurate. One use (left photo) is examination of timing in a digital circuit. Another (right photo) shows one field of a composite video signal (upper waveform), where the intensified field is the lines magnified by the faster B sweep.

In Conclusion

Making an investment of several hundred to more than one thousand dollars to buy a high-performance general-purpose oscilloscope implies a commitment to better electronic testing and servicing. Naturally, this extends to learning how to use the instrument to its utmost capability to reap all of the benefits it has to offer. So be sure to set aside the time needed to fully acquaint yourself with your new scope. **ME**