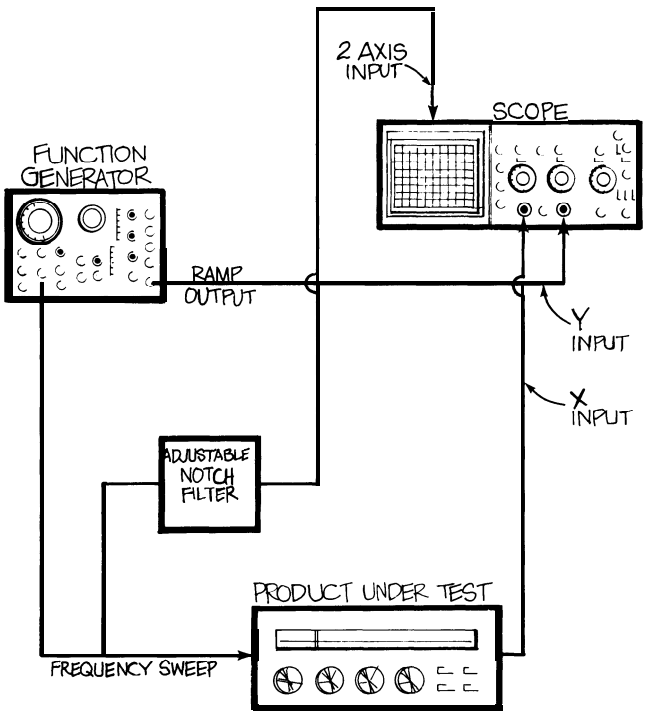


Figure 29.
USING THE Z-AXIS can provide additional information on the scope screen. In the set-up drawn above, a function generator sweeps through the frequencies of interest during the product testing-20 to 20,OOO Hz, in this case. Then an adjustable notch filter is used to generate a marker, at 15 kHz, for instance, and this signal is applied to the Z-axis input to brighten the trace. This allows the tester to evaluate the product's performance with a glance.

Using TV Triggering

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

To look at tv fields with a 2200 Series scope, use the TV FIELD mode. This mode allows the scope to trigger at the field rate of the composite video signal on either field one or field two. Since the trigger system cannot recognize the difference between field one and field two, it will trigger alternately on the two fields and the display will be confusing if you look at one line at a time.

To prevent this, you add more holdoff time, and there are two ways to do that. You can use the variable holdoff control, or you can simply switch the vertical operating mode to display both channels. That makes the total holdoff time for one channel greater than one field period. Then just position the unused vertical channel off-screen to avoid confusion.

It is also important to select the trigger slope that corresponds to the edge of the waveform where the sync pulses are located. Picking 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. Often delayed sweep is used as a convenient way to make a measurement (the rise time measurement in Exercise 10 is a good example). To make a rise time measurement without delayed sweep, you must trigger on the edge occurring before the desired transition, With delayed sweep, you may choose to trigger anywhere along the displayed waveform and use the delay time control to start the sweep exactly where you want.

Sometimes, however, delayed sweep is the *only* way to make a measurement. Suppose that 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: trigger where you have to. and delay out to where you want the sweep to start.

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

Since the 2200 Series has two types of delayed sweep, read the paragraphs and use the delayed sweep measurement exercise below that applies to your scope: "Single Time Base Scopes" and Exercise 10 for delayed sweep measurements with single time base scopes like the Tektronix 2213; or "Dual Time Base Scopes" and Exercise 11 for delayed sweep on dual time base scopes like the 2215.

Single Time Base Scopes

Very few single time base scopes offer delayed sweep measurements. Those that do may have measurement capabilities similar to those of the Tektronix 2213 which has three possible horizontal operating modes annotated on the front panel as NO DLY, INTENS, and DLY'D.

When you set the HORIZONTAL MODE switch to NO DLY (no delay), only the normal sweep functions.

When you choose INTENS (intensified sweep), your scope will display the normal sweep and the trace will also be intensified after a delay time. The amount of delay is determined by both the DELAY TIME switch (you can use 0.5 μs, 10 μs, or 0.2 ms) and the DELAY TIME MULTIPLIER control. The multi-

plier lets you pick from 1 to 20 times the switch setting.

The third position, DLY 'D (delayed), makes the sweep start after the delay time you 've chosen. After selecting this position you can move the SEC/DIV to a faster sweep speed and examine the waveform in greater detail.

This list of horizontal modes should begin to give ideas of how useful these delayed sweep features are. Start by making the rise time measurement described below. (Note that when making rise time measurements, you must take the rise time of the measuring instrument into account. Be sure to read Chapter IO.)

Dual Time Base Scopes

Delayed sweep is normally found on dual time base scopes like the 2215 with two totally separate horizontal sweep generators. In dual time base instruments, one sweep is triggered in the normal fashion and the start of the second sweep is delayed. To keep these two sweeps distinct when describing them, the delaying *sweep* is called the A *sweep;* the delayed *sweep* is called the B *sweep.* The length of time between the start of the A sweep and the start of the B sweep is called the delay time.

Dual time base scopes offer you all the measurement capabilities of single time base instruments, plus:

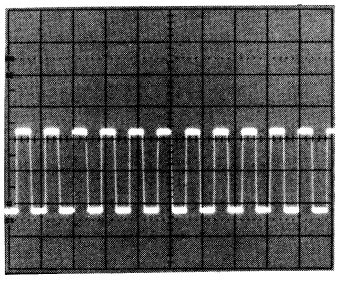
- convenient comparisons of signals at two different sweep speeds
- jitter-free triggering of delayed sweeps
- and timing measurement accuracy of 1.5%.

Most of this increase in measurement performance is available because you can separately control the two sweep speeds and use them in three horizontal operating modes. These modes — in a 2215 — are A sweep only, B sweep only, or 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 a 2215 -control the sweep speeds. See Figure 30.

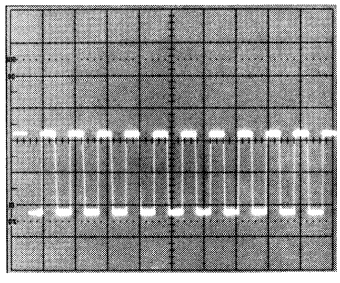
When you use the ALT (for alternate horizontal mode) position the HORIZONTAL MODE switch, the scope will display the A sweep intensified by the B sweep and the B sweep delayed. As you set faster sweeps with the B SEC/DIV switch, you'll see the intensified zone on the A trace get smaller and the B sweep expanded by the new speed setting. As you move the B DELAY TIME POSITION dial and change where the B sweep starts, you'll see the intensified zone move across the A trace and see the B waveform change.

This sounds more complicated in words than it is in practice. As you use the scope in Exercise 11, you'll find that the procedure is very easy. You will always see exactly where the B sweep starts. And you can use the size of the intensified zone to judge which B sweep speed you need to make the measurement you want.

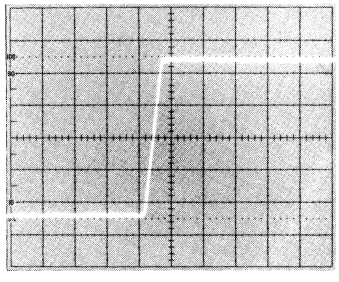
Exercise 10.2213 DELAYED SWEEP MEASUREMENTS



1. Connect your probe to the channel 7 BNC connector and the probe adjustmentjack, hook the ground strap onto the collar of the channel2 BNC, and make sure the probe is compensated.
2. Use these control settings: CH 7 VOLTS/D/V on 0.2 using the **10X** *probe VOLTS/DIV readout; CH 7 input coupling on AC; VERTICAL MODE is CH 7; TRIGGER MODE is AUTO; TRIGGER SLOPE is negative (-); trigger SOURCE is INT (for internal) and INT trigger switch is either CH 7 or VERT MODE; HORIZONTAL MODE is NO DLY; SEC/DIV is 0.5 ms. Check all the variable controls to make sure they're in their calibrated detent positions.*
3. Set the input coupling to G ND and center the trace. Switch back to AC and set the trigger LEVEL control for a stable display. The waveform should look like the first photo above.



4. Because a rise time measurement is best made at faster sweep speeds, turn the SEC/DIV control to 2 μs. Use the trigger LEVEL control to try to get all of the positive transition on the screen. You can't; you lose your trigger when you get off the slope of the signal.
5. Turn back to 0.5 msldiv and switch to the intensified display with the HORIZONTAL MODE switch. Switch the DELAY TIME to 0.2 ms and use the DELAY TIME MULTIPLIER to move the intensified zone on the waveform to a point before the first complete positive-going transition of the square wave. The intensified zone now shows you where the delayed sweep will start, like the second photo.
6. Switch the horizontal mode to DLY'D and the SEC/DIV switch to 5 μs. Now you can use the horizontal POSITION and DELAY TIME MULTIPLIER controls to get a single transition on the screen.



7. Change to 0.7 Vldiv and line up the signal with the 0 and 700% dotted lines of the graticule. (If you have a signal that doesn't fit between the 0 and 700% lines of the graticule, you have to count major and minor divisions and estimate the rise time while ignoring the first and last 70% of the transition.)

8. Use the horizontal POSITION control to move the waveform until it crosses a vertical graticule line at the 70% marking. Adjust the FOCUS control for a sharp waveform and make your rise time measurement from that vertical line to where the step crosses the 90% line. Now you can make a rise time measurement on a waveform like that in the third photograph. For example, for 7 major division and 4 minor divisions: 7.8 times the SEC/DIV setting of 5 μs is 9 μs.

Measurements at Two Sweep Speeds

Looking at a signal with two different sweep speeds makes complicated timing measurements easy. The A sweep gives you a large slice of time on the signal to examine. The intensified zone will show you where the B sweep is positioned. And the faster B sweep speeds magnify the smaller portions of the signal in great detail. You'll find this capability useful in many measurement applications; see Figure 31 for two illustrations.

Because you can use the scope to show A and B sweeps from both channel 1 and channel 2, you can display four traces. To prevent overlapping traces, most dual time base scopes offer an additional position control. On the 2215, it's labeled ALT SWP SEP for alternate sweep separation. With it and the two vertical channel POSITION controls, you can place all four traces on-screen without confusion.

Separate B Trigger

Jitter can prevent an accurate measurement anytime you want to look at a signal that isn't perfectly periodic. But with two time bases and delayed sweep, you can solve the problem with the separate trigger available for the B sweep. You trigger the A sweep normally and move the intensified zone out to the portion of the waveform you want to measure. Then you set the scope up for a triggered B sweep, rather than letting the B sweep simply run after the delay time.

On a 2215, the B TRIGGER LEVEL control does double duty. In its full clockwise position, it selects the run-after-delay mode. At any other position, it functions as a trigger level control for the B trigger. The B TRIGGER SLOPE control lets you pick positive or negative transitions for the B trigger.

With these two controls you can trigger a stable B sweep even when the A sweep has jitter.

Increased Timing Measurement Accuracy

Besides examining signals at two different sweep speeds and seeing a jitter-free B sweep, you get increased timing measurement accuracy with a dual time base scope.

Note that the B DELAY TIME POSITION dial is a measuring indicator as well as a positioning device. The numbers in the window at the top of the dial are calibrated to the major divisions of the scope screen. The numbers around the circumference divide the major division into hundreds.

To make timing measurements accurate to 1.5% with the B DELAY TIME POSITION dial:

- use the B runs-after-delay mode.
- place the intensified zone (or use the B sweep waveform) where the timing measurement begins, and note the B DELAY TIME POSITION dial setting
- dial back to where the measurement ends and note the reading there
- subtract the first reading from the second and multiply by the A sweep SEC/DIV setting.

You'll find an example of this accurate — and easy — timing measurement in Exercise 11.

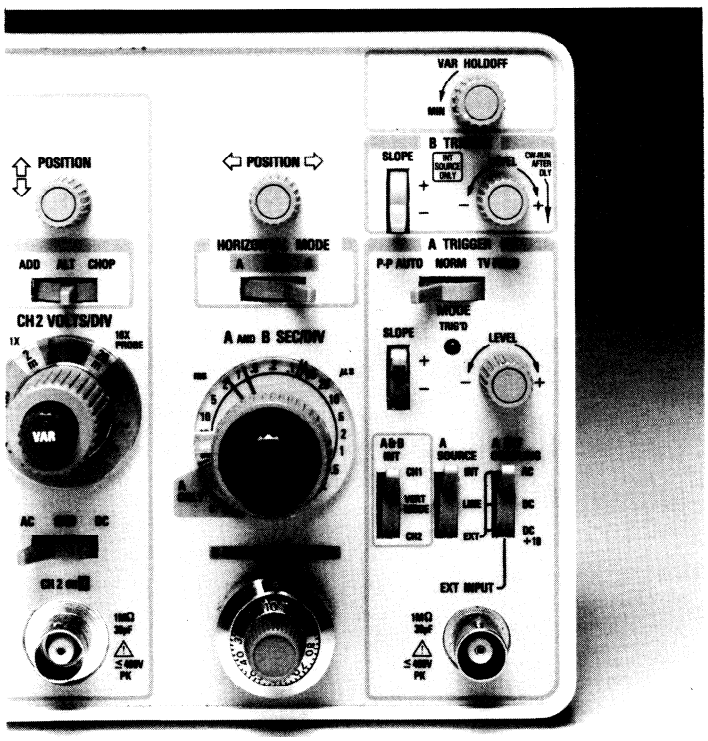


Figure 30.
THE DELAYED SWEEP CONTROLS of the dual time base 2215 are shown on the photograph above. They include: HORIZONTAL MODE (under the horizontal POSITION control); B TRIGGER SLOPE and LEVEL; ALT SWP SEP (alternate sweep separation, between the two vertical POSITION controls — not shown), and a concentric A and B SEC/DIV control. The B DELAY TIME POSITION dial is at the bottom of the column of horizontal system controls.

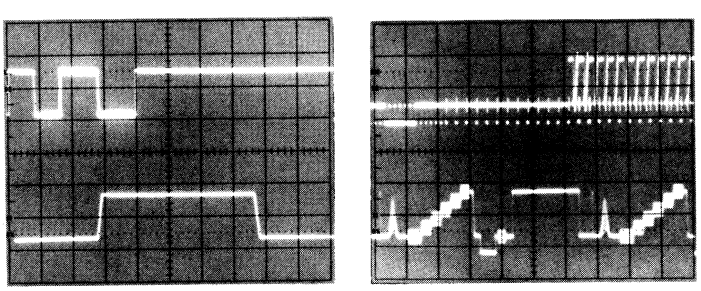
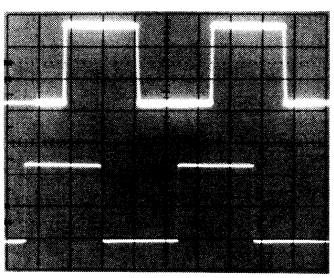
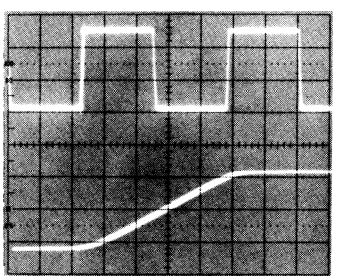


Figure 31.
ALTERNATE DELAYED SWEEP MEASUREMENTS are fast and accurate. One use, examining timing in a digital circuit, is demonstrated in the firs photograph. Suppose you need to check the width of one pulse in a pulse train like the one shown. To make sure which pulse you are measuring, you want to look at a large portion of a signal. But to measure the one pulse accurately, you need a faster sweep speed. Looking at both the big picture and a small enlarged portion of the signal is easy with alternate delayed sweep. Another example is shown in the second photo. Here one field of a composite video signal is shown in the first waveform. The intensified portion of that field is the lines magnified by the faster B sweep. With a dual time base scope, you can walk through the field with the B DELAY TIME POSITION dial and look at each line individually.

Exercise 11.2215 DELAYED SWEEP MEASUREMENTS

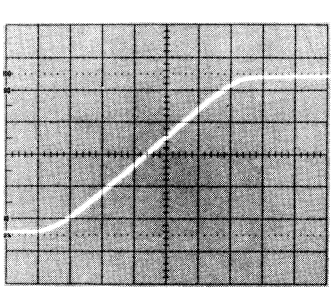
Rise Time Measurement





1. Connect your probe to the channel **7** *BNC connector and the probe adjustmentjack, hook the ground strap onto the collar of the channel2 BNC, and make sure the probe is compensated.*
2. Use these control settings: CH 7 VOLTS/DIV on 0.2 (remember to use the 10X probe readout); CH 7 input coupling on AC; VERTICAL MODE is CH 7; A TRIGGER MODE is NORM; A TRIGGER SLOPE is negative (-); A SOURCE is INT and the A&B INT trigger switch is either CH 7 or VERT MODE; HORIZONTAL MODE is A; A and B SEC/DIV is 0.2 ms. Check the variable controls to make sure they're in their calibrated detent positions.
3. Set the A TRIGGER LEVEL control for a stable display and position the waveform in the top half of the screen. Switch to the ALT (for alternate A and B sweeps) display with the HORIZONTAL MODE switch. Use the channel 7 POSITION and ALT SWP SEP (alternate sweep separation) controls to position the two sweeps so that they don't overlap.
4. Use the B DELAY TIME POSITION dial to move the beginning of the intensified zone a point before the first complete positive transition. Your screen should look like the first photo above.

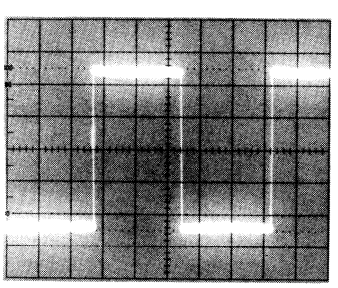
5. Pull out on the SEC/DIV knob and rotate it clockwise to change the B sweep speed to 2 μs /division. This will make the intensified zone smaller; move it to the first rising edge of the waveform as in the second photograph.
6. Switch the horizontal mode to B, the channel 7 vertical sensitivity to 0.7 volts/division, and the sweep speed to 7 μs/division. Use the horizontal and vertical POSITION controls and the B DELAY TIME POSITION control to line up the waveform with the 0 and 700% dotted lines of the graticule. (If you have a signal that doesn't fit between the 0 and 700% lines of the graticule, you have to count major and minor divisions and estimate the rise time while ignoring the first and last 10%.)

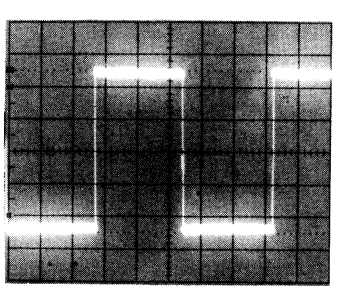


7. Position the waveform so that it crosses a vertical graticule line at the 70% marking. Adjust the FOCUS control for a sharp waveform and count major and minor divisions across the screen to where the step crosses the 90% line. If there are 4 major and 8 minor divisions, 4 and 8/10 times the SEC/DIV setting of 7 μs is 4.8 μs. The third photo shows how the screen should look now. (Note: Any jitter you see in the B sweep is from the probe adjustment circuit, not the time base.)

8. One last word on rise time measurements: the accuracy of the measurement you make depends on both the signal you're examining and the performance of your scope. In Chapter 70, you'll find a description of how the scope's own rise time affects your measurement results.

Pulse Width Measurement





1. Use these control settings: CH 7 VOLTS/D/V on 0.7; CH 7 input coupling on AC; VERTICAL MODE is CH 7; A TRIGGER MODE is NORM; A TRIGGER SLOPE is negative (-); A TRIGGER SOURCE is INT (for internal) and INT trigger switch is either CH 7 or VERT MODE; HORIZONTAL MODE is A; A SEC/DIV is 0.2 ms while B SEC/DIV is 0.05 μs. Check the variable controls.
2. Center the first complete pulse of the waveform horizontally. Switch to the A LT display with the HORIZONTAL MODE switch and move the B waveform to the bottom of the screen with the ALT SWP SEP control.
3. Center A sweep waveform vertically. Turn down the intensity so that it's easier to see the small intensified zone.
4. Move the intensified zone to the 50% point of the rising edge of the waveform with the DELAY TIME POSITION controlas in the first photo above. Note the delay time reading (the number in the window first, for example: 3.7). Move the intensified zone to the 50% point of the trailing edge as in the second photo and note the reading.
5. The time measurement, a pulse width in this case, is equal to the second dial reading minus the first times the A sweep speed: 5.77 – 3.73 x 0.2 ms = 0.528 ms. In other words, the B DELAY TIME POSITION dial indicates screen divisions for you, 7 complete turn for every major division.