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tech tips

Learning To Use The SC3100 "AUTOTRACKER"

At first glance the SC3100 "Auto Tracker" Automatic 100 MHz Waveform & Circuit Analyzer™ looks like any other conventional oscilloscope. However, the SC3100 has many powerful features to speed your waveform viewing and measuring. This Tech Tip will help you get started using the SC3100 and its features.

To better understand the SC3100's features, let's review what is needed to fully analyze any waveform. Figure 1 illustrates these waveform parameters: 1) waveshape, 2) average DC level, 3) peak-to-peak amplitude, 4) frequency, 5) average RMS (sine wave signals), 6) peak-to-peak of a waveform portion, 7) time of a waveform portion, 8) equivalent frequency of a waveform portion, and 9) instantaneous DC level at a given point on the waveform.

You can get an approximate measurement of these parameters using an oscilloscope's CRT, but this method is time consuming and inaccurate. The SC3100 Waveform & Circuit Analyzer, however, integrates the waveform viewing capabilities of a high
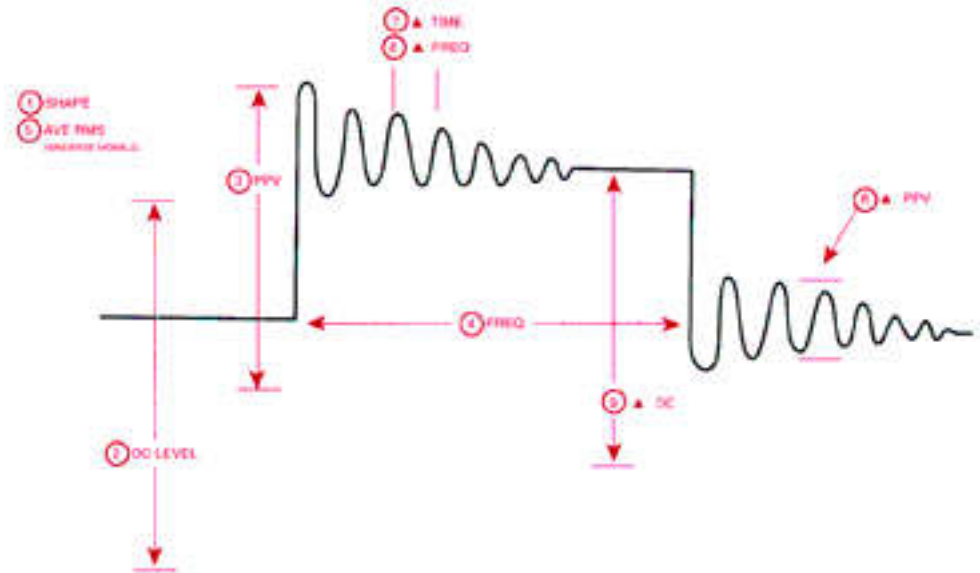

Fig. 1: Nine parameters are needed to analyze a waveform.

performance oscilloscope with the speed and measurement accuracy of a digital meter. This saves you time and frustration on every measurement you make.

To make the SC3100 easier to understand, we've divided this Tech Tip into two parts. Part 1 covers the oscilloscope section and Part 2 covers the digital analyzing features.

Part 1 - Oscilloscope Section

You only need the SC3100's CRT to view the waveshape; the remainder of the waveform parameters shown in Figure 1 are measured using the SC3100's digital functions. The SC3100's oscilloscope portion is similar to other high performance dual trace scopes. The

SC3100's front panel controls are grouped by function. To display a waveform on the CRT you will need to perform the following steps:

1) select the CRT display mode
2) apply the signal

3) adjust the vertical controls
4) adjust the trigger controls
5) adjust the horizontal controls

CRT Display Mode

The CRT Mode buttons located directly below the CRT, as shown in Figure 2, determine what is displayed on the CRT. These buttons perform the following functions:

These buttons allow you to view either the signal applied to the CH A INPUT or the
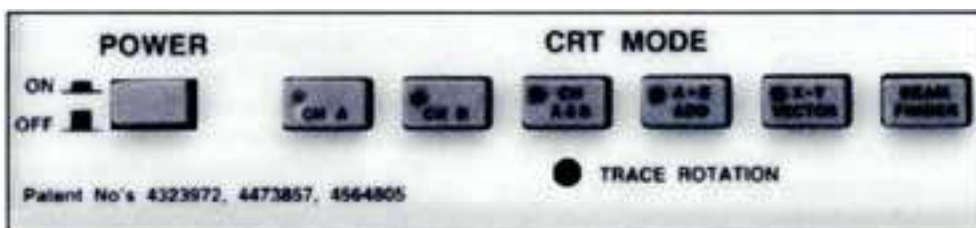

Fig. 2: Use the CRT Mode buttons to select the CRT display.

CH B INPUT on the CRT. Push the button that corresponds to the desired input.

CH A&B
Press this button to view the signal on both channels simultaneously.

A+B ADD
A few special applications require that two signals be added or subtracted. Press the "A+B ADD" button to add the signals applied to the CH A and CH B inputs together into a single waveform. Pull the CH A VERTICAL POSITION control out to display the difference (A-B) of the signals.

X-Y VECTOR
Press this button for an X-Y vector display. The signal applied to the CH A input produces vertical deflection, and the CH B signal produces horizontal deflection.

Applying Signals

Two, 10X Lo Capacity probes are supplied with your SC3100 The CRT and vertical circuits provide a proper amplitude CRT display when these 10X probes are used. You simply read the Volts/Div control directly when using the supplied 10X probes. The 10X probes allow you to view waveforms up to 2,000 volts.

Each probe has its own separate ground lead. Always connect each probe ground to the circuit ground using the shortest ground lead possible to prevent ringing and noise pickup.

WARNING

Do not connect the probe ground leads to a hot chassis. Always use an isolation transformer, such as the PR57 POWERITE or PR570, on any piece of equipment that is AC operated and does not have an internal isolation transformer.

You can use the optional DP270 direct probe to take full advantage of the SC3100's 2mV/div vertical sensitivity. If you use a direct probe, you will need to divide the numbers on the Volts/Div control by ten to determine the actual waveform amplitude displayed by the CRT. The digital readings are automatically corrected, and are read direct.
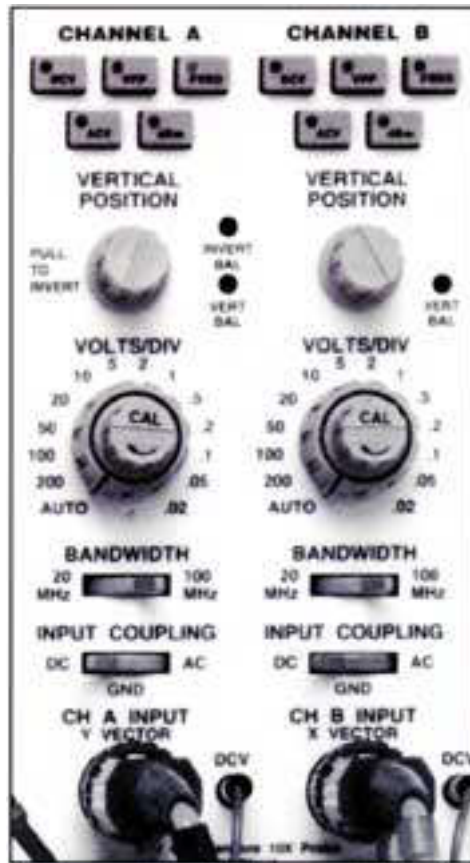

Fig. 3: Use these controls to adjust the vertical display.

Vertical Controls

The SC3100's vertical controls, shown in Figure 3, are used to adjust the vertical (amplitude) characteristics of the displayed waveform. Two identical sets of controls are provided - one for the channel A input and one for channel B.

Input Coupling
This switch determines how the signal is coupled to the SC3100's vertical amplifiers. In the "DC" position, the DC component of the signal is applied to the vertical circuits and will deflect the CRT trace. In the "AC" position, the DC component is blocked from deflecting the CRT trace.

Volts/Div
The Volts/Div control determines the amplitude of the waveform display. Because the SC3100's digital measurements are faster and much more accurate than the CRT, the role of the SC3100's Volts/Div control is greatly diminished compared to conventional oscilloscopes. Set the Volts/Div control for the desired size of the waveform displayed on the CRT.

The variable "cal" control (smaller inside knob) fine tunes the waveform's amplitude. This control must be set to the "Cal" detent to make measurements using the CRT display, but it will not affect the digital measurements.

The SC3100 has an exclusive 2 mV to 2000 volt input measuring range. This allows you to measure tiny signals, such as the output of a tape playback, or very large signals, such as the pulse at the collector of the horizontal output transistor. The input circuitry is protected against damage from voltages up to 2500 volts when the supplied 10X Lo Capacitance probes are used. This protection applies to all settings of the Volts/Div control.

Autoranging
An exclusive, timesaving feature of the SC3100 is its fully autoranged vertical attenuator. Simply set the Volts/Div control to "Auto" and the SC3100 automatically ranges to the Volts/Div range that produces a waveform display that is between 2 to 4 divisions high. (Signals larger than 800 VPP will be greater than 4 divisions).

The CRT will continue to autorange and follow the signal as you move between test points, or as the signal changes. Be sure to select "AC" coupling to prevent the DC component of the input signal from shifting the waveform off the CRT.

Bandwidth
The Bandwidth switch limits the frequency response of both the CRT and digital measuring circuits. Select "20 MHz" to reduce interference from high frequencies. This is especially important when using the lowest Volts/Div control (.02 & .05 & .1) settings. You will want to use the "100 MHz" position for most applications to take advantage of the full bandwidth.

Trigger Controls

The trigger circuits, shown in Figure 4, lock the horizontal sweep circuits to the incoming signal to provide a stable, "locked-in" waveform. If the trigger controls are set incorrectly, the waveform display will jitter and not stand still. Unlike many other oscilloscopes that have numerous trigger controls, the SC3100 requires only four trigger adjustments.
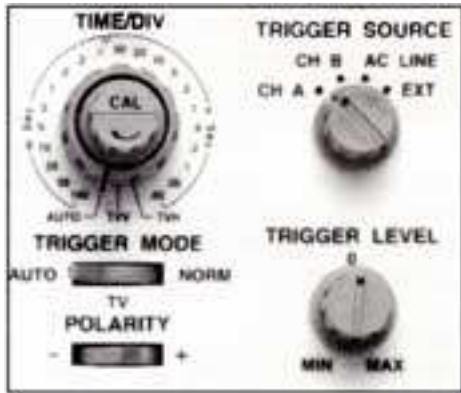
Fig. 4: The trigger controls to lock the waveform.

Trigger Source

The Trigger source control determines which input references the horizontal sweep. For most waveforms, simply set this control to match the input channel, either A or B. If you are viewing two synchronous signals that are different frequencies, set the source to the channel that has the lowest frequency.

Use "AC Line" to reference the trigger circuits to the AC power line when troubleshooting AC power supplies or isolating ripple. Use the "EXT" position to reference the trigger circuits to a signal applied to the EXT TRIG INPUT jack.

Trigger Mode

The Trigger Mode switch sets the trigger circuit operation to meet the requirements of the signal you are viewing. Use "Auto" to view most waveforms, except video or low repetition rate signals.

Use "TV" to view video waveforms. This mode enables a sync separator circuit which easily locks to composite video signals. The trigger circuits are automatically referenced to the vertical sync pulses when the TIME/DIV control is set to the "mSec" positions, and to the horizontal sync pulses when the TIME/DIV control is set to the "µSec" positions.

Use the "Norm" trigger mode to lock onto low repetition rate signals that are unstable when viewed in the "Auto" trigger mode.

Note: Don't confuse the "Auto" trigger mode with the vertical and horizontal autoranging functions. Auto trigger mode automatically shows a trace whether or not the trigger circuit is locked. It does

not automatically trigger a waveform - you must still properly set the trigger controls.

Trigger Polarity

The Trigger Polarity switch determines whether the trigger circuits respond to the rising or falling edge of the reference signal. Except for composite video signals, most waveforms will lock in either the "+" or "-" polarity. Set the Trigger Polarity switch to match the polarity of the sync pulses when viewing video signals.

Trigger Level

The Trigger Level control determines the point on the waveform that triggers the trigger circuits. For most applications, set the Trigger Level control near the "0" reference mark. Adjust the level control if necessary for a stable waveform display.

Horizontal Timebase

Like conventional oscilloscopes, the SC3100 has a calibrated timebase which allows you to make time and frequency measurements. But, because the SC3100's digital measurements are much faster and more accurate than CRT measurements, the main use of the horizontal timebase is simply for waveform viewing.
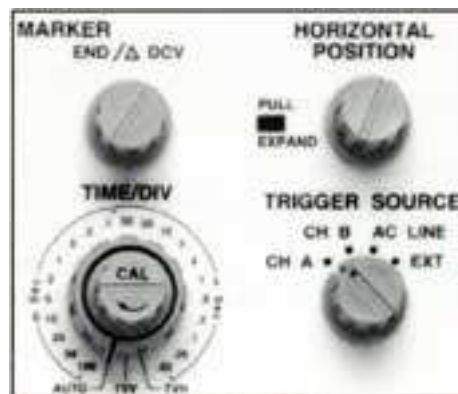

Fig. 5: Use these controls to adjust the horizontal detail of the displayed waveform.

For most applications, simply set the Timebase (Time/Div) and vernier (Cal) controls for the desired amount of waveform detail. Pull the HORIZONTAL POSITION control outward to activate the 10X expand function to see more detail.

Autorange

As with the vertical Volts/Div control, the horizontal timebase has an exclusive,

timesaving autorange position. Set the timebase control to "Auto" to allow the "AUTO TRACKER"™ to automatically choose the necessary sweep speed to display 2 to 5 cycles of the waveform. (Frequencies higher than 25 MHz will result in a display of more than 5 cycles). Neither the 10X expand or the horizontal vernier are controlled by the autorange function. You can use these controls with "auto" to fine tune the waveform display.

In order for the timebase to autorange correctly, the waveform must be properly locked with the Trigger circuits. For most waveforms, set the LEVEL to "0" and set the SOURCE to match the input. The timebase will not autorange when the TRIGGER MODE switch is set to "TV". Instead, use the video presets to automatically view a video waveform.

Video Presets

The TVV and TVH positions of the timebase control are called the video presets. These presets provide a quick way to view video waveforms because they automatically set the sweep speed and trigger circuits to view a composite video signal. "TVV" displays two vertical fields (1 frame) of the video signal, while the "TVH" position will display 2 lines.

You do not need to select "TV trigger" when using the TVV or TVH presets. However, you must set the TRIGGER "Polarity" control to match the sync polarity of the video signal.

Simplified CRT Setup

Use the following procedure illustrated in Figure 6 as a checklist for obtaining a waveform display on the SC3100:

1. Push the POWER button.

2. Press the desired CRT MODE button to produce a single trace, dual trace, or vector display.

3. Apply the signal to the vertical input:
   a. Connect the 10X Lo Capacity probes to the INPUT.
   b. Connect the probe to the signal.
   c. Set the INPUT COUPLING to "AC."
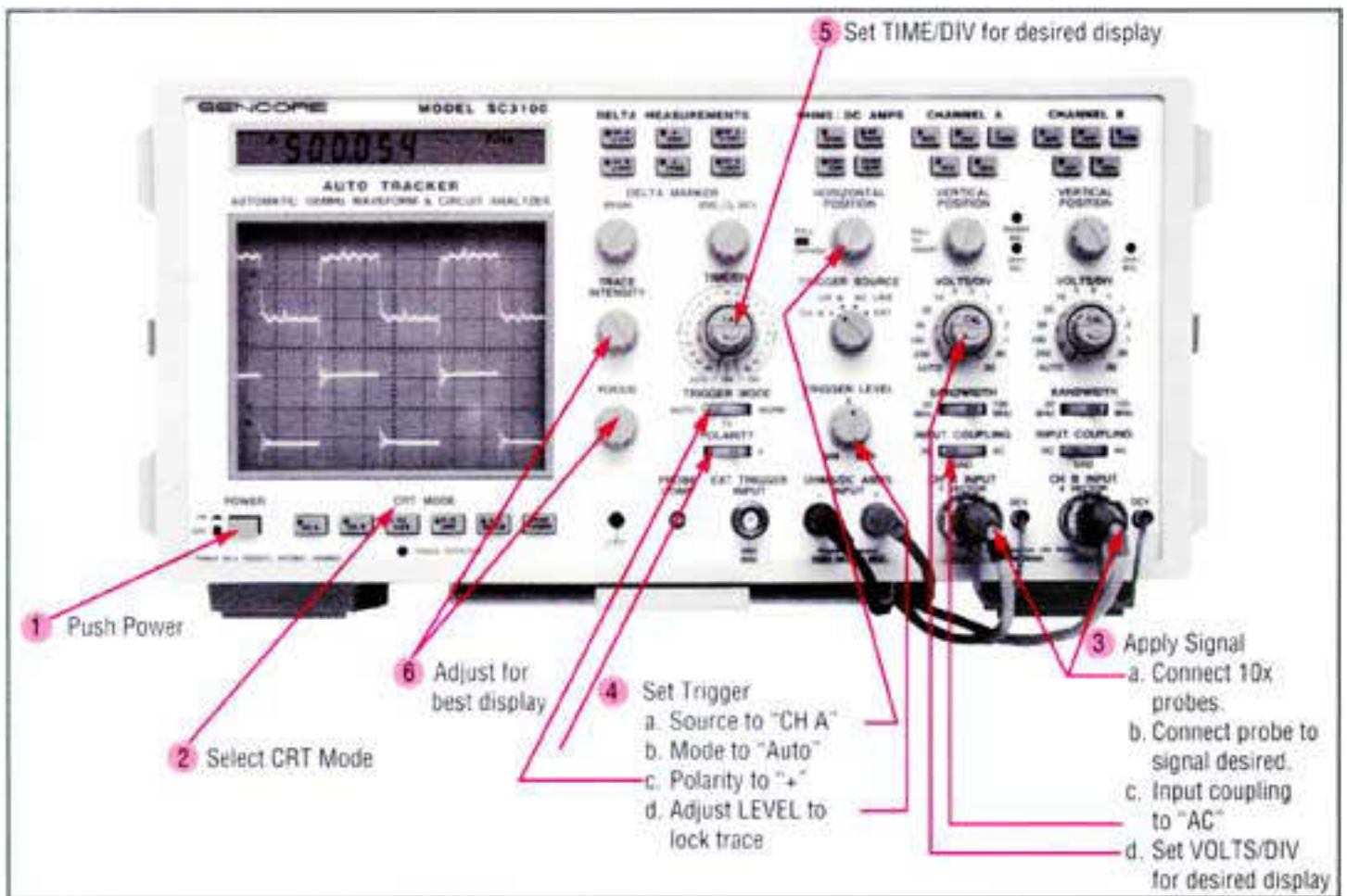   d. Set VOLTS/DIV to "Auto", or for a display 4-6 divisions high.

Fig. 6: Follow this sequence to get a trace on the CRT.

4. Adjust the TRIGGER controls:
   a. Set SOURCE to input channel.
   b. MODE to "Auto", or "TV" for video signals.
   c. POLARITY to desired polarity. Set to match sync polarity of video.
   d. Adjust LEVEL to lock waveform.

5. Set TIME/DIV to "Auto" or for desired number of cycles.

6. Adjust VERTICAL POSITION, HORIZ POSITION, FOCUS, and INTENSITY controls for the best display.

The digital measurements are faster and much more accurate than measurements based on the CRT. The readings follow the applied signal without you needing to adjust any controls. You can have the CRT display adjusted any way you want, without causing a measurement error.

In fact, you don't even need to have the waveform locked or displayed for most of the Auto-Tracking measurements. Because the digital measuring circuitry is separate from the analog CRT path, the readings are many times more accurate. Additionally, the digital measurements are free from estimating errors, calculation errors, interpretation errors, and setup errors.

Part 2 - Digital Analyzing Functions

The SC3100's digital measurement functions allow you to quickly and accurately measure the waveform parameters shown in Figure 1 without counting CRT graticules. All of the waveform parameters, except for the waveshape itself, are measured with either the Auto-Tracking or the Delta digital functions. Additionally, the AUTO TRACKER™ provides several circuit parameter tests. The Auto-Tracking and Delta measurements are made using the same probe that applies signals to the CRT.

The parameter tests are made using the DVM probes connected to the OHMS/DC AMP INPUT jacks.

Auto-Tracking Measurements

The Auto-Tracking tests, shown in Figure 7, measure the entire waveform. Unlike other digital readout oscilloscopes, the SC3100 readings are independent of the CRT circuits and are accurate for all CRT settings.

Auto-Tracking DC Volts
Simply press the "DCV" button for the corresponding channel and read the DC level of the applied signal. You will obtain the correct DC measurement no matter where the INPUT COUPLING or VOLT/DIV controls are set. (Be sure that you connect the mini-banana plug to the input connector on the front of the SC3100.)

This DCV function measures average DC voltage which is the value that is indicated
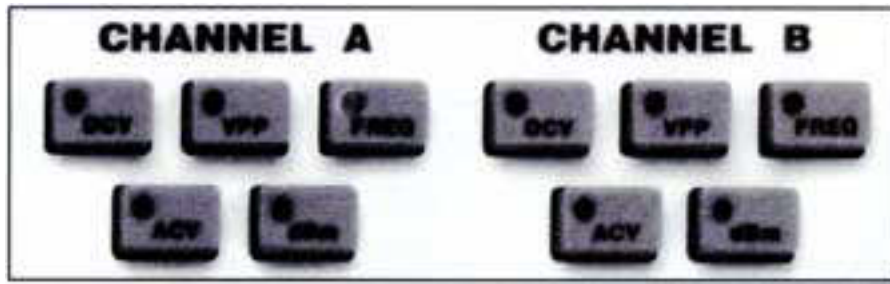
Fig. 7: The Auto-Tracking digital tests measure the entire waveform.

on schematics and measured by a DVM. If you need to measure the absolute or DC level at a single point on the waveform, such as to determine a logic level, you will need to use the Delta DC function.

Auto-Tracking Volts Peak-to-Peak

Press the corresponding "VPP" button to measure the peak-to-peak amplitude of the signal. The VPP function is semi-autoranged and the VOLTS/DIV control selects each of the four digital VPP ranges. If the digital reading shows flashing "8888", turn the VOLTS/DIV control counter-clockwise; if the digital readout shows very little resolution, turn the control clockwise. If you place the VOLTS/DIV control in the "Auto" position, both the CRT display and digital reading will fully autorange.

At times you may notice an apparent discrepancy between the amplitude of the waveform displayed by the CRT and the digital peak-to-peak reading. The digital circuits have a much better basic accuracy than the CRT display. The CRT accuracy is 4% with a frequency response of 3 dB, while the digital circuits are 2% with a frequency response of 0.5 dB to 30 MHz.

The digital meter also detects overshoot, fast spikes and random noise which are easily overlooked on the CRT. You can use the delta PPV function described later to pinpoint the location of these interferences on the waveform.

Auto-Tracking Frequency

Pressing the corresponding "Freq" button displays the frequency of the applied signal. The frequency function is fully autoranged for all settings of the TIME/DIV control.

You can measure the frequencies of two unrelated or asynchronous signals applied to the inputs, but there are two things to

remember: 1) If you want to measure the frequency of the same channel that is triggering the CRT, the waveform must be properly triggered; 2) If you are measuring the signal on the channel that is not triggering the CRT, the signal must be at least 1.5 CRT divisions high.

Auto-Tracking ACV

The ACV function measures the true RMS value of sine wave signals. This reading compares directly to values listed in service literature and to true RMS reading DVMs

Only use the ACV measurement for sine wave signals, as it is not meaningful for other waveshapes. Like the VPP function, the ACV readings are semi-autoranged.

Auto-Tracking dBm

Audio service literature often lists the signal levels in dBm. The SC3100's dBm function provides the industry standard signal measurement of 0 dBm = 1 milliwatt into 75 ohms (.7746 volts RMS).

Only use the ACV measurement for sine wave signals, as it is not meaningful for other waveshapes. Like the VPP and ACV functions, the dBm readings are semi-autoranged.

Delta Measurements

The Delta tests, shown in Figure 8, allow you to measure just selected portions of the waveform. Although you manually set the area to be measured, the Delta Measurements provide a much more accurate measurement than can be made by counting graticlues on the CRT for two reasons. First, each measurement is made using the same high accuracy circuits that are used to for the Auto-Tracking digital measurements, rather than the less accurate CRT circuits. Secondly, the Delta Bar, which is used to highlight the measured waveform portion, is part of the

CRT trace which virtually eliminates parallax and interpretation errors.

The Delta measurements are accurate for all VOLTS/DIV and TIME/DIV control and vernier settings. Selecting any of the Delta measurement functions disables the vertical and horizontal autoranging functions. The SC3100 will not automatically range to follow large changes in the input signal when a Delta function is selected.

Delta Bar

Each of the Delta measurements uses a highlighted portion of the trace to indicate the portion that is being measured. This highlighted area is called the Delta Bar. The area selected by the intensified Delta Bar is adjusted using the DELTA MARKER "Begin" and "End" controls. (The Delta DCV functions use a bright dot on the trace which is only adjusted with the "End/Delta DC" control). The Delta Bar appears on both traces. However, the measurement is made only on the selected channel.

Delta Volts Peak-to-Peak

Press either of the Delta "VPP" buttons to measure the amplitude of the intensified portion of the corresponding trace. The setting of the VOLTS/DIV control selects the range of the Delta VPP reading, the same as it does for the Auto-Tracking peak-to-peak function. The setting of the vernier, however, does not affect the measurement resolution or accuracy.

Delta Time

The Delta time function allows you to measure any waveform time relationship. This includes pulse width, and rise and fall times on individual signals, and time delay

Fig. 8: The Delta functions allow you to measure just a portion of the waveform.

or phase between two signals. The Delta Time measurement is not affected by the setting of the 10X expand or the horizontal vernier control.

Delta Frequency

The Delta Frequency function converts the Delta Time reading to the approximate frequency. The main application of this function is to determine the frequency of a signal that is part of another signal. The Delta Frequency measurement is less accurate than the Auto-Tracking measurement because it relies on how closely you estimate the beginning and ending point of one cycle. However, the Delta Frequency measurement is far more accurate than a measurement using the CRT.

Delta DCV

The Delta DC volts function allows you to measure the absolute or instantaneous voltage at any point on a waveform. This instantaneous voltage is the voltage level that the circuit responds to, such as a logic "high" or "low". Use the DELTA MARKER "End/Delta DCV" control to set the location of the highlighted marker on the waveform.

Note: The Delta DCV test will not work if the VOLTS/DIV control is set to "Auto".

Circuit Parameter Tests

The SC3100 Automatic Waveform & Circuit Analyzer allows you to completely analyze a circuit. The parameter tests include an ohmmeter, continuity tester, and a DC current meter. These test are completely separate from the CRT, and the Auto-Tracking and Delta digital tests. Each

Fig. 9: Parameter test functions.

of the Parameter tests are made using the red and black OHMS/DC AMPS INPUT Jack, as shown in Figure 9.

Ohms & Continuity Test Zero

The SC3100 automatically subtracts the test lead resistance from each resistance measurement or continuity test after you set the ohms zero. To zero the test leads simply connect the test leads together and momentarily press the OHMS ZERO button. The ohms zero remains in memory for each measurement until you re-zero a new amount. or turn off the SC3100.

Ohms Measurements

The ohms function allows you to measure resistance values up to 100 megohms. The readings are fully autoranged, and readings below 210 ohms are provided with 0.01 ohm resolution. Be sure to zero the test lead resistance before using the ohms measurement function.

Continuity Test

The continuity test provides a near-instantaneous audible indication of circuit continuity. The audio tone will sound if the resistance at the test leads is less than

approximately 10 ohms. The digital meter displays resistance readings up to 210 ohms in the Continuity Test. However, in order to maintain a fast audible response, the resolution is limited to 1 ohm. Always use the Ohms function to make accurate resistance measurements. Be sure to zero the test lead resistance before using the continuity test.

DC Current

The SC3100 rounds out your waveform and circuit analyzing needs with a DC current test. The DC amp function allows you to measure up to 2 amps of current. To use the current function, you will need to open the circuit path and connect the SC3100 DVM test *leads* in series with the circuit.

Summary

The SC3100 "AUTO TRACKER" is an *easy*-to use, high performance oscilloscope. Its Autotracking digital functions provide fast, error-free digital measurements of all waveform parameters, and its parameter tests make it a complete circuit analyzer.

For further information on any of the SC3100's operation or features, refer to the Operation and Application manual supplied with your SC3100.