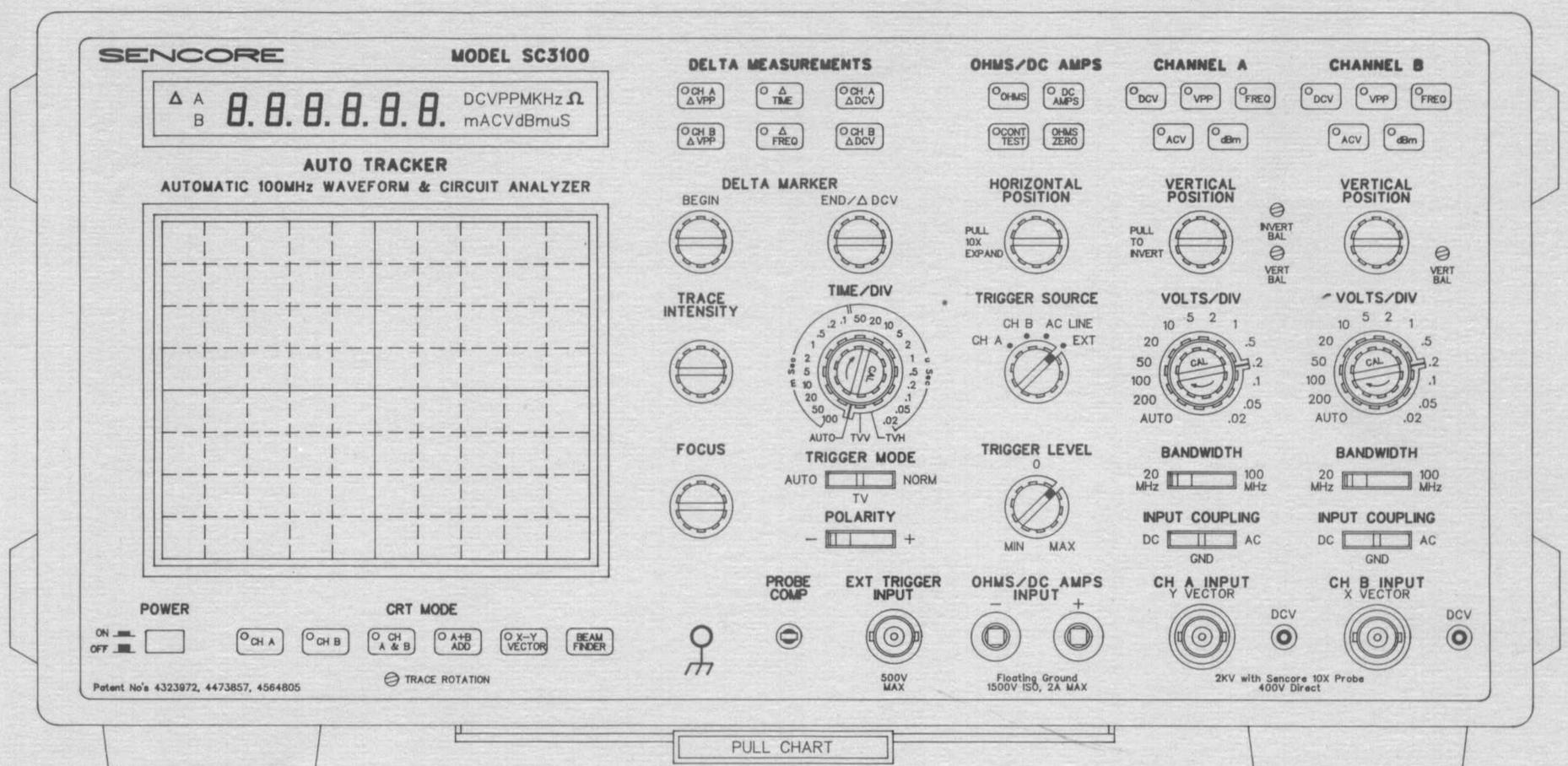


# SC3100

## "AUTO TRACKER"

### Automatic Waveform & Circuit Analyzer

#### Operation and Application Manual



# SENCORE

3200 Sencore Drive, Sioux Falls, South Dakota 57107

# DESCRIPTION

## INTRODUCTION

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The SC3100 "AUTO TRACKER™" Waveform and Circuit Analyzer offers a whole new concept in electronic test equipment. It provides all of the measurements you need to completely analyze a waveform or circuit faster, and more accurately than with any other unit.

There are other "digital" oscilloscopes that provide a digital readout of the signal displayed on the scope CRT. But these units fall short of the waveform analyzing capabilities of the SC3100 in two very important areas: ease of use and accuracy. Other digital scopes only do the graticule counting for you. You must still properly lock in the waveform and obtain a CRT display. Then you need to find the menu that contains the measurement you want and select the measurement channel before you can begin to take a reading. Both the input coupling and horizontal and vertical verniers must be set correctly to make the reading. Many other digital oscilloscopes

even require you to adjust cursors to the area of the signal you want to measure. On top of all this, the measurements are still based on the inaccurate analog CRT circuits and user interpretation, and may have errors of 15% or more.

Unlike conventional analog oscilloscopes and other digital scopes, the SC3100 "AUTO TRACKER™" allows you to measure all waveform parameters at the push of a button, without time consuming setups, graticule counting or cursor setting. For most measurements the waveform doesn't even need to be displayed on the CRT. All of measurements are made by digital circuits that are independent of the CRT circuitry, for virtually error-free measurements.

The "AUTO TRACKER™" also includes ohms, current, and continuity tests to analyze and track down problems in the whole circuit. It is a complete waveform and circuit analyzer.

## FEATURES

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The SC3100 "Waveform & Circuit Analyzer" begins with a full feature, high performance, dual trace oscilloscope. It has a 100 MHz bandwidth, useable to 120 MHz, to accurately view digital signals. The input extends from a 2 mV sensitivity direct input, to a maximum of 2000 volts with the supplied probes.

The sync circuits are streamlined to just four user controls, yet they provide "rock solid" triggering on all signals. Sync separators provide solid trigger lock on complex video waveforms. Special circuits remove the half-line shift when viewing a line of interlaced video to prevent vertical sync ghosting.

Conventional oscilloscope measurements are greatly enhanced with two types of digital waveform analyzing tests. The Auto-Tracking™ digital tests measure the frequency, DCV or AC voltage of the applied signal independently of any CRT control setting. You can select between peak-to-peak, average RMS, or dBm (1 milliwatt into 600 ohms reference) AC voltage readings. The Auto-Tracking™ measurements automatically follow any changes in the input signal.

Exclusive Delta measurements allow you to analyze the time, frequency and amplitude of any portion of the waveform. A Delta DCV test automatically

determines the absolute DC level of any waveform point referenced to ground to confirm proper logic levels or analyze trip points.

All of the Auto-Tracking™ and Delta measurements are made through the same probe that applies the signal to the CRT display. The measurements are unaffected by the vertical and horizontal vernier and position controls. Because all of the waveform measurements are made using digital circuits that are separate from the analog CRT circuits, the readings are many times more accurate and faster than conventional oscilloscope measurements.

Measure DC current up to 2 amps with minimal voltage burden. The ohmmeter is fully autoranged for resistance measurements up to 100 megohms. A special Continuity Test provides a near-instantaneous audible continuity indication for fast circuit tracing.

These tests are made through an input that is separate from the oscilloscope input to prevent accidental measurement errors and to keep high currents away from the sensitive scope input. The functions are fuse protected against overload.

Auto-Tracking and "AUTO TRACKER" are trademarks of SENCORE INC.

# SPECIFICATIONS

## Analog CRT Section

### Vertical Amplifiers:

**DISPLAY MODES:** Channel A, inverted channel

A (-A), channel B, dual trace (A&B), algebraic sum (A+B) or difference (B-A), vector (X-Y).

**INPUT COUPLING MODES:** AC, DC, and ground.

**CALIBRATION ACCURACY:**  $\pm 4\%$  at 1 kHz, 15-35° C for channel A and/or B;  $\pm 3\%$  for A+B or B-A modes.

**FREQUENCY RESPONSE (100 MHz):** AC coupled:  $\pm 3\text{dB}$  of 1 kHz level from 10 Hz to 100 MHz, useable to 150 MHz. DC coupled:  $\pm 3\text{dB}$  of 1 kHz level from DC to 100 MHz, useable to 150 MHz.

**BANDWIDTH Switch:** Reduces frequency response to 20 MHz  $\pm 5$  MHz  $\pm 3\text{dB}$ .

**DEFLECTION FACTORS:** 13 calibrated ranges in 1-2-5 sequence, plus Autorange. CRT is calibrated to read direct with supplied 39G292 10X Probe. Vernier continuously variable between ranges with detent for calibrated position. Autorange position automatically selects attenuator range (based on digital peak-to-peak meter) to show approximately 2-4 divisions of waveform amplitude.

**SENSITIVITY:** 20 mV/div. to 200 V/div. with supplied 39G292 10X probe; 2 mV/div. to 20 V/div. with (optional) DP270 Direct Probe.

**INPUT IMPEDANCE:** 10 megohms shunted by 15 pF with 39G292 10X Probe; 1 megohm shunted by 20 pF direct.

**MAXIMUM MEASURING VOLTAGE:** Supplied 39G292 probes: 2000 volts (DC + Peak AC) vernier uncalibrated, 1600 volt vernier calibrated. Direct: 200 volts (DC + Peak AC) with vernier uncalibrated, 160 volts vernier calibrated. Derated for frequencies above 1 MHz.

**MAXIMUM INPUT PROTECTION:** Supplied 39G292 10X Probe: 2500 volts breakdown (DC + Peak AC). Direct: 400 volts (DC + Peak AC). Derated for frequencies above 850 kHz.

**CHANNEL ISOLATION:**  $>58$  dB 0-100 MHz.

**TIME DELAY:** Both channels delayed to show trigger point.

**DUAL TRACE:** Dual chop automatically selected for timebase settings of 100 to .2 mSec in "A&B" mode. Pushing "A" and "B" buttons simultaneously selects alternate display mode.

**VECTOR:** Channel A is Y axis, channel B is X axis. Bandwidth:  $\pm 3$  dB DC to 2 MHz. Phase shift:  $\pm 3^\circ$  from 10 Hz to 200 kHz.

Sensitivity: Same as vertical amplifier.

### Horizontal Sweep:

**TIMEBASE RANGES:** 21 calibrated sweep rates in 1-2-5 sequence, plus Autorange, TVV and TVH. Vernier continuously variable between 1-2-5 steps, with detent for calibrated position.

**SWEEP RATES:** 100 milliseconds/division to 20 nanosecond/division. Autorange automatically selects sweep rate to show approximately 2-5 cycles of waveform, based on digital frequency counter reading.

**ACCURACY:**  $\pm 3\%$ .

**VIDEO PRESETS:** Automatically displays 2 horizontal lines (TVH) or 2 vertical fields (TVV) of standard NTSC composite video signal. TV trigger mode is automatically selected.

**10X EXPAND:** Expands horizontal sweep 10 times. Activated by pulling horizontal position control. Accuracy:  $\pm 5\%$ .

### Trigger Circuits:

**TRIGGER SOURCE:** CH A, CH B, AC power line, or external.

**TRIGGER MODES:** NORM: provides trace only when triggered. AUTO: provides trace at all times. TV: same as AUTO with sync separators added to trigger on vertical or horizontal sync pulses, vertical sync selected for all "msec" sweep rates, horizontal sync selected for all "µsec" sweep rates. TV mode is automatically selected in video presets.

**TRIGGER POLARITY:** Selectable between + and - waveform transition for non-video signals. Selects positive or negative sync on video signals.

**LEVEL SENSITIVITY:** Maximum of 0.5 divisions of CRT deflection for frequencies 10 Hz to 50 MHz AC coupled; maximum 1 division of CRT deflection for frequencies 50 MHz to 100 MHz AC coupled, increasing to 3 divisions at 120 MHz.

**TRIGGER BANDWIDTH:** DC to 120 MHz in 100 MHz bandwidth; DC to 20 MHz in 20 MHz bandwidth.

**EXTERNAL TRIGGER SENSITIVITY:** 200 millivolts pk-to-pk to 100 MHz, triggerable to 120 MHz. Maximum input: 500 volts (DC + Peak AC).

## Auto-Tracking™ Digital Tests

### DC Volts:

**DCV FUNCTION:** Provides direct reading of DC voltage on selected channel. Reading unaffected by INPUT COUPLING, vertical attenuator or other scope controls.

## Specifications Continued

**RANGES and RESOLUTION:** Four ranges automatically selected; 0.001 to 1.999, 2.00 to 19.99, 20.0 to 199.9, 200 to 1999. Direct reading with supplied 39G292 10X Probe, supplied 39G295 DC Voltage Probe, or optional DP270 Direct Probe.

**ACCURACY:**  $\pm 0.5\%$   $\pm 2$  digits using supplied 39G292 10X probes;  $\leq 0.5\%$  between channels.

**INPUT IMPEDANCE:** 15 megohms through supplied 39G292 10X probes and 39G295 DC Voltage Probe; 1.5 megohms direct input.

**MAXIMUM INPUT PROTECTION:** 2500 volts breakdown (DC + Peak AC) with supplied 39G292 10X Probes; 400 volts (DC + Peak AC) direct.

### Peak-to-Peak Volts:

**VPP FUNCTION:** Provides direct reading of peak-to-peak voltage on selected channel with either X10 or direct probes. Microprocessor controlled successive approximation to determine + and - peaks. DC coupled, 26 approximations per reading, worst-case. Reading unaffected by Trigger and Timebase controls.

**RANGES and RESOLUTION:** 4 ranges determined by channel A or B input attenuator setting (unaffected by vertical vernier); 0 to 8, 8 to 80, 80 to 800, 800 to 2000 volts with supplied 39G292 10X Probe.

**ACCURACY:**  $\pm 2\%$   $\pm 4$  counts including probes at 1 kHz;  $< 2\%$  between channels at 1 kHz.

**FREQUENCY RESPONSE:**  $\pm 0.5\text{dB}$  from 20 Hz to 30 MHz, 1dB from 30MHz to 50 MHz,  $\leq -3\text{dB}$  at 100 MHz in 100 Bandwidth;  $\pm 0.5\text{dB}$  from 20 Hz to 10 MHz in 20 MHz Bandwidth.

**MAXIMUM INPUT PROTECTION:** Same as analog CRT section.

### AC Volts:

**ACV FUNCTION:** Calculates RMS sinewave value from PPV measurement. (.707xpeak) Direct readout of selected A or B channel with either X10 or direct probes. Reading unaffected by Trigger and Timebase controls.

**RANGES and RESOLUTION:** 4 ranges determined by channel A or B input attenuator setting (unaffected by vertical vernier); 0.001 to 707 volts with supplied 39G292 10X probe.

**ACCURACY:** Same as PPV function on a 1 kHz sinewave.

**FREQUENCY RESPONSE:** Same as PPV function (sinewave applications only).

**MAXIMUM INPUT PROTECTION:** Same as analog CRT section.

### dBm:

**dBm FUNCTION:** Calculates dBm measurement from PPV sinewave measurement, referencing 1 mW across 600 $\Omega$  (0 dBm = .7746 volts RMS). Direct readout of selected A or B channel with either X10 or direct probes. Reading unaffected by Trigger and Timebase controls.

**RANGES:** 4 determined by channel A or B input attenuator setting (unaffected by vertical vernier); -60 to 59.2 with supplied 39G292 10X probe.

**RESOLUTION:** 2 or 3 digits depending on level: 1 dB for levels less than -15 dBm, .1 dB for levels -15 dBm or greater.

**ACCURACY:** Same as PPV function on a 1 kHz sinewave.

**FREQUENCY RESPONSE:** Same as PPV function (sinewave applications only).

**MAXIMUM INPUT PROTECTION:** Same as analog CRT section.

### Frequency:

**FUNCTION:** Automatically displays the frequency of the signal on selected channel. Main channel (determined by "Trigger Source") uses trigger circuit, auxiliary channel counts input signal directly.

**RANGES & RESOLUTION:** 7 ranges automatically selected; 10.00 to 99.99 Hz, 100.0 to 999.9 Hz, 1.0000 to 99.999 kHz, 100.000 to 999.999 kHz, 1.00000 to 9.99999 MHz, 10.0000 to 99.9999 MHz, 100.000 to 150 MHz.

**ACCURACY:** .001%  $\pm 1$  digit over operating temperature range; Aging:  $\leq .001\%$  per year.

**SENSITIVITY:** Main channel: same as trigger circuits, except 1.5 division maximum in .02 volts/div. range for frequencies below 100 MHz. Auxiliary channel: 1.5 division of deflection for all frequencies.

**SOURCE:** Selected with channel A or B push button. Microcomputer automatically selects between trigger circuit output or auxiliary counter amplifier, depending on "Trigger Source" switch setting.

**READ RATE:**  $< .5$  seconds for all frequencies 10 Hz to 150 MHz.

## Delta Digital Tests

### All Tests:

**FUNCTION:** The Delta tests allow measurements of a portion of the displayed waveform. All readings are direct.

**DELTA MEASUREMENT BAR** (all tests except Delta DC): Delta Begin and Delta End controls set intensified area to any portion of waveform. Function of controls automatically reverses if ends of bar are overlapped.  
**SETABILITY:** 5 ns typical.

#### **Delta Peak-to-Peak:**

**FUNCTION:** Measures amplitude of intensified area on selected channel.  
**RANGE AND SPECIFICATIONS:** Same as Peak-to-Peak function.

#### **Delta Time:**

**FUNCTION:** Measures time of intensified waveform portion.  
**ACCURACY:** Same as frequency counter function. Dependant on user setting of Delta Begin and End controls.  
**RANGE:** 5 nsec to 1 second. Automatic decimal placement and "mS" or "uS" annunciator reading.

#### **Delta Frequency:**

**FUNCTION:** Converts Delta Time reading to equivalent frequency.  
**ACCURACY:** Same as Delta Time function.  
**RANGE:** 1 Hz to 200 MHz. Automatic decimal placement and Hz, kHz, or MHz annunciator reading.

#### **Delta DC Volts:**

**FUNCTION:** Measures DC voltage level of marked waveform point in respect to ground using the PPV and DCV functions.  
**MARKER:** Fully adjustable over entire range of waveform with "Delta DC/Delta End" control.  
**RANGES and RESOLUTION:** Same as VPP function.  
**ACCURACY:** Better than 2.5%  $\pm$ 5 digits at 1 kHz using supplied 39G292 10X Probe.  
**FREQUENCY RESPONSE:**  $\pm$ .5dB 20 Hz to 10 MHz.

### **Circuit Parameter Tests:**

#### **Ohms**

**FUNCTION:** Provides in- or out-of-circuit ohms and continuity test through OHMS/CURRENT INPUT Jacks.  
**RANGES and RESOLUTION:** 5 ranges, automatically selected; 0.00 to 210  $\Omega$ , 200 to 21.0 k $\Omega$ , 20.0 k $\Omega$  to 2.1 M $\Omega$ , 2.00 M $\Omega$  to 11.00 M $\Omega$ , 10 M $\Omega$  to 100 M $\Omega$ .

**ACCURACY:** 0.2%  $\pm$ 2 digits except 0.5%  $\pm$ 3 digits 2.00 M $\Omega$  to 100 M $\Omega$  range.  
**MAXIMUM TEST CURRENT:** 1 mA.  
**MAXIMUM TEST VOLTAGE:** 200 mV in the 3 lowest ranges; 2 volts in top two ranges.  
**INPUT PROTECTION:** Fuse protected; 1500 volts (DC + Peak AC) between input jack and from either jack to chassis.

#### **Continuity Test:**

**FUNCTION:** Provides audible tone of continuity.  
**RANGE:** 0 to 210  $\Omega$ . Audible tone turns on if resistance is  $<$ 10  $\Omega$  and turns off if resistance is  $>$ 15  $\Omega$ ,  $\pm$  2 $\Omega$ .

#### **DC Current:**

**FUNCTION:** Provides measurement of DC current through OHMS/CURRENT INPUT Jacks.  
**RANGES and RESOLUTION:** 5 ranges, automatically selected: .001 to 1.999 mA, 2.00 to 19.99 mA, 20.0 to 199.9 mA, 200 to 999 mA, 1.00 amp to 1.99 amp.  
**ACCURACY:** 0.3%  $\pm$ 2 digits.  
**VOLTAGE BURDEN:**  $<$ 1.5 volts at 2 amps;  $<$ 750 mV typical for currents below 1 amp.  
**OVER VOLTAGE PROTECTION:** 1500 volts (DC + Peak AC) between input jack and from either jack to chassis with internal high voltage fuse.  
**OVER CURRENT PROTECTION:** 2 A, 250 volt externally-accessible fuse and 3 A, 600 volt internal fuse.

#### **Digital Display:**

**TYPE:** 6-digit liquid crystal, fast response time and high contrast with back lighting.  
**ANUNCIATORS:** Automatically controlled for each function, with channel indicator preceding readout when required.

#### **CRT Display:**

**SIZE:** 96.4 x 120 mm.  
**TYPE:** High sensitivity and brightness with GH (P31 blue-green) phosphor.  
**ACCELERATING VOLTAGE:** 14 kV to match CRT requirements.  
**GRATICULES:** 8 x 10 grid internally etched on CRT faceplate with 0, 10, 90, and 100% markings.  
**BEAMFINDER:** Disables trigger and intensity controls, and reduces vertical and horizontal gain to locate beam.

## Specifications Continued

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**WARM UP TIME:** Unit completely operational as soon as CRT trace appears. Fully meets specifications after 20 minutes.

**OPERATING TEMPERATURE:** -10° to 45° C (14° to 113° F).

**CASE:** Vinyl-clad aluminum. Full EMI shielding.

**SIZE:** 7.25" x 13.75" x 15" HWD (18.4 x 34.9 x 38.1 cm).

**WEIGHT:** 25 lbs (9.33 kg.)

**POWER:** 105-125 VAC 50/60 Hz. Factory convertible to 210-250 VAC 50/60 Hz operation.

**POWER CONSUMPTION:** 80 watts maximum.

### Accessories:

#### Supplied:

2 ea: 39G292 10X Low Capacity probe with 5" ground, 12" ground and retractable tip.

1 ea: 39G295 DVM Test Leads.

1 ea: 39G331 10X Probe Accessory Kit containing:  
ID bands (2 yellow, 2 red),  
Ground Insulator Ring (2)

### Optional:

IB72 IEEE 488 Interface Accessory

IB78 RS232 Interface Accessory

HP200: 50 KV High Voltage Probe

PL207: RF Pickup Loop

TP212: 10 KV Transient Protector Probe

PC269: Protective Cover

DP270: 1:1 Direct Probe

39G81A: 250 MHz Demodulator Probe

39G303: Probe Accessory Kit

*Covered by Patents #4,473,857, #4,564,805 and 4,323,972  
Specifications subject to change without notice.*

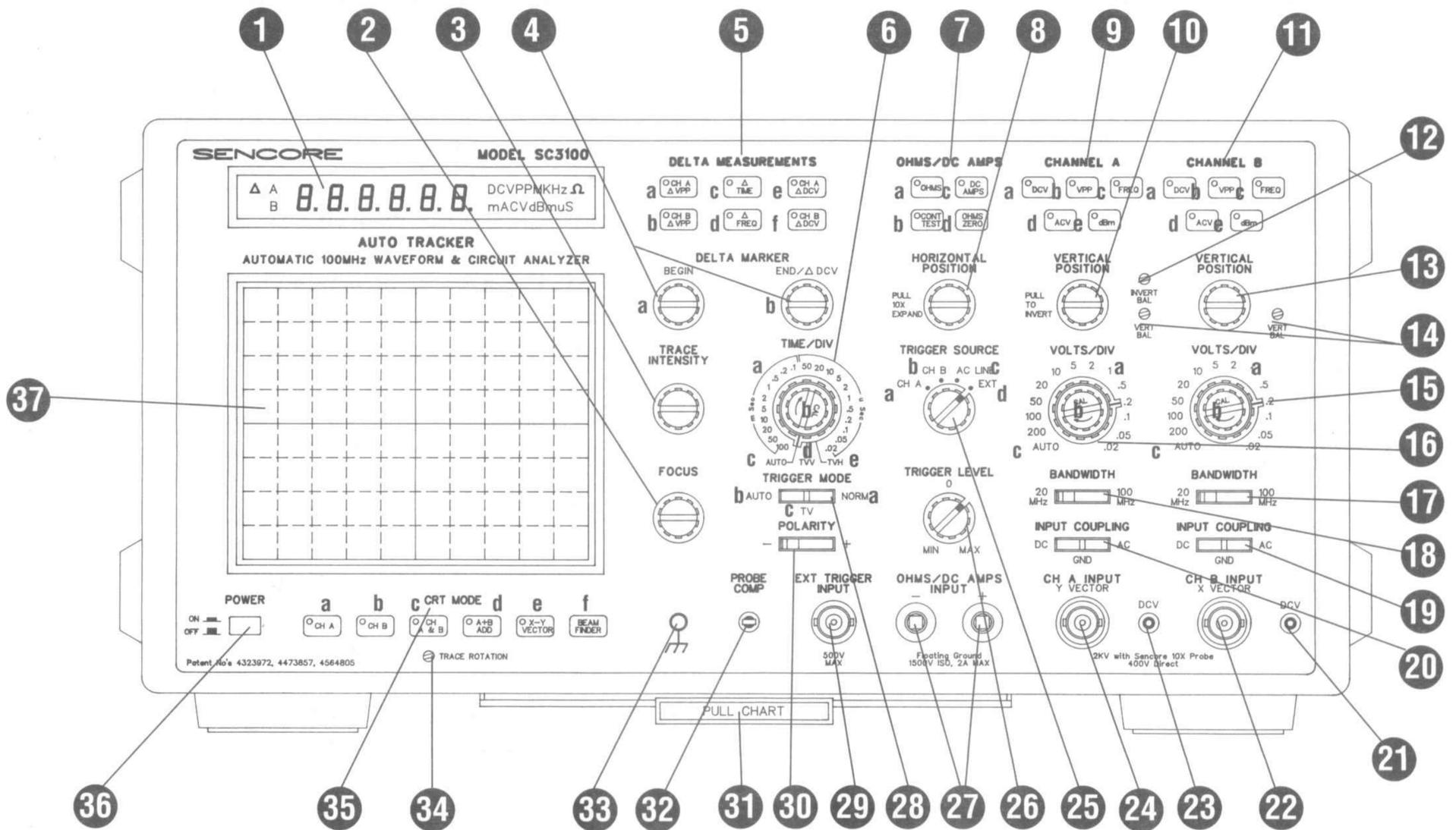


Fig. 1 - Front panel controls and features.

## CONTROLS

1. **DIGITAL READOUT** - Provides a readout of any of the DELTA MEASUREMENTS (5), OHMS/DC AMPS (7), CHANNEL A DIGITAL TESTS (9) or CHANNEL B DIGITAL TESTS (11) functions. The correct decimal placement and annunciators to indicate the channel, function, and range are automatically displayed.

2. **FOCUS** - Adjust for sharpest trace on CRT DISPLAY (37).

3. **INTENSITY** - Determines brightness of CRT trace.

4. **DELTA MARKER Controls** - Use with the DELTA MEASUREMENTS Buttons (5) to position the intensified Delta Measurement Bar on the waveform.

a & b. **BEGIN & END** - Controls automatically exchange function if the Delta Bar end is positioned before the beginning.

b. **END/ $\Delta$ DCV** - Adjusts the intensified point when the Delta DCV functions are selected (5e & f).

5. **DELTA MEASUREMENTS** - Selects the parameter that is measured by the Delta Bar. Readings are displayed in the DIGITAL READOUT (1).

- CH A  $\Delta$ PPV** - Measures the peak-to-peak voltage of the intensified portion of the channel A waveform.
- CH B  $\Delta$ PPV** - Measures the peak-to-peak voltage of the intensified portion of the channel B waveform.
- TIME** - Measures the time duration of the Delta Bar for either the channel A or channel B waveform.
- $\Delta$ FREQ** - Converts the time duration of the Delta Bar to the approximate frequency.
- CH A DELTA DCV** - Measures the instantaneous voltage to ground of the intensified point on the channel A waveform. Use with the DELTA DC MARKER Control (5b).
- CH B DELTA DCV** - Measures the instantaneous voltage to ground of the intensified point on the channel B waveform. Use with the DELTA DC MARKER Controls (5b).

## Controls Continued

6. **TIMEBASE** - Sets the sweep speed at which the CRT beam moves horizontally across the CRT. Controls do not affect the digital measurements.

- a. **TIME/DIV** - Selects the time value for one major CRT division.
- b. **VERNIER** - Allows the sweep speed to be varied within the major steps selected by the TIME/DIV Control.
- c. **AUTO** - Allows the microprocessor to automatically select the sweep speed needed to display 2 to 5 cycles.
- d. **TVV VIDEO PRESET** - Displays two vertical fields of composite video and automatically selects video sync separators.
- e. **TVH VIDEO PRESET** - Displays two horizontal lines of composite video and automatically selects video sync separators.

7. **OHMS/DC AMPS** - Use with the OHMS/DC AMPS INPUT (27) and DVM TEST LEADS (43) to measure circuit parameters. Readings are displayed in the DIGITAL READOUT (1).

- a. **OHMS** - Select to measure resistance values up to 100 megohms.
- b. **CONT TEST** - Provides a near-instantaneous audible tone indication of continuity and digital readout of resistance values to 210Ω.
- c. **DC AMPS** - Select to measure DC current.
- d. **OHMS ZERO** - Push when either the OHMS or CONT TEST (7a or b) is selected and the test leads are shorted together to zero out the internal and test lead resistances.

8. **HORIZ POSITION/10X EXPAND Control** - Use to adjust the horizontal position of the CRT trace. Pull to expand the CRT display horizontally by a factor of 10.

9. **CHANNEL A AUTO-TRACKING TEST Buttons** - Selects the measured parameter of the waveform applied to the CH A INPUT Jack (24).

- a. **DCV** - Measures the average DC voltage.
- b. **VPP** - Measures the peak-to-peak voltage.
- c. **FREQ** - Measures the frequency.
- d. **ACV** - Measures the RMS AC voltage.
- e. **dBm** - Measures the dBm voltage level.

10. **VERTICAL POSITION (CH A)** - Determines vertical position of the channel A trace. Pull knob to invert the polarity.

11. **CHANNEL B AUTO TRACKING TESTS** - Selects the measured parameter of the waveform applied to the CH B INPUT Jack (22).

- a. **DCV** - Measures the average DC voltage.
- b. **VPP** - Measures the peak-to-peak voltage.
- c. **FREQ** - Measures the frequency.
- d. **ACV** - Measures the RMS AC voltage.
- e. **dBm** - Measures the dBm voltage level.

12. **INVERT BAL** - Calibrates the channel A invert amplifier for the same DC reference level for inverted and noninverted displays.

13. **VERTICAL POSITION (CH B)** - Determines the vertical position of the channel B trace.

14. **VERT BAL (Channels A & B)** - Calibrates the input circuits for the same DC reference level for each setting of the VOLTS/DIV switch.

15. **VOLTS/DIV (CH B)** - Selects the vertical deflection factor for the channel B CRT waveform display and the range for the VPP readings.

- a. **VOLTS/DIV Control** - Sets the voltage value for one major CRT division.
- b. **VERTICAL VERNIER** - Allows the vertical deflection to be varied within the major steps selected by the VOLTS/DIV Control. Does not affect the digital measurements.
- c. **AUTO** - Allows the microprocessor to automatically select the VOLTS/DIV range needed to display 2 to 4 divisions of deflection.

16. **VOLTS/DIV (CH A)** Selects the vertical deflection factor for the channel A CRT waveform display and the range for the VPP readings.

- a. **VOLTS/DIV Control** - Sets the voltage value for one major CRT division.
- b. **VERTICAL VERNIER** - Allows the vertical deflection to be varied within the major steps selected by the VOLTS/DIV Control. Does not affect the digital measurements.
- c. **AUTO** - Allows the microprocessor to automatically select the VOLTS/DIV range needed to display 2 to 4 divisions of deflection.

17. **BANDWIDTH (CH B)** - Determines the bandwidth of the signal applied to the CRT, digital meter, and trigger circuits from the CH B INPUT Jack (22).

18. **BANDWIDTH (CH A)** - Determines the bandwidth of the signal applied to the CRT, digital meter, and trigger circuits from the CH A INPUT Jack (24).

19. **INPUT COUPLING (CH B)** - Selects DC or AC input coupling, or ground reference of the signal applied to the CH B INPUT Jack (22).
20. **INPUT COUPLING (CH A)** - Selects DC or AC input coupling, or ground reference of the signal applied to the CH A INPUT Jack (24).
21. **DCV Jack (CH B)** - Input routes DC signals around the channel B INPUT COUPLING switch (19) to allow DC measurements while CRT is AC coupled.
22. **CH B INPUT Jack** - Supplies signals for all channel B tests except DCV.
23. **DCV Jack (CH A)** - Input routes DC signals around the channel A INPUT COUPLING switch (20) to allow DC measurements while CRT is AC coupled.
24. **CH A INPUT Jack** - Supplies signals for all channel A tests except DCV.
25. **TRIGGER SOURCE** - Selects signal source that is used to trigger the sweep circuits.
- CH A** - Selects the signal applied to the CH A INPUT (24).
  - CH B** - Selects the signal applied to the CH B INPUT (22).
  - AC LINE** - Locks the trigger circuits to the 60 Hz AC line.
  - EXT** - Selects the signal applied to the EXT TRIGGER INPUT Jack (29).
26. **TRIGGER LEVEL** - Determines the amplitude of the input signal that triggers the trigger circuits. The trigger circuits will trigger at the center of a symmetrical waveform when set to "0". The "+" and "-" areas indicate amplitude change only, not trigger polarity.
27. **OHMS/DC AMPS INPUT** - Provides a connection for the DVM TEST LEADS (43) to make ohms and DC current measurements.
28. **TRIGGER MODE** - Selects three different options for triggering the waveform.
- NORM** - Produces a trace only when the triggering circuits are locked to the incoming signal selected by the TRIGGER SOURCE switch (25).
  - AUTO** - Produces a trace at all times.
  - TV** - Selects special sync separators to trigger on the sync pulses of composite video signals. Automatically selects vertical sync for "msec" sweep speeds and horizontal sync pulses for "µsec sweep speeds.
29. **EXT TRIG INPUT Jack**- Allows an external trigger signal to be used when the TRIGGER SOURCE switch (25) is set to "EXT".
30. **TRIGGER POLARITY** - Sets the trigger circuits to trigger on either the positive (+) or negative (-) transition of the incoming signal. The polarity refers to the sync pulse polarity of video signals .
31. **PULL CHART** - Provides simplified operation instructions.
32. **PROBE COMP** - Provides a square wave signal for compensating the 10X LOW CAPACITY PROBES (42).
33. **GROUND Jack** - Provides a connection to use the black DVM TEST LEAD (43) for grounding and DC measurements. To prevent waveform distortion do not use as the signal ground when measuring signals greater than 100 kHz.
34. **TRACE ROTATOR** - Electrically positions the trace to compensate for different magnetic field conditions. Adjust so that the CRT trace is parallel to the horizontal lines etched on the CRT.
35. **CRT DISPLAY MODE Buttons** - Use to select the trace display mode on the CRT.
- CH A** - Displays a single trace of the CH A INPUT (24). Press together with CH B Button for A & B dual alternate display.
  - CH B** - Displays a single trace of the CH B INPUT (22). Press together with CH A Button for A & B dual alternate display.
  - A & B** - Displays both the channel A & B traces. Dual chop display is selected when the TIMEBASE TIME/DIV Control (6a) is set between 100 and .1 msec. Dual alternate operation occurs between 50 and .02 µsec. Select dual alternate mode for slower sweep rates by pushing the CH A and the CH B CRT DISPLAY MODE Buttons simultaneously.
  - A+B ADD** - Provides a single trace display showing the algebraic sum of the CH A and CH B input signals.
  - X-Y VECTOR** - Selects X-Y operation. The CH A INPUT Jack (24) provides vertical deflection and the CH B INPUT Jack (22) provides horizontal deflection.
  - BEAM FINDER** - Press to locate the relative position of the trace(s).
36. **POWER** - Push in to apply AC power; push and release to remove power.

## Controls Continued

37. **CRT DISPLAY** - Provides a waveform display of the signal applied to the CH A INPUT (24) or CH B INPUT (22).

## REAR PANEL FEATURES

38. **OHMS PROTECTION FUSE** - Protects the unit from damage due to external voltage or current applied to the OHMS/DC AMPS Input (27) when the ohms function is selected. Replace only with 1/8 amp, 3AG 250 volt Fast-Blo fuse.

39. **DC AMPS PROTECTION FUSE** - Protects unit from damage due to currents greater than 2 amps applied to the OHMS/DC AMPS Input (27). Replace only with 2 amp, 3AG 250 volt Fast-Blo fuse.

40. **AC LINE FUSE** - Protects unit from damage due to internal problems which cause excessive current draw. Replace only with 1 amp, 3AG, 250 volt Slo-Blo fuse.

41. **INTERFACE ACCESSORY Jack** - Provides connection for the optional IB72 IEEE 488 INTERFACE BUS Accessory (53) or IB78 RS232 INTERFACE Accessory (54).

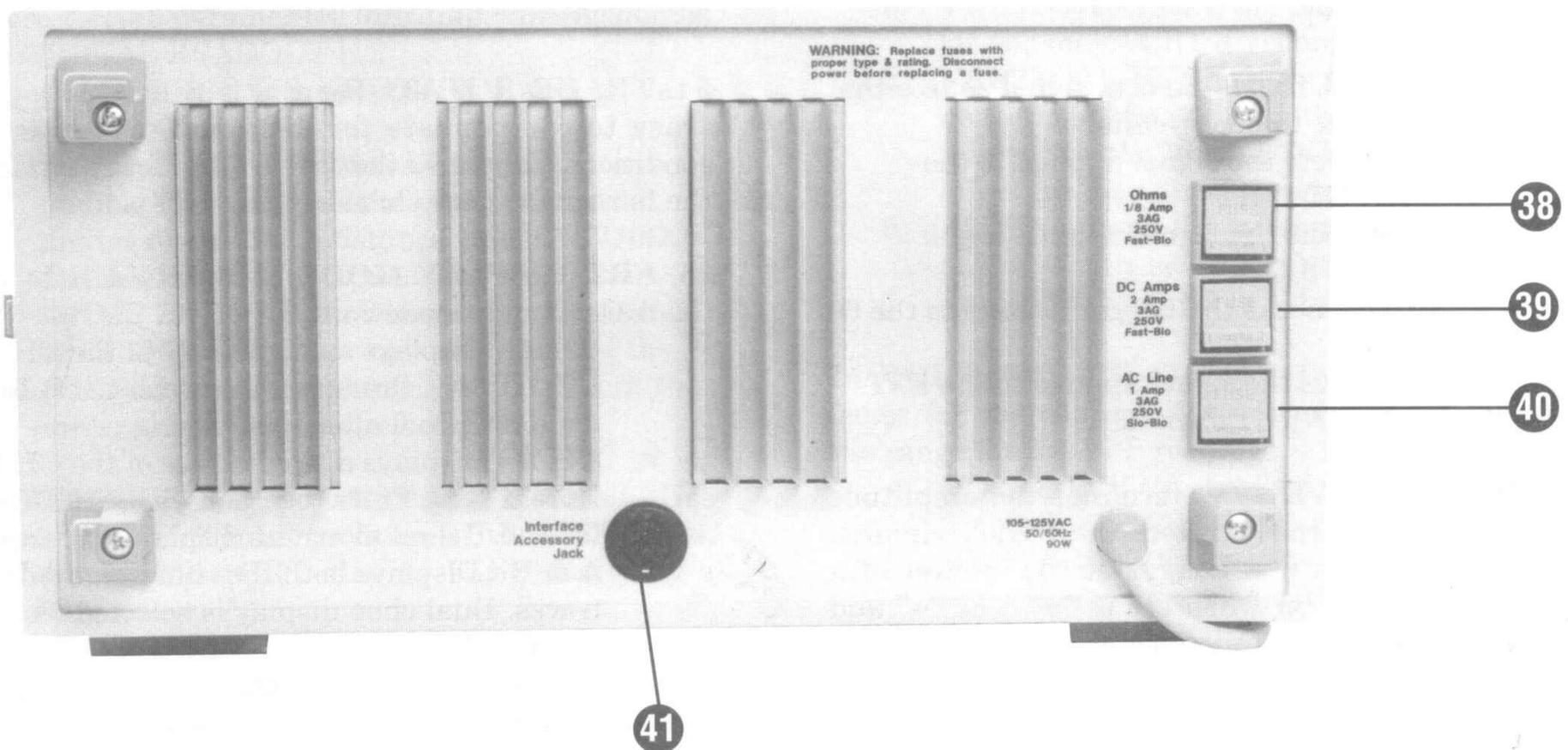


Fig. 2 - SC3100 rear panel features

## SUPPLIED ACCESSORIES

42. **10X LOW CAPACITY PROBES (39G292)** (2 supplied) - Use to apply signals for reading on CRT or digital readout. Connect BNC connector to the CH A or CH B INPUT Jacks (22 or 24) and mini banana connector to DCV IN Jacks (21 and 23).
43. **DVM TEST LEADS (39G295)** - Connect to OHMS/DC AMPS INPUT Jack to make ohms and DC current measurements. Also use black lead to connect to GROUND Jack (33) when an extra earth ground connection is needed.
44. **PROBE ACCESSORY KIT (39G331)** Includes 2 yellow and 2 red Probe ID Bands and 2 Ground Ring Insulators.

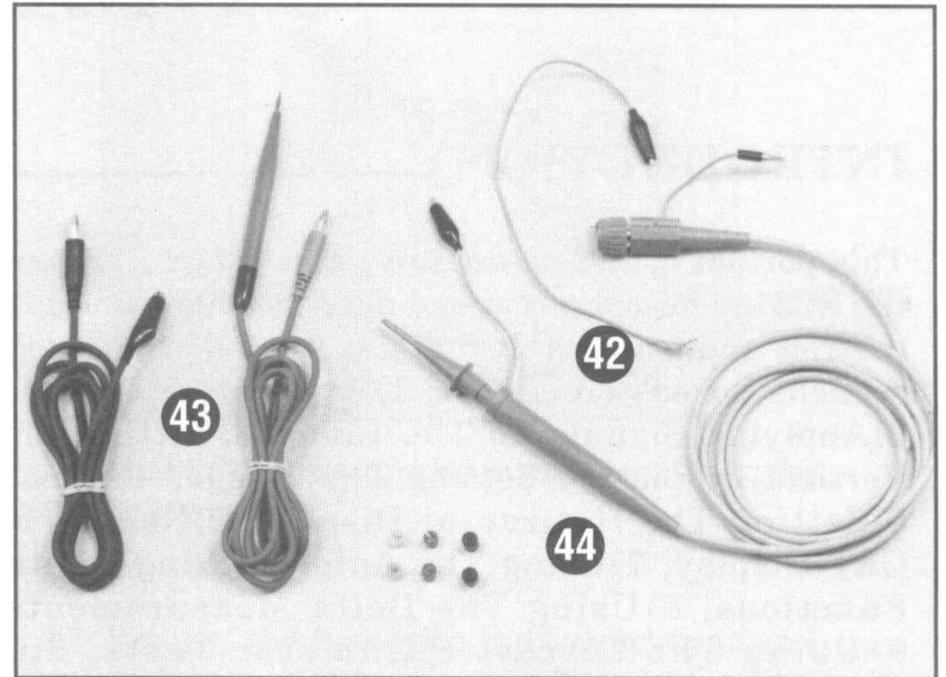


Fig. 3 - SC3100 Supplied accessories

## OPTIONAL ACCESSORIES

45. **HP200 50 kV HIGH VOLTAGE PROBE** - Use with the (optional) DCV PROBE (50) to extend the DCV measuring range to 50 kV.
46. **PC269 PROTECTIVE COVER** - Snap-on cover protects front panel and provides test probe storage.
47. **PL207 RF PICKUP LOOP** - Used for inductive pickup of signals when peak-to-peak voltage is not important.
48. **TP212 10 kV TRANSIENT PROTECTOR PROBE** - Use with (optional) DCV PROBE (50) to extend the DCV measuring range to 10 kV.
49. **DP270 1:1 DIRECT PROBE** - Provides direct input for measuring signals in the 5 to 50 millivolt range and frequencies up to 15 MHz.
50. **DCV PROBE (39G157)** - Allows DC voltages to be measured separately from the 39G294 Low Capacity Probes. Connect to DCV Jacks (21 & 23).
51. **250 MHz DEMODULATOR PROBE (39GB1A)** - Shows the detected envelope of an AM modulated signal up to 250 MHz..
52. **PROBE TIP ACCESSORY KIT (39G303)** - Includes accessories to use with the supplied 39G292 10X LOW CAPACITY PROBES (42), or the (optional) DP270 1:1 DIRECT PROBE (49). Includes:

- Ground Bayonet
- BNC adapter
- Mini-Grabber (red)
- Mini-Grabber ground lead adapter
- Small alligator clip
- IC Leg isolator
- Long Needle point clip

53. **IB72 IEEE 488 INTERFACE BUS Accessory** - Connects between the INTERFACE ACCESSORY Jack (41) and the IEEE 488 port of a bus controller to allow the SC3100 to be used in an IEEE system.

54. **IB78 RS232 INTERFACE Accessory** - Connects between the INTERFACE ACCESSORY Jack (41) and the RS232 port of a controller to allow the SC3100 to be used for automated testing.

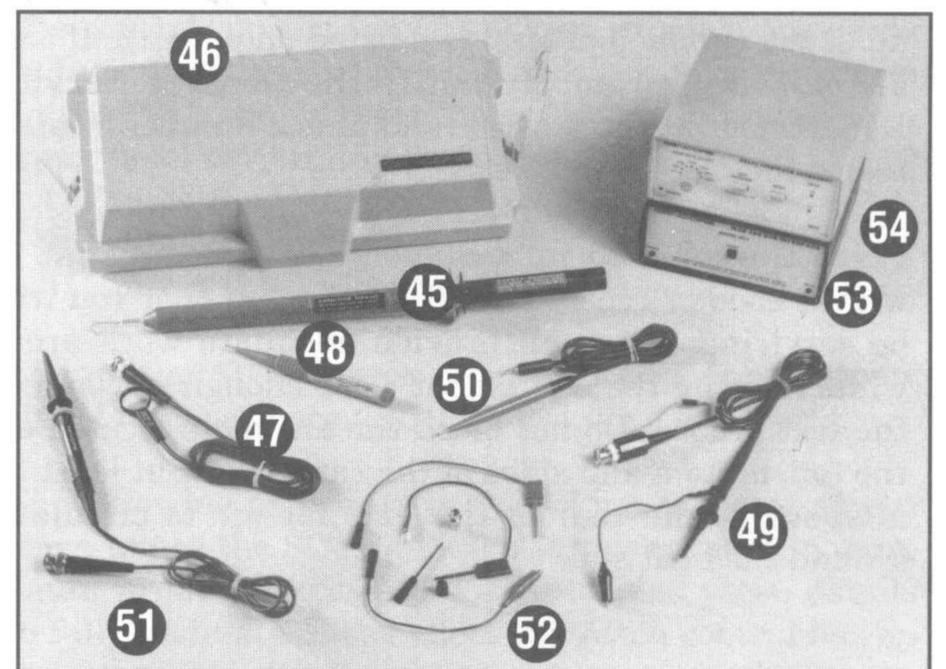


Fig. 4 - SC3100 Optional accessories

# OPERATION

## INTRODUCTION

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This portion of the manual explains how to prepare the SC3100 for operation and describes how to use its controls and features. It contains the following major sections for easy reference; 1)Preparation For Use, 2)Applying Signals To The Input, 3)Setting The Vertical Display, 4)Setting The Trigger Circuits, 5)Setting The Horizontal Display, 6)Using The CRT Display, 7)Using The Auto-Tracking Digital Functions, 8)Using The Delta Measurements, 9)Using The Circuit Parameter Tests, and 10)Computer Automated Operation

The operation of the SC3100's CRT display section is identical to that of a standard analog oscilloscope. The vertical and horizontal controls are calibrated to

allow CRT analog measurements of signals when desired.

Most of the measurements you need to make however, will be made using the digital readout. The Waveform & Circuit Analyzer's digital functions give results that are faster, more accurate and subject to much less operator error than conventional analog oscilloscope measurements.

Once you have become familiar with the features and operation of the SC3100, you can operate it using the information on the front panel and on the Pull Chart located beneath the unit. The APPLICATION section of this manual includes information on specific applications.

## PREPARATION FOR USE

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The SC3100 is ready to use when it is removed from its packing material and connected to a proper source of AC power. All of the supplied accessories are in the same box as the SC3100. When you first unpack the "AUTO TRACKER", confirm that you have received all of the supplied accessories listed on page 10. If any are missing, promptly notify the Sencore Service Department at the address and phone number located inside the back cover.

Place the SC3100 in a convenient location that is within about 24 inches of the equipment that you will be servicing. This will provide adequate work area, while keeping the equipment close enough to connect the test probes. Do not block the air vents located on the top, bottom and sides of the case. Allow at least 3" of space at the rear of the unit for air to circulate around the heat sink.

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### CAUTION

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**Position the SC3100 to allow proper air circulation. Allow 3 inches of space behind the rear panel heat sinks.**

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The SC3100 is equipped with two tilt bails located on the front feet. These tilt bails allow the front of the unit to be raised by approximately 4" when the unit is used on a bench top. The tilt bails may be moved to the rear feet to allow the rear of the unit to be

elevated, such as when it is located on a shelf above the work area. To relocate the tilt bails simply remove the screw that holds the plastic foot to the case .

### AC Power Connection

The SC3100 is wired for use on a 105-125 VAC, 50 or 60 Hz AC line when shipped from the factory. It may be converted for 210-250 VAC operation by the Sencore Service Department.

Always connect it to a properly grounded AC outlet. The 3rd wire ground connection ensures continued safety in the event of a circuit failure inside the SC3100, or if the ground of the SC3100 is connected to a test point that has a potentially dangerous voltage.

In either case, the ground connection ensures that the metal parts of the SC3100 do not become a shock hazard. The 3rd wire ground also provides a return path for interference when the unit is used in electrically noisy environments.

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### CAUTION

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**The SC3100 must be used with a properly grounded 3 wire AC system for safe operation and minimum pickup of external interference.**

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**WARNING**


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Always use an isolation transformer on any piece of equipment that is AC operated and does not have an internal isolation transformer. All warranties are voided if the 3rd wire ground is bypassed, or if damage occurs from making a connection to an unisolated hot-ground system.

---

**To operate the SC3100 from an AC line:**

1. Connect the power cord to a properly grounded, 105-125 VAC power source.
2. Push the POWER button in to apply power. The button should lock in.
3. After applying power, allow approximately five seconds for the internal circuits to reset.

The following LEDs should be lit:

“CH A&B” CRT Display mode and channel A “DCV”. The DIGITAL READOUT should also show a display.

The SC3100 is now fully operational and ready for use. Allow a 20 minute warm up time for specified accuracy.

**If the LEDs and LCD display do not come on:**

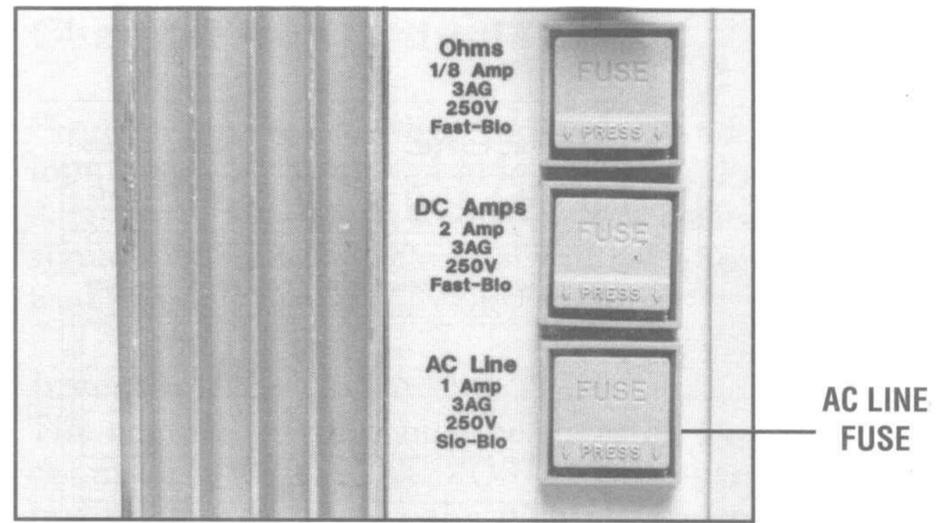
1. Confirm that the AC power source is correct.
2. Check the AC line fuse.

The traces should be visible on the CRT after the CRT filaments have warmed for approximately 15 seconds. If a trace does not appear use the BEAM FINDER to determine if the trace is positioned out of the CRT display area. See “Locating The Trace With The Beam Finder”, page 14.

**AC Line Fuse** - An AC line fuse is located on the rear panel of the unit. This fuse protects the SC3100 from excessive damage caused by internal failures. If it is blown locate the cause of the problem and correct it before replacing the fuse. Replace the fuse with another of the same type and rating. An incorrect fuse may damage the unit, and will void all warranties. The proper fuse value is 1 amp, type 3AG, 250 volt Slo-Blo.

**To replace the AC line fuse:**

1. Press to release the snap-in fuse holder.
2. Pull the holder and the fuse out of the fuse holder base.



*Fig. 5 - If the SC3100 fails to come on when power is applied. Check the AC line fuse.*

3. Replace the fuse with the correct type and rating.
4. Insert the holder and fuse into the fuse holder base and snap it back into place.

---

**CAUTION**


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**Using the wrong fuse may damage the SC3100. Only replace the AC line fuse with the following: 1 amp, 3AG, 250 volt Slo-Blo.**

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**Simplified CRT Setup**

The controls on the front panel are grouped according to their function. To display and lock in a waveform on the CRT simply move from right to left across the front panel performing these steps:

- 1) apply the signal.
- 2) adjust the trigger controls.
- 3) adjust the horizontal sweep controls.

Follow the above steps whenever you apply a new signal or experience difficulty locking a waveform.

The following procedure is a checklist to follow as you learn to use the SC3100. Each step is covered in more detail in later sections. Be sure to read those details to fully understand the effect that each control has on the waveform. After you understand what each control does, use these simplified instructions or the those on the Pull Chart as a reminder.

**To obtain a waveform display on the CRT:**

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

### 5. Set TIME/DIV for desired display

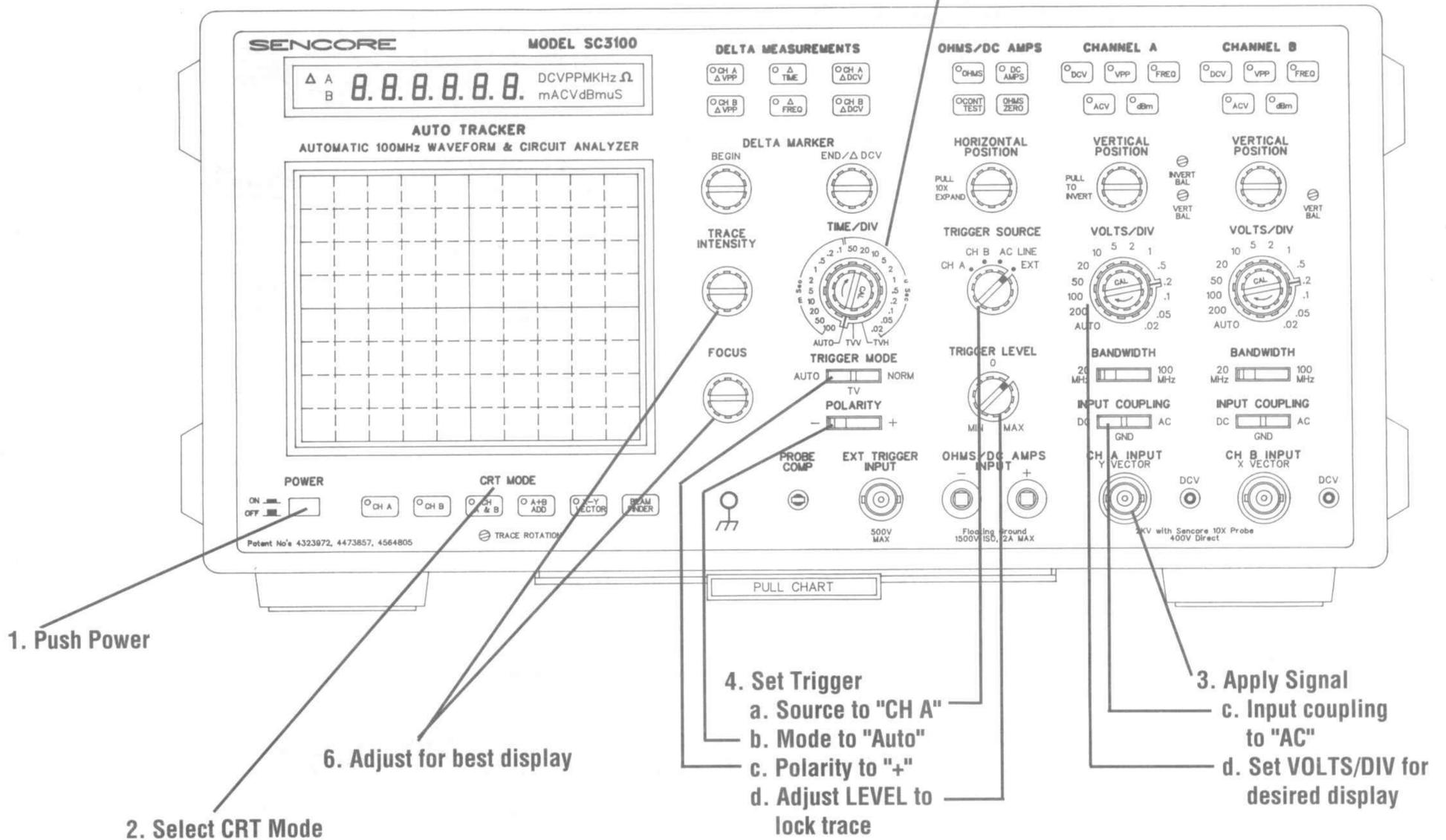


Fig. 6: Follow this sequence to get a trace on the SC3100. In this example the trigger controls are set for a channel A signal.

3. Apply the signal to the vertical input:
  - a. Connect the 10X LOW CAPACITY Probe to the INPUT Jack of the desired channel.
  - b. Connect the 10X LOW CAPACITY Probe to the signal.
  - c. Set the INPUT COUPLING switch to "AC".
  - d. Set the VOLTS/DIV switch to "AUTO", or set it to produce a display that is 4 to 6 CRT graticules high.
4. Adjust the TRIGGER controls to lock the waveform:
  - a. SOURCE to match the input channel, or to the desired reference channel.
  - b. MODE to "Auto". Use "TV" for composite video signals.
  - c. POLARITY to the desired polarity. Set to match the sync polarity for composite video.
  - d. Adjust LEVEL to lock the trace.
5. Adjust the TIMEBASE Control to "AUTO", or set for the desired number of cycles..
6. Adjust the VERTICAL POSITION, HORIZONTAL POSITION, FOCUS and INTENSITY controls as desired for the best waveform display.

in the section entitled "Setting The Trigger Controls," on page 24.

### Locating The Trace With The Beam Finder

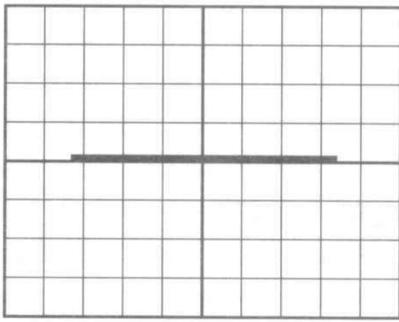
At times you may not be able to see one or both CRT traces because one or more of the CRT controls is improperly set. At these times use the beam finder to help you locate the trace. Pressing the BEAM FINDER button overrides four controls or circuits: 1) The intensity is increased, 2) "AUTO" trigger mode is selected, 3) The gain of the vertical amplifiers is reduced to bring the trace onto the CRT screen no matter where the VERTICAL POSITION controls are set, and 4) The gain of the horizontal amplifier is reduced.

These four conditions will force the trace onto the screen for any combination of front panel settings. The location of the trace(s) on the CRT when you push the BEAM FINDER button tells you what to do next to obtain a visible trace.

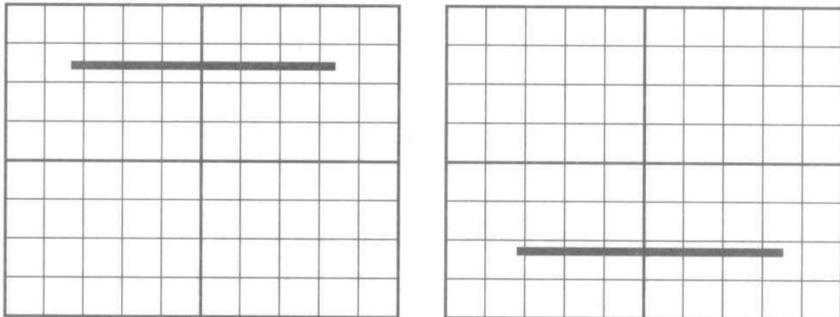
Figure 7 shows how to interpret what you see on the CRT when you press the BEAM FINDER button. Note that one or two traces will be displayed depending on which CRT display mode is selected.

More details about the trigger controls may be found

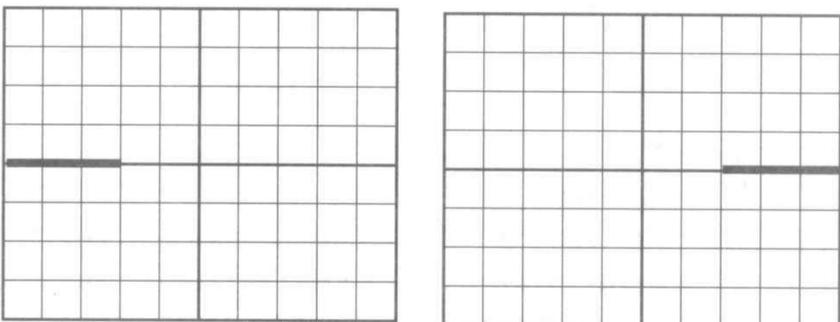
Press **BEAM FINDER**, trace appears:



Adjust: **INTENSITY** or **TRIGGER MODE**



Adjust: **VERTICAL POSITION**



Adjust: **HORIZONTAL POSITION**

Fig. 7: The **BEAM FINDER** button forces a CRT trace by overriding several front panel control settings.

## CRT Modes

The SC3100 has six different CRT display modes which are selected by the four CRT push buttons located below the CRT, as shown in Figure 8. The display options are: 1) Channel A single trace; 2) Channel B single trace; 3) Channel A & B dual chop; 4) Channel A & B dual alternate; 5) Channel A+B add, and 6) X-Y Vector. Each mode is described in the following paragraphs.

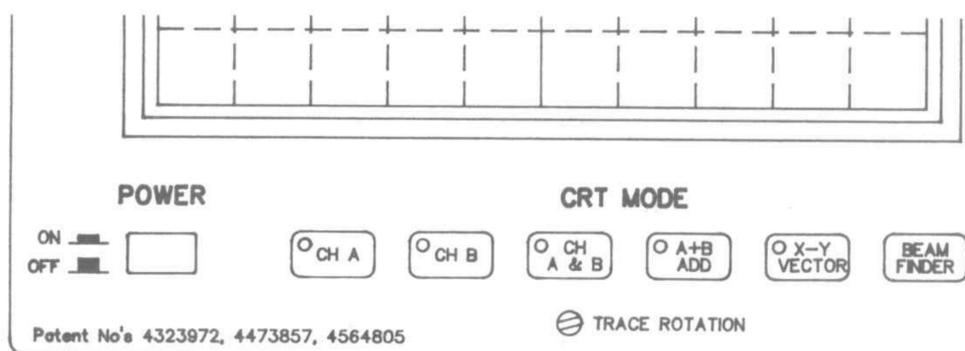


Fig. 8 - Use the push buttons located below the CRT display to select the CRT display mode..

## Channel A or B Single Trace

Signals applied to the channel A and channel B inputs may be displayed independently. Press the CH A or the CH B button to display the desired signal. A signal applied to one channel will not affect the signal that is displayed on the other channel.

### Inverting The Channel A Trace

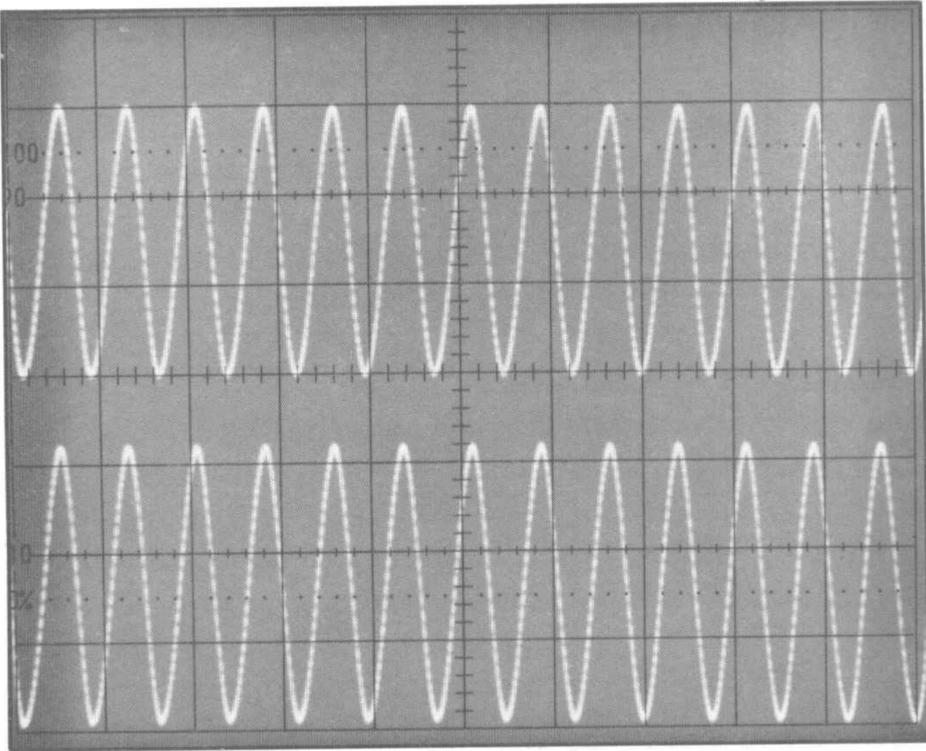
The channel A trace may be inverted by pulling the channel A **VERTICAL POSITION** control out. The inversion affects only the displayed waveform. The triggering polarity of the inverted signal does not change when channel A is inverted.

*NOTE: Be sure the trace is in the noninverting mode when making standard measurements and setting the triggering controls. Confusion may result if the channel A trace is unintentionally inverted.*

## Dual Trace

Press the "A&B" button to view both waveforms simultaneously. The SC3100 automatically selects between dual chop display mode or dual alternate display mode depending on the setting of the **TIME/DIV** Control. All of the sweep rates between "100 msec" and ".2 msec" produce the dual chop mode. Dual chop means that the CRT electron beam draws portions of each trace as it moves across the CRT. This reduces flicker at the slow sweep speeds. The sweep speeds from ".1  $\mu$ sec" to ".02  $\mu$ sec" produce the dual alternate mode. In the dual alternate mode the electron beam draws the complete trace for one channel and then draws the complete trace for the other channel. This prevents the traces from appearing segmented.

At times the dual chop mode may cause interference in the trace at the "msec" sweep speeds, as shown in Figure 9. This interference is common with all dual-trace oscilloscopes and is caused by the CRT beam quickly moving between the channel A and B traces. The interference only becomes noticeable when the frequency of the input signal is at or close to a multiple of the chopping frequency. If this interference occurs, place the SC3100 into the dual alternate mode by simultaneously pressing the CH A and CH B **CRT MODE** buttons so that both LEDs are lit.



*Fig. 9 - Simultaneously pressing the "CH A" and "CH B" CRT mode buttons forces the SC3100 into the dual alternate mode to eliminate chop interference at low sweep speeds.*

### **Algebraic Addition Or Subtraction (A+B or B-A)**

Some applications require two signals to be added to form a composite, or subtracted to show the difference of two signals. Press the "A+B ADD" CRT MODE Button to algebraically add the two signals. To subtract the signals press the "A+B ADD" button and pull the channel A VERTICAL POSITION control out to invert the channel A display.

The phase relationship of the signals determines whether the resulting waveform is larger or smaller in amplitude than the applied signals. If the signals are in phase, adding them will increase the size of the displayed waveform and subtracting them will produce a waveform that is either smaller than either of the applied signals or that shows total cancellation. If the two signals are  $180^\circ$  out of phase, the opposite occurs: adding produces cancellation and subtracting causes an increase in the resulting waveform. The resulting display of signals having phase shifts other than  $0^\circ$  or  $180^\circ$  will be their instantaneous sum or difference.

### **Vector (X-Y) Operation**

Press the "X-Y VECTOR" CRT MODE button to use the CRT as an X-Y display. In the vector mode the signal applied to the channel A input causes vertical (Y) deflection and the signal applied to the channel B input causes horizontal (X) deflection. The resulting Lissajous pattern shows the phase and frequency relationships of the two signals.

The vertical gain is controlled by the channel A VOLTS/DIV Control, and the channel A VERTICAL POSITION Control adjusts the pattern's vertical position. Use the channel B VOLTS/DIV Control to set the horizontal gain and use the HORIZONTAL POSITION Control to adjust the horizontal position. (The channel B VERTICAL POSITION Control has no effect when the vector function is selected).

## APPLYING SIGNAL TO THE INPUTS

Signals may be supplied to the SC3100 using either of several methods: 1) 10X Low Capacity Probes (supplied); 2) DP270 Direct Probe (optional); 3) PL207 RF Pickup Loop (optional); or 4) 39G157 DCV Probe (optional). Each method offers certain advantages and disadvantages that should be considered before making a connection.

With the exception of the PL207 RF Pickup Loop, each of these methods of supplying a signal requires making a ground connection to the chassis.

### Connecting To A Hot Chassis

As with other oscilloscopes, the BNC input connectors, probe ground leads and front panel GROUND Jack of the SC3100 are connected to the AC line 3rd wire safety ground. This requires extra care when you connect to a "hot chassis" piece of equipment. A hot chassis is a device that does not have an internal isolation transformer. Consequently the chassis ground or common is not referenced at earth ground and is typically 67 volts above earth ground potential.

### Use With Sweep Generators Or Curve Tracers

You can use the vector mode to display the output from a sweep generator or curve tracer if it provides a horizontal output drive signal. Connect the vertical output of the sweep generator or curve tracer to the CH A INPUT and connect the horizontal output to the CH B INPUT of the SC3100. Use either AC or DC coupling as required.

**Always connect a hot chassis to an isolation transformer, such as the Sencore PR57 AC "POWERITE"® before connecting the SC3100 to the device.** The isolation transformer allows the hot chassis to float in reference to earth ground. Connecting the ground of the SC3100 to the hot chassis without isolating the chassis will damage the chassis power supply or the ground connections in the SC3100. Only connect the chassis to the isolation transformer; do not connect the SC3100 to the isolation transformer.

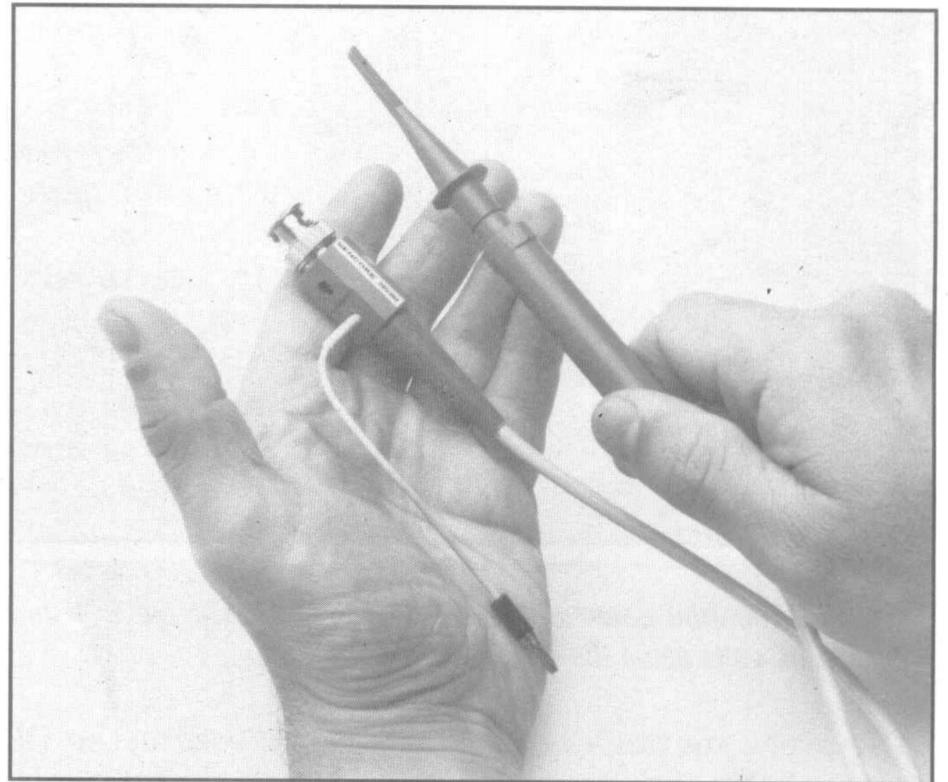
*NOTE: 1) Using an external transformer with a device that contains internal isolation will not cause a problem. If in doubt, always use an isolation transformer. 2) It may not always be practical to connect some devices to an external isolation transformer because they draw too much AC current or use 3 phase power. Refer to the section "Making Differential Measurements" on page 53 for information on testing these devices.*

### WARNING

**Always use an isolation transformer on any piece of equipment that is AC operated and does not have an internal isolation transformer. All warranties are voided if the 3rd wire ground is bypassed, or if damage occurs from making a connection to an unisolated hot-ground system.**

### 10X Low Capacity Probes

Most measurements are made using the supplied 39G292 10X Low Capacity Probes. These probes isolate the capacitance of the test lead and the input circuits from the circuit test point. This reduces circuit loading and the resulting measurement errors. The special design of the 39G292 Probe protects the SC3100 to 2000 volts DC or AC peak-to-peak. The 39G292 Probe also provides a separate isolated circuit for making DC voltage measurements independent of the CRT input controls.



**Fig. 10 - Use the supplied 10X probes for most signal connections.**

The only disadvantage of using the 10X Low Capacity Probe is reduced sensitivity. The 10X Probe limits the lowest measuring range of the SC3100 to 20 mV/div. This allows useful measurement of signals as small as 10 millivolts (.010 volts) which is adequate for most circuit tests.

*NOTE: Use the DP270 direct probe to increase the input sensitivity to 2 mV/div.*

Read the digital tests direct and use the markings around the VOLTS/DIV Control directly when using the 10X Probes with the SC3100. You do not need to multiply readings by ten as you do with some other oscilloscopes. (You will need to divide the VOLTS/DIV scale markings by ten when using a direct, 1X probe.)

### Special Design Of The 39G292 10X Probe

The 39G292 10X Low Capacity Probe is specially designed to route the DC voltage to digital circuits separately from the CRT or digital peak-to-peak function. You do not need to have the INPUT COUPLING switch set to "DC" to measure DC voltage on the digital display.

These separate paths require two connections to the SC3100. The BNC connector couples the signal to the CRT and digital VPP circuits while the mini-banana DCV jack couples the DC voltage to the digital display. Be sure to make both probe connections to the SC3100.

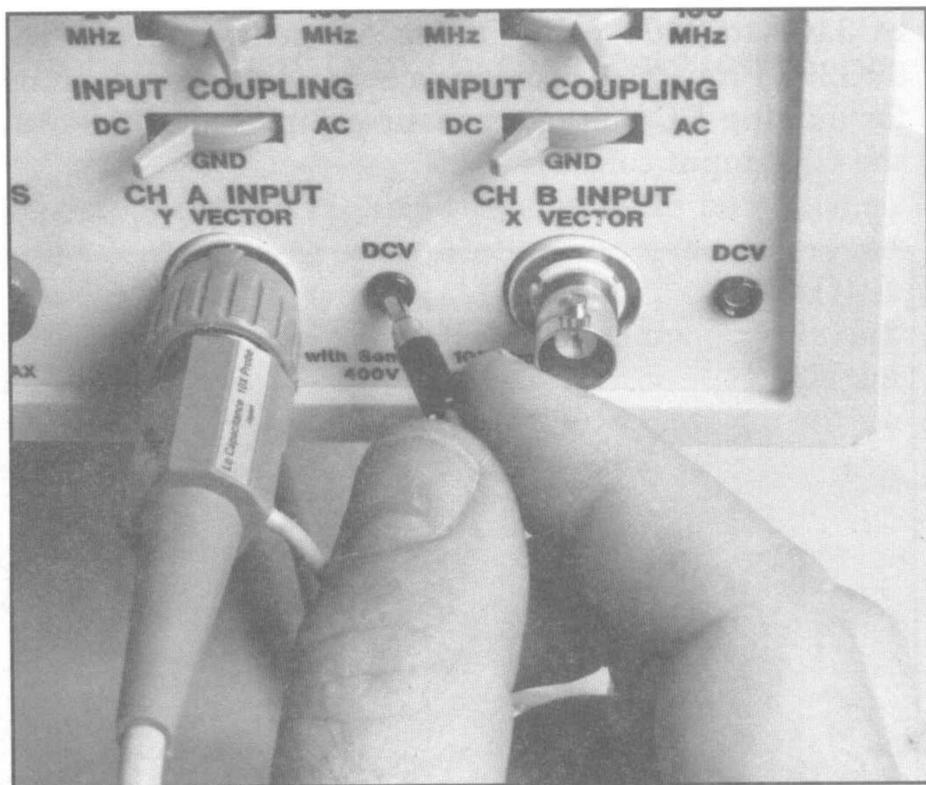


Fig. 11 - The mini-banana plug must be connected to the DCV Jack to read DC volts using the 10X Low Capacity Probe.

The probe contains separate 10:1 dividers for the DC digital display measurement path and for the CRT/VPP measurement path. This prevents loading problems caused by the capacitance of the DC lead. The input impedance of the CRT circuits at the BNC input jack without the probe connected is 1 megohm DC coupled and 2 megohms AC coupled. The impedance at the DCV input jack is 1.5 megohms.

Connecting the 10X Probe to the inputs increases both input impedance values by ten, making the AC impedance 10 megohms and the DC input impedance 15 megohms. The circuit test point, however, sees both of these measuring paths in parallel, which effectively make the impedance at the probe tip 6 megohms. While this is a somewhat lower impedance

than most oscilloscopes, very few circuits will be affected by the 6 megohm impedance. If circuit loading is a problem, disconnect the DCV lead from the DCV Input Jack to increase the input impedance to 10 megohms.

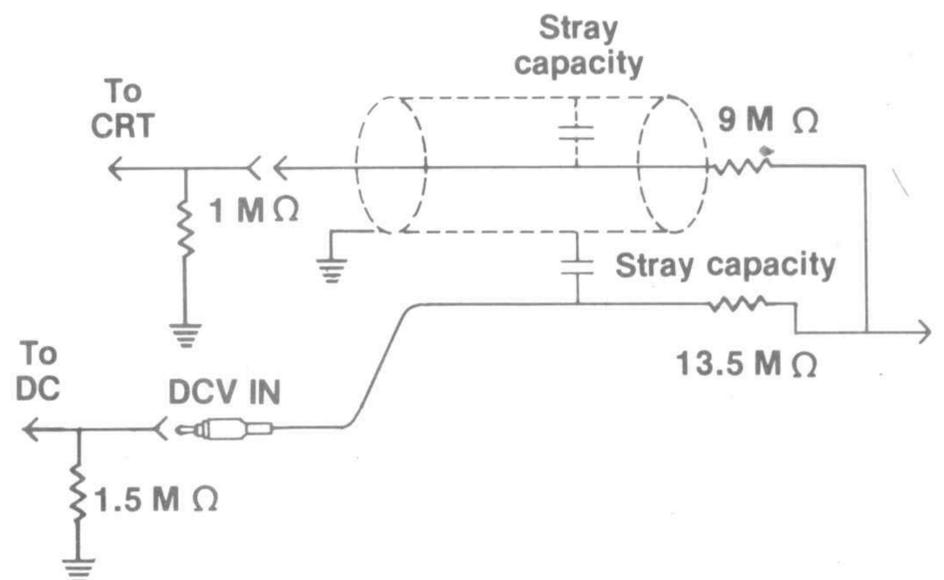


Fig. 12 - Isolation resistors for the AC and DC signals prevent the stray lead capacitance from loading high frequency circuits.

### Probe ID Bands

The supplied 10X Probe Accessory Kit contains two yellow and two red Probe ID Bands. Place one band around the probe wire near the tip and the other band of the same color around the wire near the BNC end. Color coding each probe in this manner allows you to quickly know which probe is connected to each input without tracing the wires back to the probe tip.

The two 39G292 10X Low Capacity Probes supplied with your SC3100 may be used on either channel. However, the probe compensation adjustment uniquely matches the probe to the impedance of CH A or CH B INPUT. Be sure to check the probe compensation and readjust it if you move a probe to the other channel than it was compensated for.

### Ground Connectors

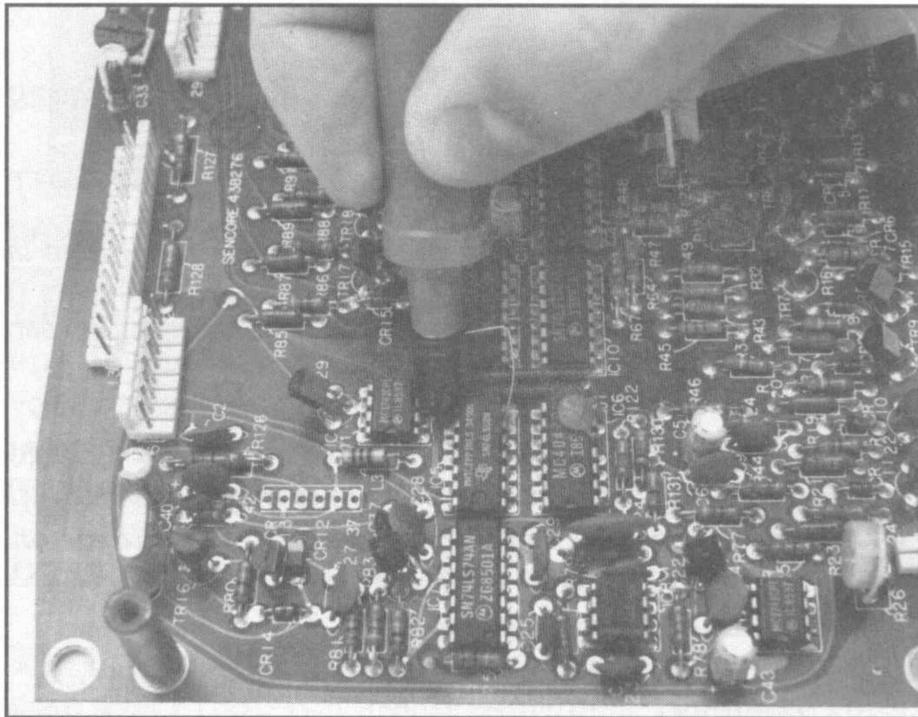
Each probe should always be grounded to the circuit ground point to prevent interference or other waveform distortion. The supplied 39G331 10X Probe Accessory Kit contains a 5" and a 12" ground lead for each probe. Always use the short, 5" ground lead when working in high frequency circuits or digital circuits that have square wave signals with fast rise times. The extra inductance of the 12" ground lead will cause distortion in these signals. The 12" ground lead should only be used with low frequency signals, such as video and audio. Connect the alligator clip of either probe to a ground point that is as close as possible to the test point you are measuring.

*NOTE: Use the front panel GROUND Jack only for DC voltage measurements or to tie the SC3100 together with other test instruments to a common ground. Do not use it instead of a probe ground lead.*

### WARNING

**Do not connect the ground leads to a hot chassis unless an isolation transformer is used. Be sure to only connect the probe ground leads to ground points that are the same, earth ground potential.**

**Ground Bayonet Clip** - Use the Ground Bayonet clip, included in the optional Probe Accessory Kit, when making tests in digital stages. This clip provides the shortest possible ground length to prevent signal distortion on fast rise time signals. Simply remove the retractable probe tip and slide the Ground Bayonet clip over the probe end.

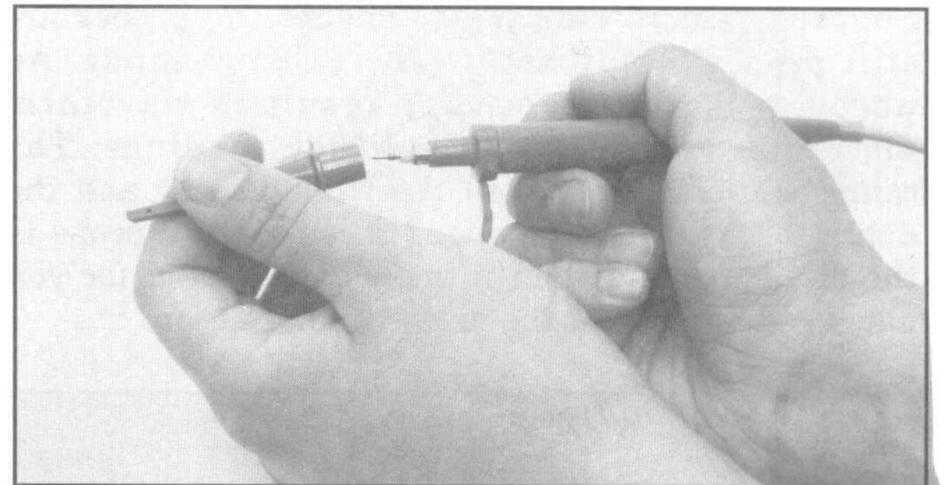
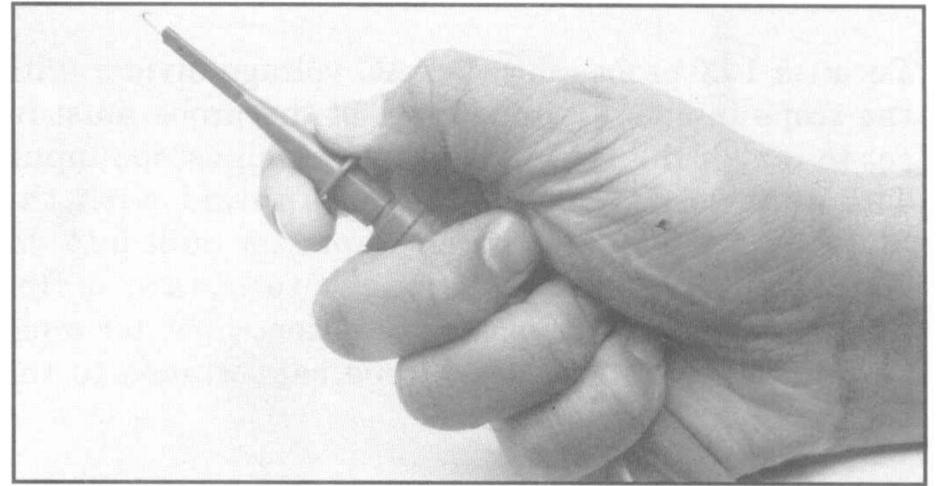


*Fig. 13 - The (optional) Ground Bayonet provides the shortest possible ground connection and a convenient way to connect to IC pins. It is part of the optional Probe Accessory Kit.*

### Connecting The Probe To The Circuit

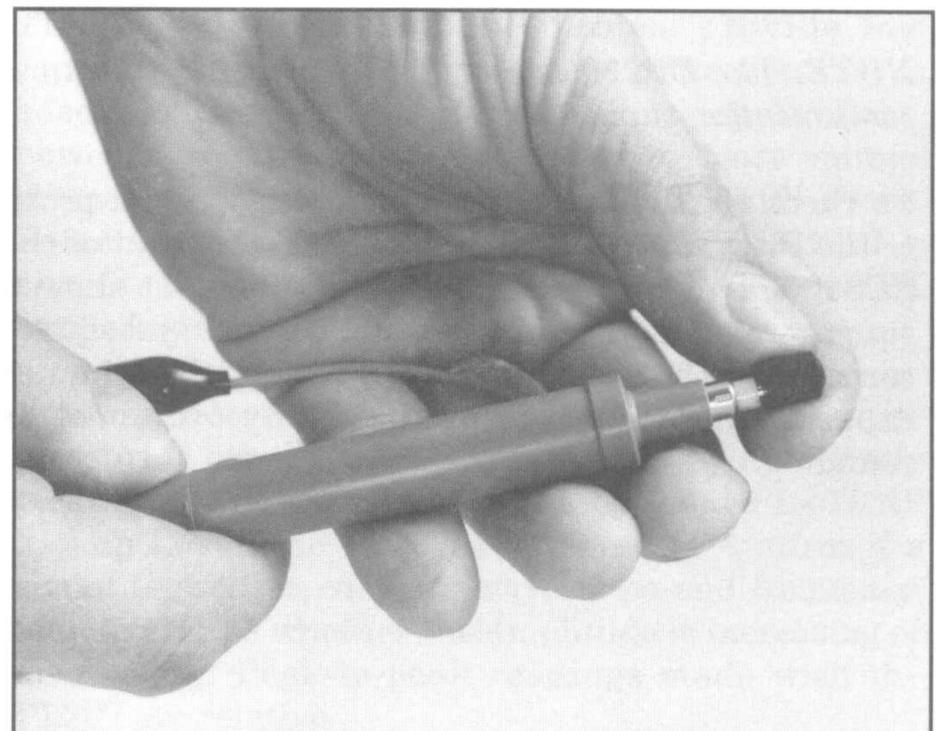
The supplied 10X Probes may be connected to the circuit in either of two ways; with the retractable hook tip, or with a needle point connector. To use the retractable tip simply pull back on the collar to expose the hook. Then slip the hook over the component lead or test point and release the collar. The sleeve will slide forward to hold the probe in place.

To expose the needle point tip unscrew and remove the retractable tip. The optional Probe Accessory Kit includes several other options for connecting the probe.



*Fig. 14 - Pull back on the retractable tip to expose a metal hook to connect to the circuit (a). Unscrew the probe tip to expose a needle probe tip (b).*

**Ground Ring Insulator** - Unscrewing the retractable probe tip also exposes a metal ground ring. This ground ring allows you to use the optional Ground Bayonet Clip when working in high frequency circuits, but it may accidentally short against components and IC pins if you are using the needle tip. The supplied Probe Accessory Kit includes an Ground Insulator Ring that slips over the probe tip and covers up the metal ground band on the probe tip, when you use the needle tip.

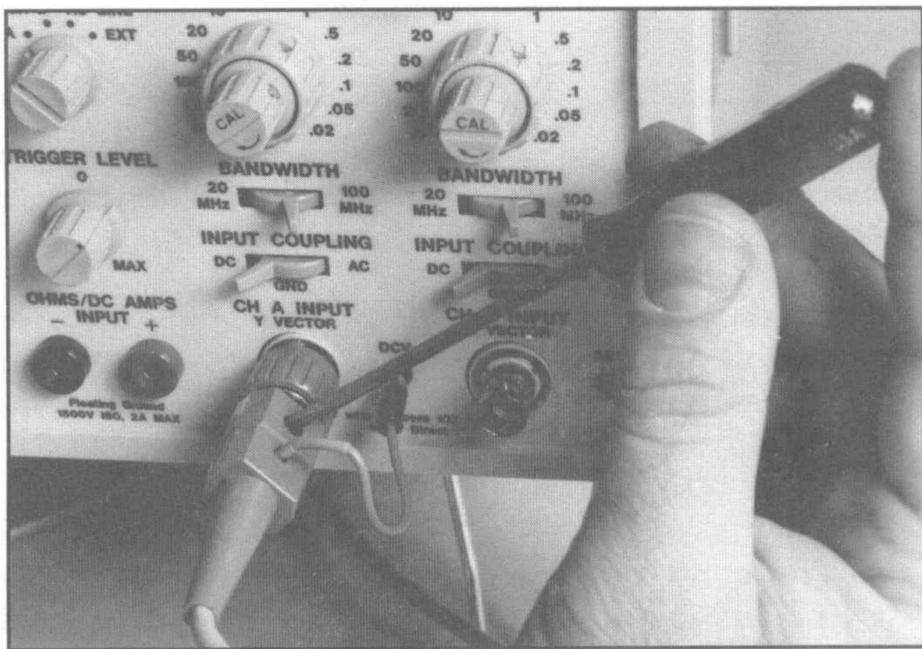


*Fig. 15 - Use the supplied Ground Insulator Ring to insulate the ground ring when you are not using the retractable probe tip.*

## Probe Frequency Compensation

Because 10X probes form an AC voltage divider with the scope input, the impedance of the probe must be set to match the impedance of the oscilloscope input. The 10X Lo Capacity Probes supplied with the SC3100 have a small trimmer capacitor built into the BNC connector body. In order to obtain a flat frequency response this compensation capacitor must be adjusted to match the probe capacitance to the capacitance at the input jack.

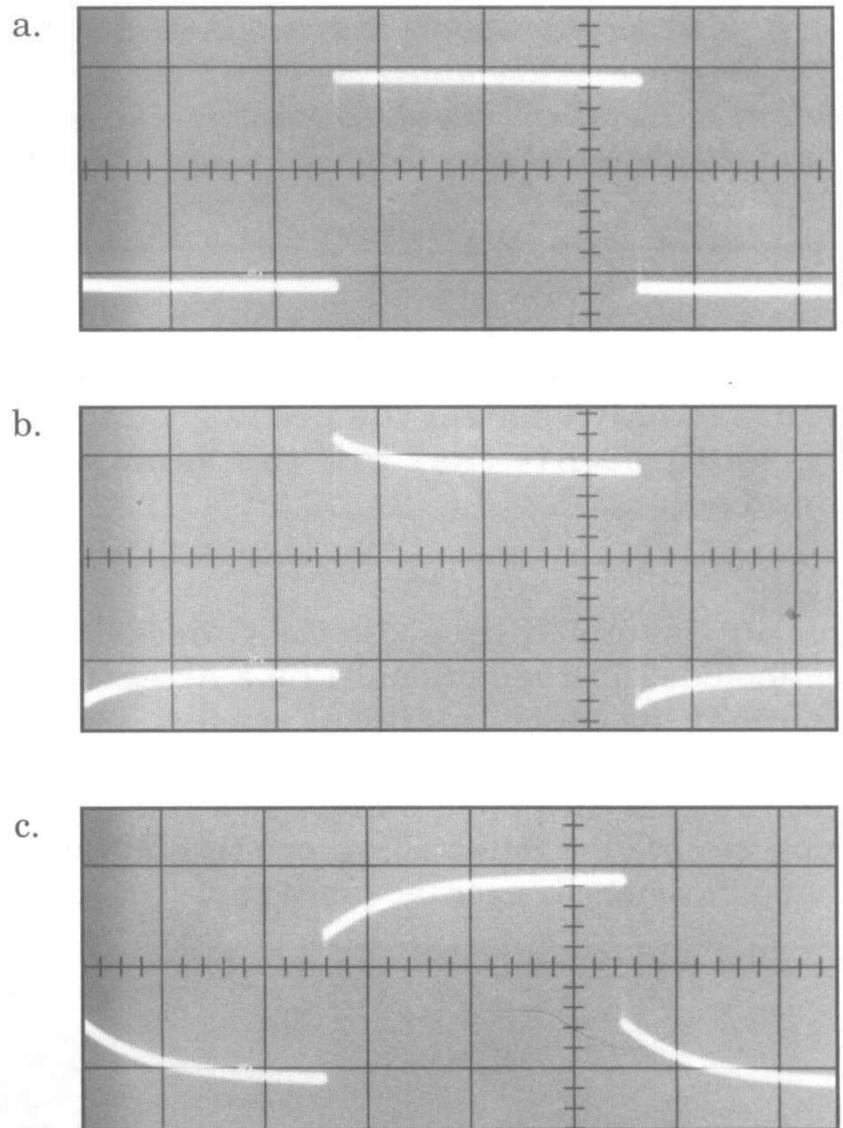
Once you have compensated the probe, check the compensation periodically to ensure the probes are still properly matched to the SC3100 input. An uncompensated probe may result in waveform distortion or incorrect amplitude readings. The compensation affects both the CRT display and the digital peak-to-peak function. If you move a probe to the other channel than it was compensated for you may need to readjust the probe compensation.



**Fig. 16 - The probe compensation capacitor matches the probe capacity to the scope's input capacity.**

*NOTE: The DP270 Direct Probe does not contain a compensation capacitor.*

To check the probe compensation, connect the probe to the PROBE COMP Jack located on the front of the SC3100. The resulting CRT display should show a square wave having a flat top and bottom, and square corners, as shown in Figure 17. Adjust the trimmer capacitor if the waveform shows any overshoot or rounding.



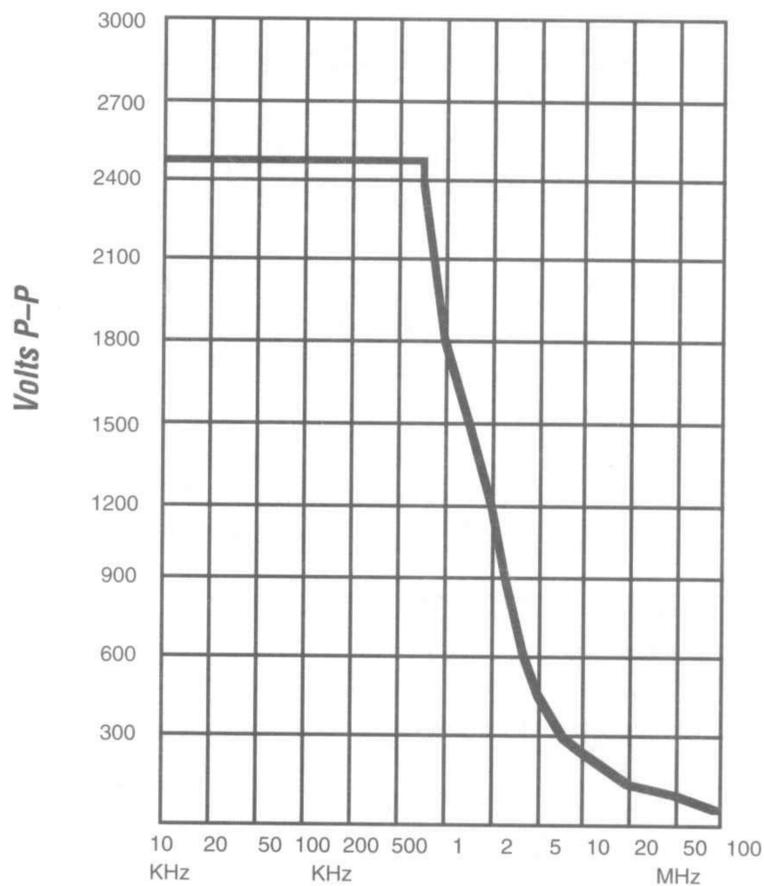
**Fig. 17 - Adjust probe compensation so that the signal from the PROBE COMP Jack is square (a). Overshoot (b) or rounding (c) indicates that the probe compensation capacitor needs adjustment.**

*NOTE: The PROBE COMP signal has square edges but may not be 50% duty cycle. Do not use the PROBE COMP signal as a frequency or amplitude calibration.*

### To compensate the probes:

1. Connect the probes to the PROBE COMP Jack.
2. Set the VOLTS/DIV Control for both channels to ".5".
3. Set the TIME/DIV Control to ".1 msec".
4. Lock in the waveform with the TRIGGER controls.
5. Select the channel A display.
6. Adjust the probe compensation capacitor in the probe connection to the CH A INPUT for the best square wave.
7. Repeat steps 5 and 6 for the channel B probe.

*NOTE: Recompensate the probe if you move it to the input channel other than the one it was compensated on.*



**Fig. 18 - The voltage breakdown of the 39G292 10X probe reduces at high frequencies.**

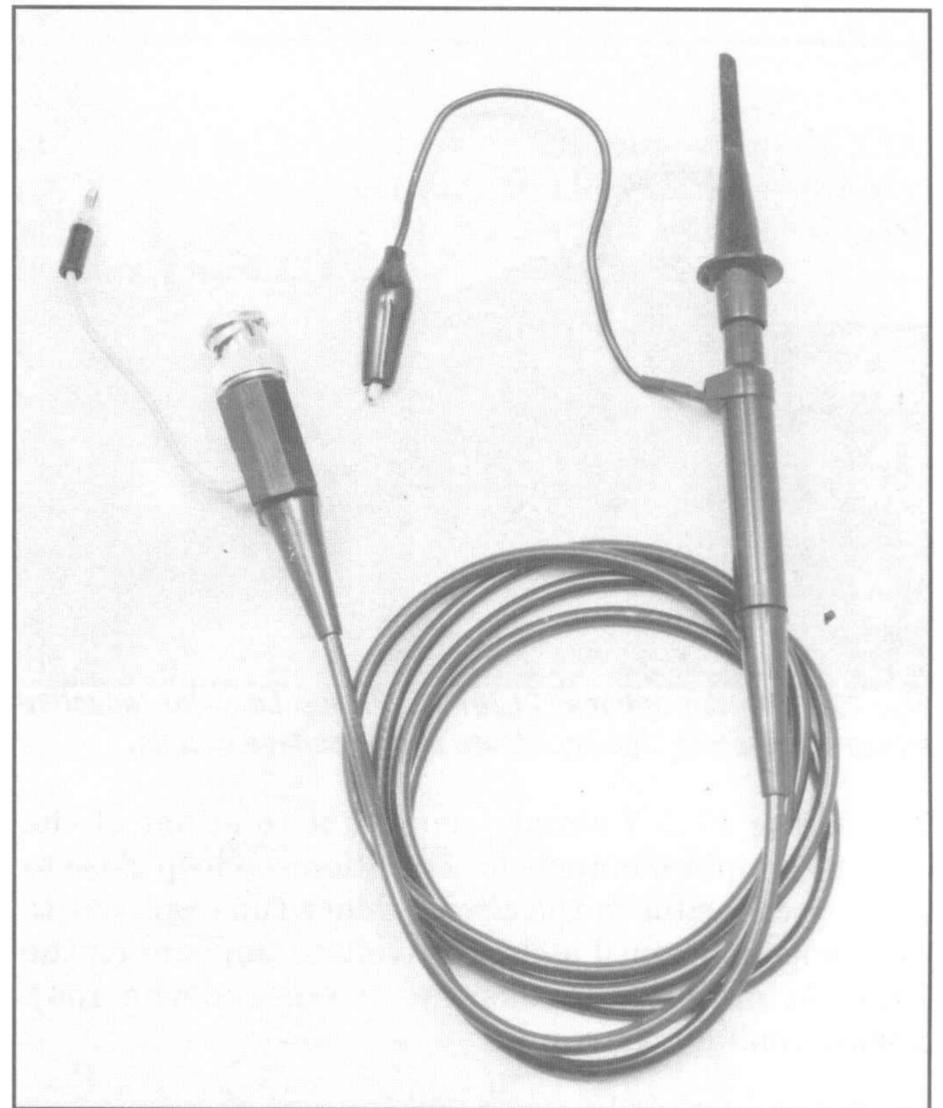
### 2500 V Breakdown Protection

The voltage rating of all high frequency, low capacity probes drops as the applied frequency increases. The graph in Figure 17 shows the breakdown limits of the 39G292 10X Lo Capacity Probe for high frequency applications. Few applications require a higher voltage vs. frequency rating than this. If you need to measure a signal that is outside these limits, use the (optional) PL207 RF Pickup Loop.

### DP270 Direct Probe (Optional)

The optional DP270 provides direct connections for both the AC signal (BNC) and the DC voltage (mini banana) inputs to the SC3100. This probe allows ten times more vertical sensitivity than is possible using the supplied 10X Low Capacity Probes and enables you to take advantage of the low 2 mV sensitivity offered by the SC3100 when measuring extremely small signals. However, there are three disadvantages of using a direct probe.

First, a direct probe does not isolate the capacitance of the scope's input circuitry from the test point. This will affect the operation of high frequency circuits. Secondly, the input impedance is reduced from 10 megohms to 1 megohm which will load high impedance circuits. Lastly, the frequency response of the SC3100 is reduced to 15 MHz when using a direct probe. (The frequency response is limited by using high resistance wire in the direct scope probe to reduce ringing.) For these reasons, only use the optional DP270 when you need increased sensitivity on signals that are lower than 15 MHz.



**Fig. 19 - The optional DP270 provides a direct input connection to take full advantage of the SC3100's 2 mV input sensitivity.**

The SC3100 senses when you have connected the DP270 to either of the channel inputs and automatically compensates all of the digital voltage readings. Continue to read the Digital Display direct when using the DP270. You only need to divide the setting of the VOLTS/DIV Control by 10 if you are measuring the signal using the CRT.

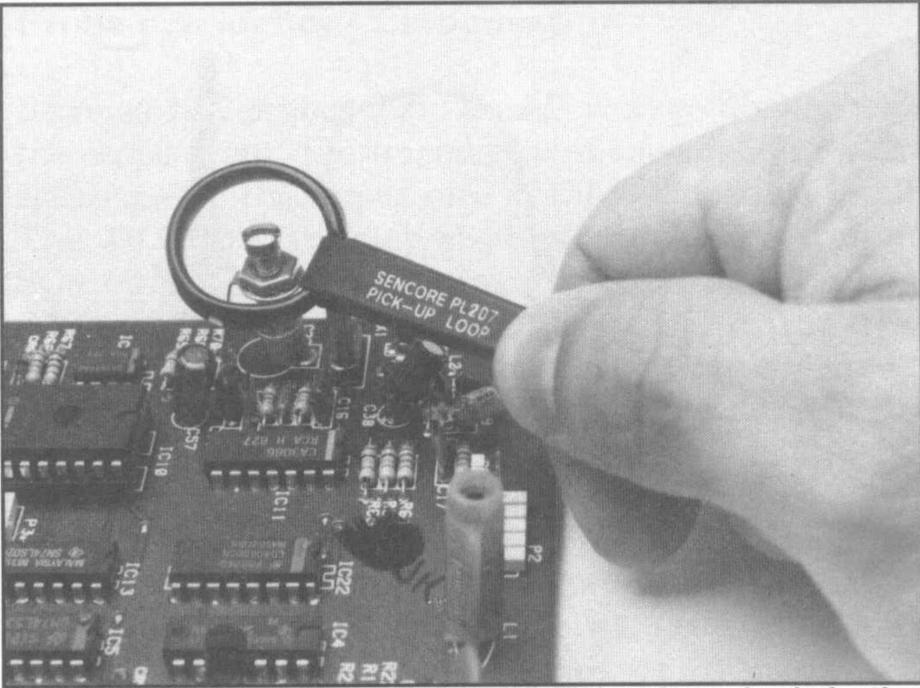
### PL207 Indirect Connections (Optional)

The supplied 39G292 10X probes provide low capacitive loading and high voltage protection that is adequate for most measurements. Some applications, however, require even less loading or more voltage protection than is offered by the 39G292 10X Probe. Some high impedance/high frequency oscillator circuits, for example, will be loaded by any 10X oscilloscope probe.

You can decrease circuit loading and extend the measuring capabilities of your SC3100 by inductively picking up the signals with the optional PL207 RF Pickup Loop. The PL207 allows you to confirm if a signal is present, view its waveshape and frequency, and determine whether the amplitude is increasing or decreasing. Peak-to-peak readings made with the PL207 are relative.

## DC Voltage Probe (Optional)

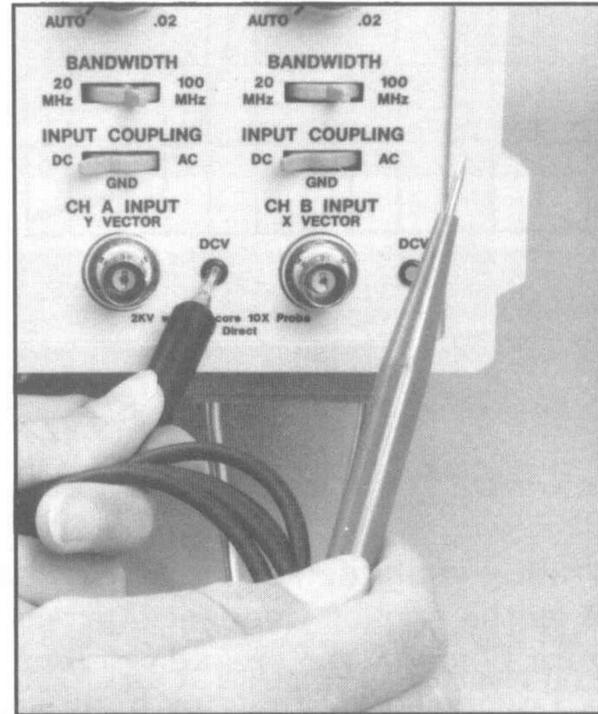
The optional 39G157 DC Voltage Probe allows you to measure the DC voltage at a point different from where the scope probe is connected. To use this probe unplug the DCV IN connector from the 10X probe that goes to either the channel A or B input and replace it with the 39G157 plug. Press the DCV DIGITAL READOUT button for the channel that you have connected the DCV probe to. Read the voltage in the display directly, as the 39G157 DCV Probe contains the necessary divider network.



**Fig. 20 - Use the optional PL207 RF Pickup Loop for inductive pickup of signals in high impedance or high voltage circuits.**

To use the PL207 simply connect it to either of the SC3100's input channels and position the loop close to a coil or capacitor in the circuit. Move the loop near to the component until a clear waveform appears on the CRT. It may be necessary to change the loop orientation for best results.

The PL207 may also be used to sample signals in circuits with operating potentials above 2000 volts. Use extreme caution when working around high voltage circuits to prevent a direct contact between the PL207 and a high voltage point.



**Fig. 21 - The 39G157 DCV Probe provides DC voltage measurements separate from the normal low capacity probes. The 39G157 has a multiplier resistor so all readings are direct.**

## SETTING THE VERTICAL CRT DISPLAY

### VERTICAL CRT DISPLAY

The vertical CRT display section of the SC3100 functions like other oscilloscopes to provide a visual display of the signal applied to the input channels. This section explains how to obtain a locked in waveform on the CRT.

*NOTE: The Auto-Tracking™ measurements can be made without displaying the waveform.*

But this trace shifting may be annoying when the DC component is not important, or when the DC voltage is being monitored with the Auto-Tracking™ digital DCV readout.

You will use AC coupling for most tests. In this mode, a capacitor is connected in series with the input circuits to block the DC component. This allows the trace to stay at the same vertical position on the CRT as the DC voltage changes, or as the probe is moved to different test points.

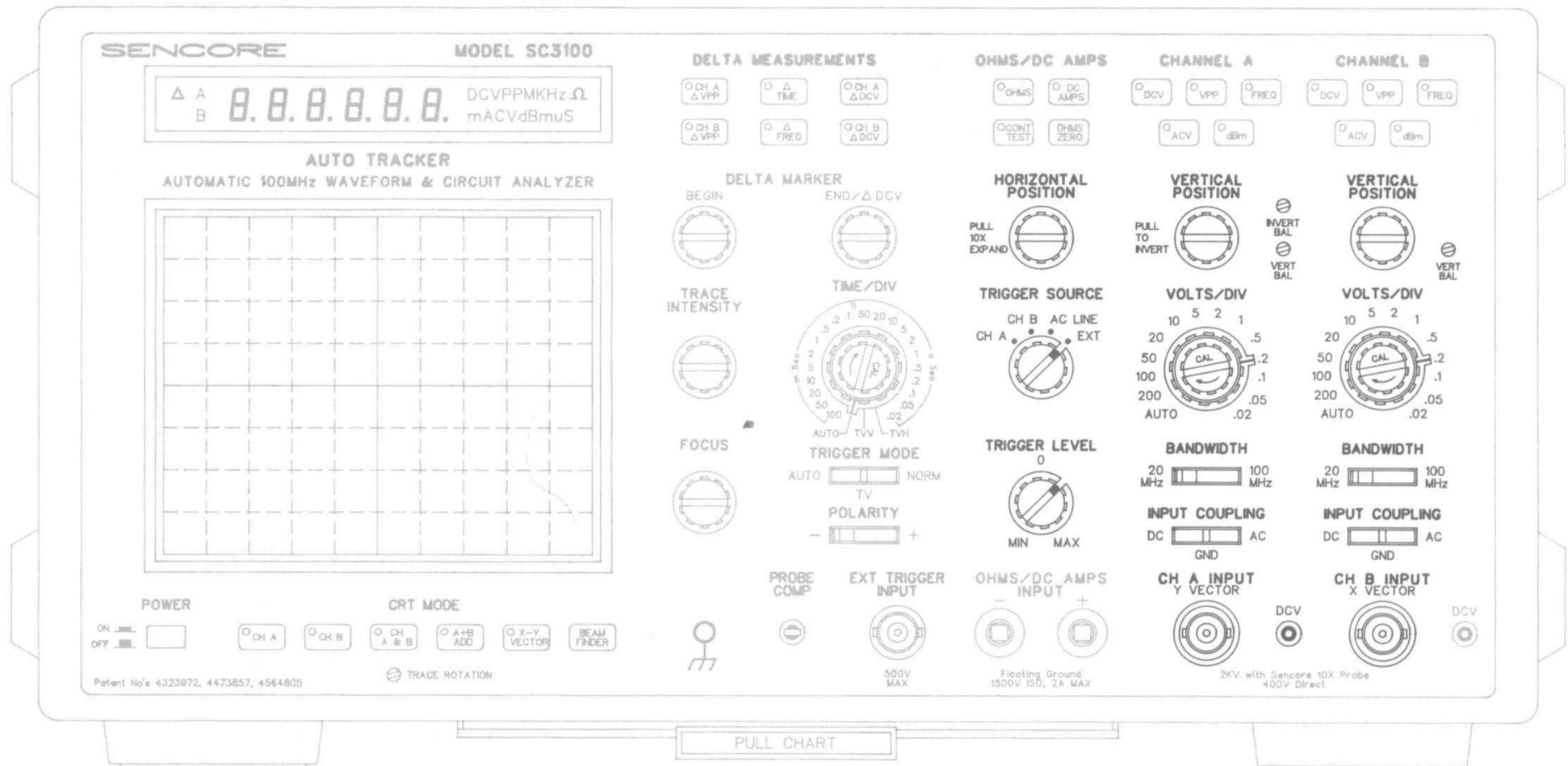


Fig. 22 - Use these controls to obtain a waveform display on the CRT.

### WARNING

Do not exceed the input rating of the SC3100; 2000 volts (DC + Peak AC) with the 39G292 low capacity probes, or 400 volts (DC + Peak AC) direct. Use caution when measuring high voltages to avoid contact with the end of the test probe or the circuit being tested.

### Selecting AC or DC Coupling

The INPUT COUPLING switch selects how the signal is coupled to the vertical circuits. When the switch is in the "DC" position, any change in the average DC level applied to the BNC input will cause the trace to move vertically by an amount proportional to the DC voltage. This is important when you need to view the sum of the AC and DC components of the signal.

*NOTE: The INPUT COUPLING switch may be in any position when making any of the digital readout measurements.*

### Setting The Vertical Size

The VOLTS/DIV switch controls the amplitude (vertical size) of the displayed waveform by adjusting the amount of gain or attenuation of the vertical circuits in fixed steps. The role of the VOLTS/DIV switch is greatly diminished in most of SC3100's applications compared to conventional analog oscilloscopes. This is because the Waveform & Circuit Analyzer's digital display provides a faster and much more accurate measurement direct readout of all voltages.

*NOTE: Changing the setting of the VOLTS/DIV switch will not affect the input protection.*

For most applications you simply set the VOLTS/DIV switch for the desired amount of vertical detail or until you see the entire waveform displayed on the CRT. Turning the VOLTS/DIV switch clockwise will increase the amplitude of the displayed waveform, while turning it counterclockwise decreases the amplitude. Calibrated voltage markings around the switch allow you to match alignment instructions and waveform displays in service literature.

A variable vernier ("CAL") control located in the center of the VOLTS/DIV switch allows you to "fine tune" the waveform's amplitude. The setting of the vernier control does not matter (it does not need to be in the cal position) when using any of the digital display measurements. However, it must be turned fully clockwise to the calibrated detent position if you are making CRT based measurements. The CRT is calibrated for direct readings when using the supplied 39G292 10X low capacity probes. The digital meter circuits automatically compensate and read direct when either a 10X or direct probe is used.

### **Autoranging**

When the VOLTS/DIV switch is set to the "Auto" position the SC3100 automatically selects the range needed to produce a display that is approximately 3 vertical divisions tall. The ranges that are automatically selected are the same as those available by manually turning the VOLTS/DIV switch. Therefore, the amplitude of the display will vary between 2 and 4 divisions depending upon the range that is selected. The vertical vernier control is not automatically adjusted in "Auto" and may be used manually to fine tune the size of the waveform display.

*NOTE: Signals that are larger than 800 VPP will result in a display that is larger than 4 divisions.*

The SC3100 will autorange to follow the input signal as you move between test points. You will, however, need to the adjust the VERTICAL POSITION control

to position the trace on the screen. Select "AC" INPUT COUPLING when using "Auto" VOLTS/DIV so that the DC component of the signal does not move the waveform as you move between test points.

### **Vertical Position**

Use the channel A and channel B VERTICAL POSITION controls to position the trace(s) at any desired location on the CRT. If the INPUT COUPLING switch is set to "DC" you may need to reposition the trace each time you move to a new test point. Unless the DC component is important, leave the INPUT COUPLING switch set to "AC" so that you do not need to reposition the trace as you probe different test points.

The channel A VERTICAL POSITION control also contains a switch to invert the channel A display. Pull the control outward to invert the display and push the control in for a normal display.

### **Bandwidth Switch**

The BANDWIDTH Switch allows you to select the frequency range of the signal applied to the CRT and digital measuring circuits. The "100 MHz" position allows the full bandwidth of the SC3100 and is used for most signals.

The "20 MHz" position attenuates all signals above approximately 20 MHz. Use this position to prevent high frequency noise from causing interference with measurements and waveform displays. This position is especially useful to eliminate interference when using the most sensitive (.02 to .1) attenuator settings.

*NOTE: The "20 MHz" BANDWIDTH position may attenuate or completely filter out fast glitches and transients. Use the "100 MHz" BANDWIDTH position when looking for fast signal transitions and frequencies above 5 MHz.*



TV switches sync separators into the trigger circuits to provide stable triggering on composite video signals. The trigger circuits are referenced to either the horizontal sync pulses or the vertical sync pulses depending on the setting of the TIME/DIV switch. All "msec" sweep speeds reference vertical sync while all "µsec" sweep speeds reference the horizontal sync pulses. The TRIGGER POLARITY Switch must be set to match the polarity of the video sync pulses when using TV trigger mode.

*NOTE: It is not necessary to have the TRIGGER MODE set to "TV" when using the video preset positions of the TIME/DIV switch.*

**NORM** (normal) produces a trace only when the trigger circuits receive a large enough amplitude signal, as controlled by the TRIGGER "Level" and VOLTS/DIV Controls. The CRT will remain blank until a trigger pulse occurs. The normal trigger mode can be used to trigger on all waveforms, except video signals. Use the normal mode to view low repetition rate signals that are unstable when viewed in the "Auto" mode.

In the "Auto" TRIGGER MODE the sweep circuits keep the electron beam from scanning across the screen for a short time while they wait for a trigger pulse. But, if no trigger pulse occurs, the circuits automatically start the electron beam across the screen. The repetition rate of most signals is fast enough so that the trigger pulse occurs before the trace starts. The repetition rate of a few signals, however, is slow enough so that the trace has already moved part way across the screen before the signal transition occurs. This causes the displayed waveform to appear unlocked. The normal trigger mode prevents this problem by not starting the electron beam until the input signal triggers the circuits.

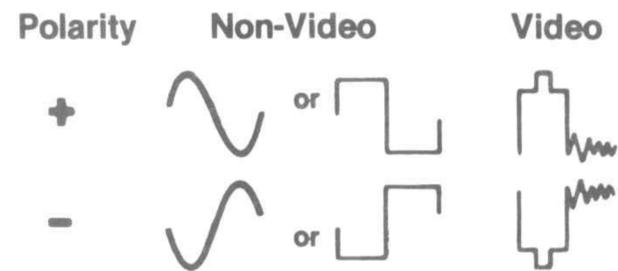
### TRIGGER POLARITY

The TRIGGER POLARITY switch determines whether the trigger circuits respond to the positive or negative voltage transition of the input signal. The "+" position starts the trace on the portion of the signal that is increasing in amplitude, while the "-" position starts the trace on decreasing transitions.

Most signals will lock equally well with either polarity selected. One exception is video signals. Here the POLARITY switch must be set to match the polarity of the video sync pulses so that the sync separator can properly separate the sync pulses from the video information. Set the TRIGGER POLARITY switch to "+" if the video sync pulses are positive (pointing up) and to "-" if the video sync pulses are negative. Selecting the wrong polarity may result in an unstable trace and will produce incorrect peak-to-

peak readings when using the Delta Peak-to-Peak function on video signals.

*NOTE: The TRIGGER POLARITY switch will appear to work backwards if the channel A trace is inverted and the CH A TRIGGER SOURCE is selected.*



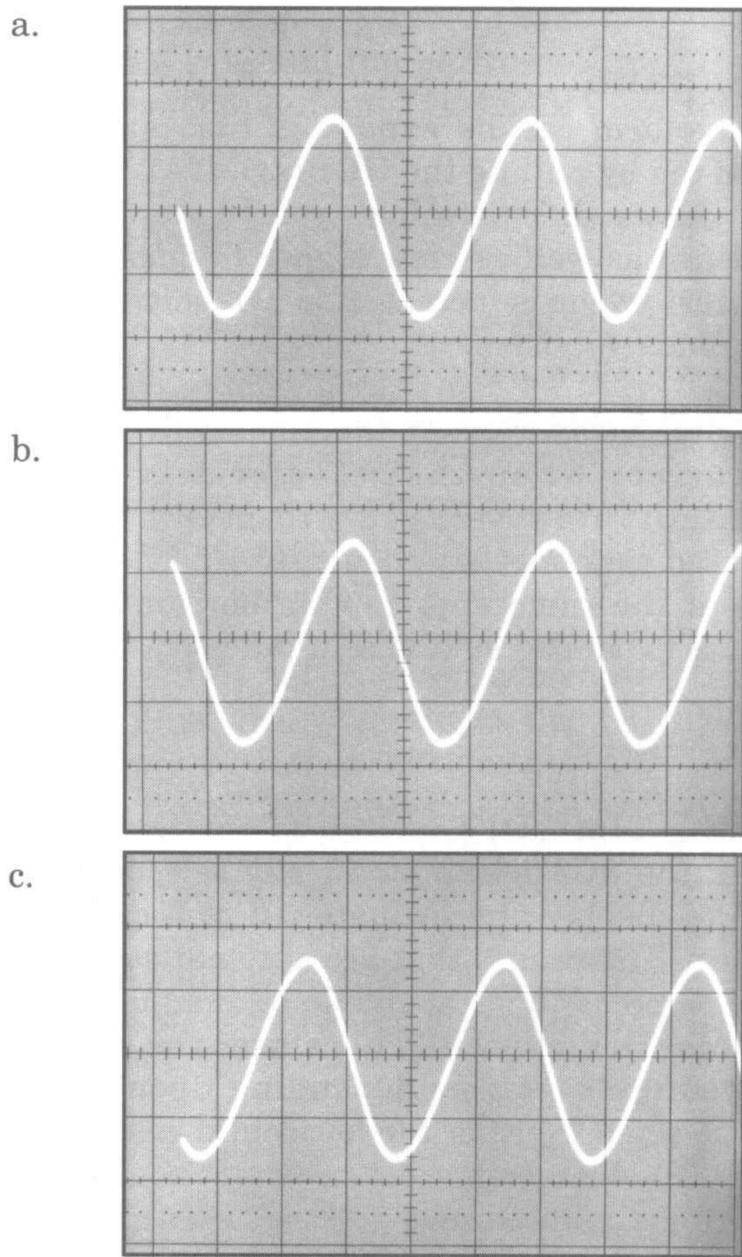
**Fig. 25 - The TRIGGER POLARITY switch determines whether the trigger circuits use the rising or falling signal transition.**

### TRIGGER LEVEL

The TRIGGER LEVEL control sets the voltage level of the input signal that will trigger the SC3100's trigger circuits. All symmetrical waveforms have two points that are the same voltage level. The POLARITY control determines whether the voltage level selected by the TRIGGER LEVEL control is on the rising transition or on the falling transition. The "+" and "-" markings on the TRIGGER LEVEL control refer to where the trace begins relative to the top and bottom of the CRT. This is true with either TRIGGER POLARITY switch setting.

Figure 26 illustrates the affects of the LEVEL control on a sine wave with "-" POLARITY. The top picture shows the waveform with the TRIGGER LEVEL control set to "0". Notice that the trace starts near the midpoint of the negative going portion of the waveform. The middle picture shows the same signal with the TRIGGER LEVEL control turned towards "+". This causes the trace to start on highest "+" amplitude portion of the signal. Notice that trigger point again is on the falling portion of the signal (because "-" POLARITY is selected). The bottom picture shows the waveform starting at the most "-" point as the TRIGGER LEVEL control is turned "-".

*NOTE: The effect will appear to be reversed if the channel A signal is inverted and the SC3100 is triggering from channel A because the signal inversion takes place after the trigger take-off point.*



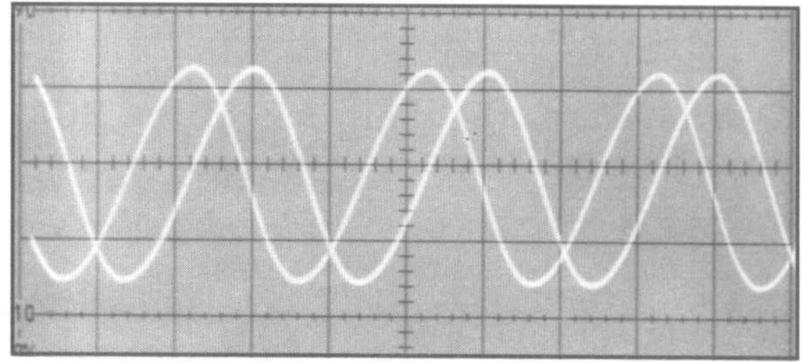
**Fig. 26 - The trigger point is in the middle of the waveform with the TRIGGER LEVEL control at zero. (A) Turning the control in the "+" direction causes the starting point to move up (B). Moving the control towards "-" causes the opposite effect (C). (POLARITY is set to "-").**

### Triggering On Sine Waves With Distortion

Low frequency sine wave signals can be the most difficult waveforms to trigger on. This is because the voltage changes are relatively slow, especially at the rounded tops and bottoms. Any noise or distortion on the signal causes two waveform points to have the same voltage level and transition polarity. The trigger circuits alternately trigger on both points, resulting in the double pattern similar to the waveform in Figure 27.

If a signal mistriggers it can usually be corrected one of two ways. First, try resetting the TRIGGER LEVEL control slightly to reference the trigger circuits at a different point. Use the "Norm" TRIGGER MODE to simplify setting the trigger circuits. Simply adjust the LEVEL control until the trace just appears on the CRT. This will insure that the LEVEL control is set for the highest amplitude signal.

Secondly, select the "20 MHz" position of the BANDWIDTH switch. This will attenuate high frequency noise and interferences to provide stable triggering when viewing signals below about 15 MHz.

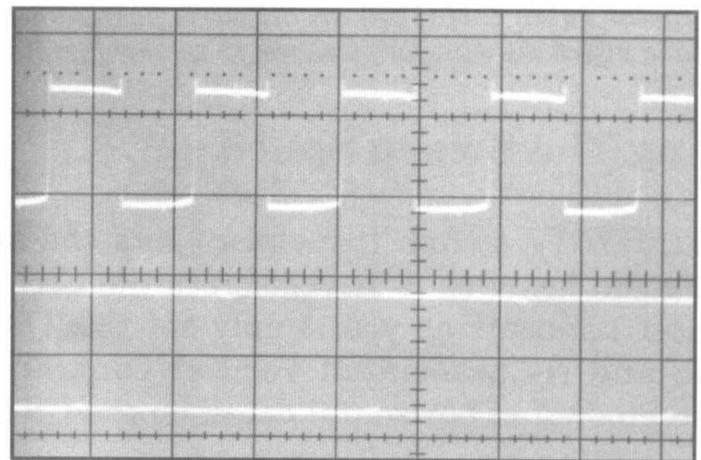


**Fig. 27 - Sine waves that have distortion or high frequency interference may cause mistriggering. Readjust the TRIGGER LEVEL control or select "20 MHz" BANDWIDTH to lock the waveform.**

### Viewing Signals That Are Multiples

When viewing signals that are multiples of each other it may appear that one of the two signals is not locked on the CRT display. Always set the TRIGGER SOURCE switch to trigger from the signal that is the lowest frequency. If the TRIGGER SOURCE is set to the higher frequency the other waveform will be randomly displayed.

You will only be able to obtain a locked display of both waveforms if the two signals are synchronized to each other, such as the output of a digital flip-flop.



**Fig. 28 - When viewing two signals that are multiples of each other always trigger on the lower frequency signal.**

## SETTING THE HORIZONTAL DISPLAY

The TIME/DIV switch (timebase) sets the horizontal time parameter of the displayed waveform. This section explains how to produce the desired waveform display. Keep in mind that the digital measurement functions provide much faster and accurate time and frequency measurements than can be made using the CRT. Therefore, the main use of the SC3100's timebase is for waveform viewing.

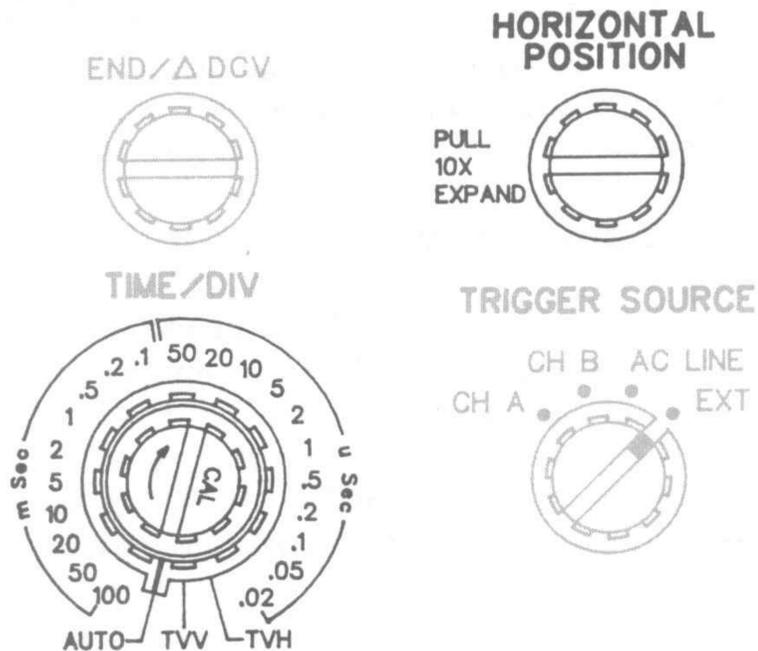


Fig. 29 - Use the TIME/DIV and Vernier controls to set the amount of horizontal detail displayed on the CRT. Time markings are provided to match the waveforms shown in service literature.

### Setting The Sweep Speed

The TIME/DIV switch (timebase) sets the speed of the electron beam as it moves across the CRT screen. For most applications you simply set the TIME/DIV switch and its associated vernier control for the desired amount of horizontal detail on the CRT.

Turning the TIME/DIV switch clockwise causes the electron beam to move faster across the CRT. This expands a waveform horizontally and allows you to see more waveform detail. It also allows you to view higher frequency signals. Turn the TIME/DIV switch counter-clockwise to view signals that are lower frequencies.

Calibrated time markings around the TIME/DIV switch allow you to set the controls to match alignment instructions and waveform displays in service literature. The SC3100 provides sweep speeds from 100 milliseconds/division to .02 microseconds (20 nanoseconds)/division.

### 10X Expand

The waveform can be expanded horizontally by a factor of ten by pulling the HORIZONTAL POSITION control outward. This allows you to view signals in more detail as well as view higher frequency signals. The fastest sweep is increased to .002 microseconds (2 nanoseconds) /division.

The digital measurement functions will continue to read correct when the waveform is expanded horizontally. However, you will need to divide all CRT-based time measurements by 10. The waveform will be at the same approximate horizontal position when it is expanded as it was in the normal view.

### Autoranging

When the TIME/DIV switch is set to the "Auto" position, the SC3100 automatically selects the range needed to display approximately 2 to 5 cycles of the waveform. The ranges that are automatically selected are the same as those available by manually turning the TIME/DIV switch. Therefore, the number of displayed cycles varies depending upon the range that is selected. Neither the horizontal vernier control nor the 10 expand are automatically controlled and may be operated normally to fine tune the waveform display in the "Auto" position.

*NOTE: Frequencies higher than 25 MHz will result in a display of more than 5 cycles.*

The SC3100 will autorange to follow the input frequency as you move between test points. In order for the SC3100 to automatically select the sweep speed, the TRIGGER circuits must be set to properly lock-in the waveform. Simply set the TRIGGER controls the same as you would if you were manually setting the TIME/DIV switch. For most signals set the LEVEL control to "0" and the SOURCE to match the input channel. Always set the TRIGGER SOURCE switch to the input that has the lowest frequency when you are displaying two different frequencies. The timebase will autorange to match the frequency of the channel selected by the TRIGGER SOURCE switch.

The timebase speed is selected based on the digital frequency counter. If the timebase does not seem to range correctly, push the digital FREQ button for the channel you are viewing. An unstable frequency reading means that the timebase will not properly autorange. You will need to readjust the TRIGGER controls so that they are able to better lock the waveform, or set the TIME/DIV switch manually.

The timebase will not autorange when the "TV"

TRIGGER MODE is selected. This is because there are two possible sweep speeds that may be desired - the vertical rate and the horizontal rate. Use the TV preset positions of the TIME/DIV switch for fast setup of video waveforms.

## Video Presets

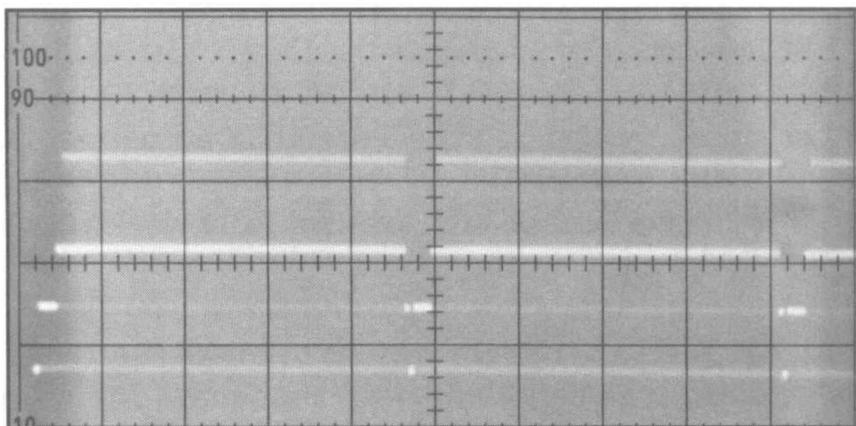
The video preset positions of the TIME/DIV switch provide a quick way to view video waveforms. Selecting either the TVV or TVH preset automatically selects the proper sweep rate, the "TV" TRIGGER MODE and sets the trigger circuits to trigger on the correct video sync pulse no matter where the TRIGGER MODE switch is set.

This simplifies setup when alternately measuring video and non-video signals, as the TRIGGER MODE switch may be left in either the "Auto" or "Norm" position. Switching the TIME/DIV switch out of the video preset position returns control of the trigger circuits to the MODE switch.

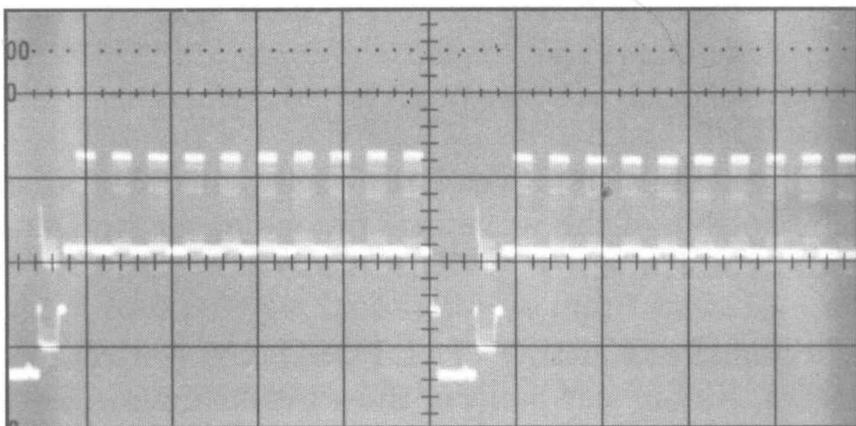
**TVV** - displays two vertical fields (1 frame) of video.

**TVH** - displays two horizontal lines of video.

### TVV



### TVH



**Fig. 30** - The TVV preset automatically sets the sweep speed to show one video frame, while the TVH preset displays 2 video lines.

Be sure to set the TRIGGER POLARITY switch to match the sync polarity of the video sync pulses and set the TRIGGER LEVEL control to "0" when using the video presets.

If you need to view the video signal in more detail than is provided by the presets, you can use the TIME/DIV switch and the "TV" TRIGGER MODE.

## Using The TIME/DIV Switch To View Video Signals

You expand the area following vertical or horizontal sync to view details such as color burst or the VIRS or VITS signals.

To do so simply select the "TV" position of the TRIGGER MODE switch. This selects the video sync separators for all of the positions of the TIME/DIV switch and enables you to simply set the TIME/DIV switch for the detail you need.

The setting of the TIME/DIV switch automatically selects either the vertical or horizontal sync separators. All sweep speeds in the "msec" range will show the vertical portion of the composite video signal, while all the sweep speeds in the "μsec" range show the horizontal signal.

## USING THE CRT DISPLAY

The role of the CRT display is greatly diminished in most of SC3100's applications compared to conventional analog oscilloscopes. This is because the Waveform & Circuit Analyzer's digital display provides a faster and much more accurate readout of all voltage, frequency, and time measurements. Instructions for using the digital readout to measure these waveform parameters begin on page 32.

We've included this section to briefly explain some of the conventional scope measurements so that you will have a complete understanding of your SC3100 Waveform & Circuit Analyzer. Use these procedures only if it is necessary to use conventional analog measuring procedures.

### Measuring Time With The CRT

The numbers around the TIME/DIV switch represent the time it takes for the electron beam to move one major horizontal division across the CRT screen. For these times to be correct the horizontal vernier control must be set fully clockwise to the "CAL" position.

#### To measure time using the CRT:

1. Apply the signal to the SC3100.
2. Lock the signal using the TRIGGER adjustments.
3. Set the horizontal vernier fully clockwise to the "CAL" position.
4. Adjust the TIME/DIV switch to show sufficient detail on the CRT. Use the 10X expand feature if necessary. Do not use the "Auto" position of the TIME/DIV switch.
5. Adjust the VERTICAL POSITION control to align the waveform portion to be measured with the center horizontal graticule.
6. Adjust the HORIZONTAL POSITION control to align the beginning of the waveform portion that is to be measured with a vertical CRT graticule.
7. Count the number of graticules covered by the portion that is to be measured. Each minor division represents .2 major divisions.
8. Multiply the number of divisions by the setting of the TIME/DIV switch. If the 10X expand is pulled the sweep rate is one-tenth the marked time.

### Determining Frequency With The CRT

The digital circuits provide a much faster and far more accurate frequency measurement of an entire waveform or waveform portion than does the CRT. However, the calibrated times provided by TIME/DIV switch allow you to determine the approximate frequency of a signal.

To find the frequency of the signal, determine the time of one cycle, as explained above. Then divide the time of one cycle into 1 ( $\text{freq} = 1/\text{time}$ ).

### Using The CRT To Measure Peak-to-Peak Volts

The numbers around the VOLTS/DIV switch represent the voltage for one major vertical division on the CRT screen. For these voltages to be correct the vertical vernier control must be set fully clockwise to the "CAL" position.

#### To measure peak-to-peak voltage with the CRT:

1. Apply the signal to the SC3100 using either the 10X low capacity probes or the DP270 Direct Probe.
  2. Lock the signal using the TRIGGER adjustments.
  3. Turn the vertical vernier control fully clockwise to the "CAL" position.
  4. Adjust the VOLTS/DIV switch to make the waveform between 2 and 4 divisions tall. Do not use the "Auto" position.
- NOTE: Signals larger than 800 volts will be greater than 4 divisions tall. Signals greater than 1600 VPP can not be accurately measured using the CRT.*
5. Adjust the VERTICAL POSITION control to align the bottom of the waveform on one of the horizontal CRT graticules.
  6. Adjust the HORIZONTAL POSITION control to align the highest point of the waveform with the center, vertical CRT graticule.
  7. Count the number of divisions occupied by the waveform. Each minor graticule mark represents .2 major divisions.
  8. Multiply the total number of major divisions and parts of a division by the setting of the VOLTS/DIV switch to obtain the peak-to-peak level.

It is not necessary to move the decimal if the supplied 10X Low Capacity probes are used. However, if the DP270 Direct Probe is used, you must divide the number obtained in step 8 by ten (move the decimal one place to the left).

## Using The CRT To Measure DC Volts

There are two different types of DC measurements; 1) average DC, and 2) instantaneous DC (DC + AC at a given waveform point). An example of average DC is a power supply or B<sup>+</sup> voltage, while an example of instantaneous DC is a trip level or digital logic level.

You will want to use the SC3100's digital readout to determine the average DC. The digital DCV measurement is much more accurate than the CRT display and the digital circuits automatically determine the average DC level of the AC component to agree with the DC voltages shown on schematics.

The digital Delta DCV also provides much faster and more accurate measurement of instantaneous DC. However, the CRT can also be used to make quick, approximate measurements of instantaneous DC.

### To measure DC voltage with the CRT:

1. Apply the signal to the SC3100 using either the 10X low capacity probes or the DP270 Direct Probe.
2. Lock the signal using the TRIGGER adjustments.
3. Turn the vertical vernier control fully clockwise to the "CAL" position.
4. Set the VOLTS/DIV switch to a position that is between one-half to one-eighth the expected DC level. For example, if the expected voltage is 10 volts set the VOLTS/DIV switch to the "2" or "5" position.
5. Set the INPUT COUPLING switch to "GND" to establish a zero reference point.

*NOTE: The TRIGGER MODE switch must be set to "Auto" to produce a trace with no input signal.*

6. Adjust the VERTICAL POSITION control to align the bottom of the waveform to one of the horizontal CRT graticules.

This is your zero reference line.

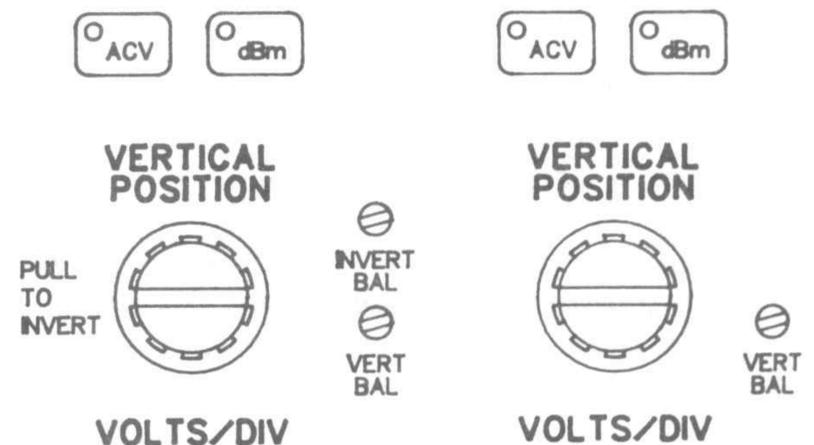
7. Move the INPUT COUPLING switch to "DC".
8. Use the HORIZONTAL POSITION control to place the portion of the waveform that is to be measured on the center, vertical graticule.

9. Count the number of divisions from the zero reference line (step 5) to the point you want to measure on the waveform. Each minor mark on the graticule represents .2 major divisions.
10. Multiply the total number of major divisions and parts of a division by the setting of the VOLTS/DIV switch to determine the DC value.

It is not necessary to move the decimal if the supplied 10X Low Capacity probes are used. If the DP270 Direct Probe is used divide the voltage by ten (move the decimal one place to the left).

## Secondary User Controls

Four secondary user adjustments are accessible through small holes in the front panel: TRACE ROTATOR, VERT BALANCE (for channel A and B) and INVERT BALANCE. These controls require only periodic adjustment to compensate for slight drift in the internal circuits. The following instructions explain how to test or adjust each of the secondary controls, using a small screwdriver.



**Fig. 31 - Location of the TRACE ROTATOR, VERT BAL and INVERT BAL controls.**

### TRACE ROTATOR

The TRACE ROTATOR ensures that the trace(s) made by the electron beam is parallel to the CRT graticules. External magnetic fields (including the earth's) affect the trace on all oscilloscopes. Once you have set the TRACE ROTATOR you should not need to reset it unless the SC3100 is moved to a new location or position on the workbench. The TRACE ROTATOR needs to be set if the trace looks crooked.

### To set the TRACE ROTATOR:

1. Set the TRIGGER MODE to "Auto".
2. Set the Channel A INPUT COUPLING to "GND".
3. Press the "CH A" CRT MODE button.

4. Adjust the Channel A VERTICAL POSITION control to place the trace adjacent to a CRT graticule.
5. Adjust the TRACE ROTATOR control to make the trace parallel to the CRT graticule.

### **VERTICAL BAL**

Each input channel has a VERT BAL control that is used to set the DC bias of the vertical amplifiers. If the vertical balance is not set correctly, the trace will move vertically when the VOLTS/DIV or VERTICAL VERNIER controls are adjusted.

#### **To set the VERT BALANCE:**

1. Set the TRIGGER MODE to "Auto".
2. Set the Channel A INPUT COUPLING switch to "GND".
3. Press the "CH A" CRT MODE button.
4. Set the Channel A VOLTS/DIV switch to ".05".
5. Set the Channel A VERTICAL VERNIER control fully counterclockwise.
6. Adjust the Channel A VERTICAL POSITION control to align the trace on the center horizontal graticule.
7. Turn the Channel A VERTICAL VERNIER control clockwise. If the trace moves away from the graticule, adjust the Channel A VERT BAL to align the trace back on to the graticule.
8. Repeat steps 5-7 until the trace no longer moves as the VERTICAL VERNIER control is turned.
9. Repeat steps 2-8 for Channel B.

### **INVERT BAL**

The INVERT BALance control sets the DC bias on the Channel A invert amplifier. If the trace shifts vertically when you pull the VERTICAL POSITION control outward to invert the trace, the INVERT BAL control needs to be adjusted. Do not set the INVERT BAL until you have set the CH A TRACE BAL.

1. Set the Channel A TRACE BAL.
2. Set the TRIGGER MODE to "Auto".
3. Set the Channel A INPUT COUPLING switch to "GND".
4. Press the "CH A" CRT MODE button.
5. Set the Channel A VOLTS/DIV switch to ".05".
6. Adjust the Channel A VERTICAL POSITION control to align the trace on the center horizontal graticule.
7. Pull the Channel A VERTICAL POSITION control outward to the invert position. Be careful to not reposition the trace by turning the control.
8. If the trace moves adjust the INVERT BAL to return the trace to the center graticule.
9. Carefully push the channel A VERTICAL POSITION control back to the noninverted position. If the trace moves, repeat steps 5-7 until there is no further improvement.

## USING THE AUTO TRACKING™ DIGITAL FUNCTIONS

### Introduction

The Auto-Tracking™ digital tests provide AC voltage, DC voltage and frequency measurements of the signal applied to either the channel A or B inputs at the push of a button. These digital parameter measurements are called Auto-Tracking™ because the readout constantly and automatically follows the input signal without you needing to adjust any controls or set measurement cursors. In fact, the signal does not even need to be displayed on the CRT to use the Auto-Tracking™ tests. The signals for both the CRT display and digital readout are applied through the same probe.

Most of your waveform measurements will be done using either these Auto-Tracking™ digital tests or the SC3100's Delta tests. The Auto-Tracking™ digital tests measure parameters of the entire waveform, while the Delta tests are used to measure a portion of the waveform. This section explains how to use the Auto-Tracking™ digital tests. The next section explains how to use the Delta tests.



**Fig. 32 - The Auto-Tracking™ digital tests provide peak-to-peak, DC voltage, frequency, ACV and dBm measurements at the push of a button.**

### Digital Readout Not Affected By CRT Controls

The signal takeoff to the digital circuits (both the Auto-Tracking™ and Delta tests) is made ahead of the CRT controls, such as the vertical and horizontal position controls, vertical and horizontal vernier controls, and input coupling switches. This allows you to set the CRT display to any convenient size without affecting the digital tests. Because the digital tests are independent of the circuits, they are also much more accurate than CRT-based measurements.

The Auto-Tracking™ digital tests operate properly without the CRT trace locked or displayed. This allows you to use the digital readings to help set the CRT controls.

The digital frequency and peak-to-peak readings, for example, can be used to set the TIME/DIV and VOLTS/DIV controls.

*NOTE: The digital tests for channel A and B share some common circuitry but also use some different circuitry. While the two channels are closely matched, each channel may show a slightly different reading if you were to connect both probes to the same test point. This is due to the normal tolerances, and is similar to the difference you would see if you used two different pieces of test equipment.*

### DC Voltage Measurements

You can measure the DC voltage at the test point by simply pushing the "DCV" button of the corresponding channel. The DCV function is fully autoranged and operates independent of the CRT display. You may adjust the CRT display to any convenient size or set the INPUT COUPLING switch to any position (even "GND") without affecting the DC reading.

The image shows a digital display with the number '1.250' and the label 'DCV' to its right.

**Fig. 33 - The digital display provides fully autoranged readings of the DC voltage at either channel input.**

The DCV function measures average DC voltage. Average DC voltage is the same value that is indicated on schematics and is the power supply or B<sup>+</sup> voltage, for example, that a DVM measures. Sometimes you may need to measure the instantaneous or absolute DC + AC voltage at a waveform point, such as the logic high or low level of a digital signal. For these measurements use the Delta DC function, as explained on page 39.

In addition to the supplied 39G292 10X Low Capacity Probe, you can use the optional DP270 Direct Probe, or the 39G157 DC Voltage Probe to supply signals to the SC3100's DC inputs. The 39G157 DC Voltage Probe allows you to measure the DC voltage at a test point independent from the CRT input and also allows you to use the optional TP212 or HP200 to measure DC voltages that are higher than 2 kV.

### To measure DC volts:

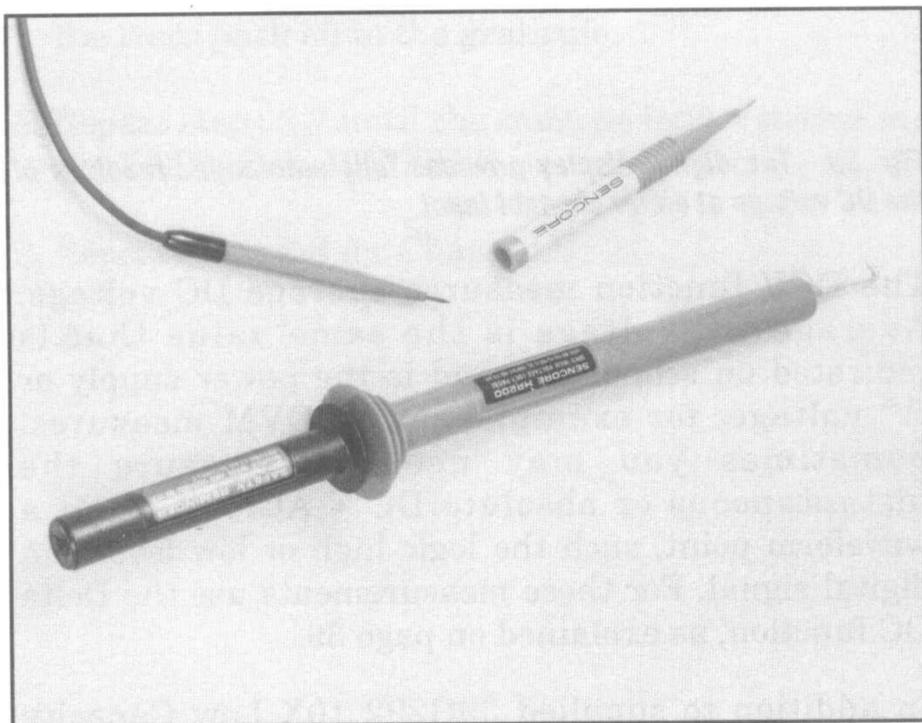
1. Connect the DC signal to the CH A or CH B DCV Jack.
2. Press the channel A or B "DCV" DIGITAL READOUT button.
3. Read the digital display.

### Measuring Over 2000 VDC

Two optional probes, the TP212 and HP200, allow you to measure DC voltages that are higher than 2000 kV. These probes must be used with the optional 39G157 DCV Probe. These multiplier probes also increase the input impedance and allow you to make measurements in high impedance circuits with minimum DC loading. The TP212 provides a 150 megohm input impedance and the HP200 produces a 1500 megohm (1.5 gigohm) input impedance.

The TP212 Transient Protector Probe divides the DC voltage by 10 and allows you to measure up to 10 kV. Multiply the digital readout by 10 (move the decimal one place to the right) for the actual circuit voltage. A reading of 395 volts, for example, represents a circuit voltage of 3950 volts.

The HP200 High Voltage Probe divides the DC voltage by 100 and allows you to measure up to 50 kV. Multiply the digital readout by 100 (move the decimal two places to the right) for the actual circuit voltage. A reading of 395 volts, for example, represents a circuit voltage of 39,500 volts.



**Fig. 34 - The optional 39G157 DC Voltage Probe allows you to use either the optional TP212 or HP200 to measure voltages greater than 2 kV.**

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### WARNING

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**Read and understand the following warnings and instructions before making high voltage measurements.**

1. **Never measure more than 2000 volts without using a high voltage probe.** Doing so may damage the SC3100, the equipment under test, and/or cause a severe shock hazard.
  2. **Remove the power to the circuit before connecting or disconnecting the high voltage probe to the circuit test point.**
  3. **Immediately remove power to the circuit if either the ground lead or the multiplier probe become detached during a measurement.** Do not touch the ground lead, the SC3100, or the high voltage probe until the power has been removed as there is a possibility of a severe shock hazard.
  4. **If the high voltage probe must be held, do so with extreme caution.** Hold the probe behind the molded safety rings to prevent the possibility of contacting the high voltage test point and to prevent arcing to your hand.
- 

### DC loading

The input impedance at the DCV input (mini banana jack) is 1.5 megohms. The 39G292 10X Low Capacity Probe and the optional 39G157 DCV Probe contain a 13.5 megohm resistor which increases this impedance to 15 megohms. The 15 megohm DCV input impedance, however, is in parallel with the 10 megohm input impedance of the CH INPUT Jack (BNC connector). Therefore, the impedance at the tip of the 39G292 10X Low Capacity Probe is 6 megohms.

If you are working in a high impedance circuit you may wish to take full advantage of the full 15 megohm DC input impedance. You can do this one of two ways. 1) Disconnect the probe's BNC connector from the input but leave the mini-banana plug connected to the DCV Jack. 2) Use the optional 39G157 DCV Probe to measure the DC voltage. In either case connect the front panel GROUND lead to the circuit ground to provide a ground path.

### Peak-to-Peak Voltage Measurements

The SC3100 provides a direct readout of the peak-to-peak amplitude of any signal applied to the input. Simply press the "VPP" DIGITAL READOUT button for the corresponding channel. Specially designed circuits allow you to make VPP measurements on low duty cycle, low frequency signals to 20 Hz as well as high frequency signals up to 120 MHz.

1.150 VPP

**Fig. 35 - The digital display provides a reading of the peak-to-peak voltage at either channel input.**

The PPV function is semi-autorange and has four ranges selected by the VOLTS/DIV control. This insures that the measuring circuits have proper signal level to provide a correct reading. If the digital readout shows flashing "8888", turn the VOLTS/DIV switch counterclockwise. If the LCD shows a PPV reading with very little resolution, turn the VOLTS/DIV switch clockwise. The digital PPV reading is not affected by the setting of the vertical vernier controls.

*NOTE: The PPV readings are fully autoranged when the VOLTS/DIV switch is set to "Auto".*

The frequency response of the digital circuits closely matches the CRT response for direct digital readout of the amplitude of any waveform the CRT is capable of displaying. However, at times the digital readout may show a higher PPV value than is displayed on the CRT. If so, always use the digital PPV value.

The digital display is more accurate than the CRT for two reasons. First, the digital circuitry has a much better basic accuracy. 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. Secondly, the digital meter catches fast signal transitions which are easily overlooked on the CRT. Overshoot, fast spikes and random noise often go unnoticed on the CRT but are detected by the digital PPV meter. You can use the Delta PPV function to pinpoint the location of these spikes on the waveform.

#### **To measure PPV volts:**

1. Connect the signal to the CH A or B INPUT Jack.
2. Set the INPUT COUPLING switch to either "DC" or "AC".
3. Press the channel A or B "VPP" DIGITAL READOUT button.

4. Read the digital display.

The SC3100 automatically senses whether you are using the supplied 39G292 X10 Lo Capacity Probe or a X1 direct probe and compensates to provide a direct digital reading.

## **Frequency Measurements**

Pressing the channel A or B "FREQ" button displays the frequency of the signal applied to the vertical input from 10 Hz to 150 MHz. The frequency function is fully autoranged, so there is no need to select resolution, read rates, or frequency ranges. All readings are updated in .5 seconds or less.

2.4500 KHz

**Fig. 36 - The digital display automatically shows the frequency of the signal at either channel input.**

### **Obtaining Stable Frequency Readings**

The SC3100's frequency function allows you to measure the frequencies of two totally unrelated or nonsynchronous signals. This is accomplished by having two different internal inputs for the counter circuits - a "main" input and an "auxiliary" input. The microprocessor automatically selects which input is used depending on which "FREQ" button is selected and which TRIGGER SOURCE switch setting is selected.

The "main" counter input comes from the CRT trigger circuits. This input is automatically selected when the channel A "FREQ" button is pressed and the TRIGGER SOURCE switch is set to "CH A" or when the channel B "FREQ" button is pressed and the TRIGGER SOURCE switch is set to "CH B". The CRT waveform display must be locked to the incoming signal when the main counter mode is used. The display will read "0000" if the trigger circuits are not locked. Use the main counter input for most frequency measurements and to count the frequency of video waveforms.

Sometimes the CRT display will appear to be locked but the frequency counter reading will be unstable. This is caused by random noise on the signal causing occasional mistriggering. The mistriggering may not be severe enough to be noticed on the CRT (although you may see faint ghost traces), but it is picked up by

the digital counter circuits. Often carefully resetting the TRIGGER LEVEL control will stabilize the counter reading. A faster way to get a stable reading is to select the "auxiliary" counter input.

The "auxiliary" counter input has an auto-baseline circuit that seeks the average DC level of the incoming signal independently of the trigger control settings. This provides a stable frequency reading on most signals. The auxiliary counter input requires a signal level amplitude of 1.5 or more major CRT graticules (the waveform does not need to be locked).

Use the auxiliary counter input when the main input provides unstable readings or to count the frequency of the signal applied to the channel that is not being displayed on the CRT. Table 1 shows when the main and auxiliary channels are selected.

Trigger Source	"FREQ" Button Selected	
	A	B
CH A	Main	Aux
CH B	Aux	Main
AC Line	Aux	Aux
EXT	Aux	Aux

**Table 1 - The "main" or auxiliary" counter input is automatically selected depending on the signal source that is triggering the CRT display.**

## AC Voltage Measurements

The ACV function allows you to measure AC voltage as an RMS value (.707 of peak) for direct comparison to service literature and to true RMS reading DVMs. Most service literature, for example, lists the AC voltage at switches, fuses and other AC power supply test points as an RMS value. Use the SC3100's ACV function when making these measurements to eliminate calculating the RMS voltage value from peak-to-peak readings.

*Note: The ACV Reading is correct for all sinewave measurements. It will not agree with RMS meters on non-sinewave waveshapes.*

0.350 ACV

**Fig. 37 - The digital display provides a direct reading of the RMS voltage at either channel input.**

The ACV function is semi-autorange and has four ranges selected by the VOLTS/DIV control. This insures that the measuring circuits have proper signal level to provide a correct reading. If the digital readout shows flashing "8888", turn the VOLTS/DIV switch counterclockwise. If the ACV reading has very little resolution, turn the VOLTS/DIV switch clockwise. The ACV readings are unaffected by the setting of the trigger and timebase controls and vertical verniers.

*NOTE: The ACV readings are fully autoranged when the VOLTS/DIV switch is set to "Auto".*

### To measure average RMS voltage:

1. Connect the signal to the CH A or CH B INPUT Jack.
2. Set the INPUT COUPLING switch to either "DC" or "AC".
3. Press the channel A or B "ACV" DIGITAL READOUT button.
4. Read the digital display.

The SC3100 automatically senses whether you are using the supplied 39G292 X10 Lo Capacity Probe or a X1 direct probe and compensates to provide a direct digital reading.

## dBm Measurements

Audio service literature often lists the amplitude of the audio signals at various amplifier and signal processing test points as a dBm level. The SC3100's dBm function provides the industry standard dBm reference of 0 dBm = 1 milliwatt into 600 ohms (0.7746 volts RMS). The dBm readings are unaffected by the setting of the trigger and timebase controls.

The dBm function greatly simplifies stage gain measurements. To determine stage gain simply measure the dBm level and the input and at the output of a stage. Then subtract the input level from the output level. The difference is the gain in dB.

The dBm function is semi-autorange and has four ranges selected by the VOLTS/DIV control. If the digital readout shows flashing "8888", turn the VOLTS/DIV switch counterclockwise. If the dBm reading has very little resolution, turn the VOLTS/DIV switch clockwise. The reading is not affected by the setting of the vertical vernier controls.

A digital display showing a reading of -5.2 dBm. The number '5.2' is large and bold, with a minus sign to its left. The unit 'dBm' is positioned to the right of the number.

**Fig. 38 - The dBm function provides the industry standard measurement of 1 mW into 600 ohms.**

A “-” dBm reading does not indicate signal polarity. It simply means that the signal level is less than 1 mW (<.7746 VRMS).

#### **To measure dBm:**

1. Connect the signal to the CH A or CH B INPUT Jack.
2. Set the INPUT COUPLING switch to either “DC” or “AC”.
3. Press the channel A or B “dBm” DIGITAL READOUT button.
4. Read the digital display.

The SC3100 automatically senses whether you are using the supplied 39G292 X10 Lo Capacity Probe or a X1 direct probe and compensates to provide a direct digital reading.

## USING THE DELTA MEASUREMENTS

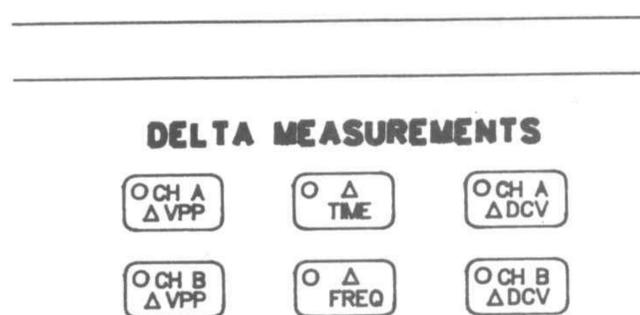
### Introduction

Many applications require you to measure the peak-to-peak amplitude, instantaneous DC voltage, time, or frequency of only a portion of a waveform. This is the function of the SC3100's digital DELTA MEASUREMENTS.

The Delta Measurements provide a much more accurate waveform measurement than can be made using 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. Secondly, the Delta Bar (as explained later) is part of the CRT trace which virtually eliminates errors caused by parallax and interpretation.

The delta functions are accurate for all settings of the TIME/DIV or VOLTS/DIV controls or verniers. The "Auto" positions of the TIME/DIV and VOLTS/DIV controls are disabled when any of the Delta Measurement functions is selected. The SC3100 will not autorange to follow changes in the input signal.

This portion of the manual explains how to use the Delta Measurement functions. Refer to the APPLICATIONS section for examples of how to make special tests with the Delta Measurement functions.



**Fig. 39 - Use the Delta Functions to make parameter measurements on a portion of a waveform.**

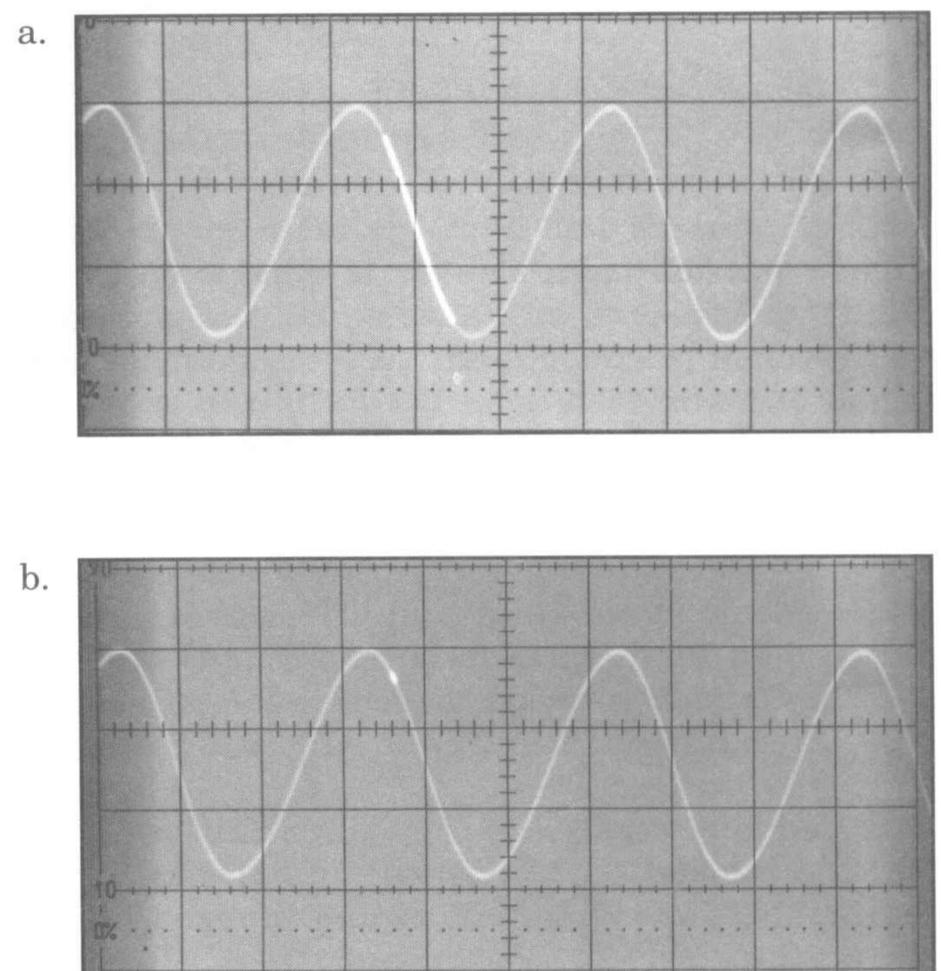
### The Delta Bar

The Delta Bar is a portion of the trace that is brighter than the rest of the trace. It defines the part of the waveform that is measured by the digital circuits. The DELTA MARKER "Begin" and "End" controls set the portion of the trace(s) that is intensified when one of the DELTA MEASUREMENT buttons is selected. If you have selected a dual trace display mode, both CRT traces will show the Delta Bar. Which channel is measured depends on the selected function.

The DELTA MARKER "Begin" and "End" controls are multi-turn potentiometers. The function of the two controls automatically reverses if you position the end of the Delta Bar before the beginning. This prevents you from losing the intensified bar if the beginning and end are exchanged. This is also helpful when you want to make a measurement before and after a certain point on the waveform, as it is only necessary to change the position of one end of the Delta Bar to make the two measurements.

When you select the Delta DCV function, only a small spot of the waveform will be intensified. This is the Delta DC Marker. You can move the position of the Delta DC marker with the "End/ΔDCV" DELTA MARKER control.

The intensified area of the Delta Bar and Delta DC Marker is part of the waveform. This eliminates parallax errors, errors in interpreting a part of a CRT division, and minimizes interpretation errors when setting the waveform portion that is measured. Other digital scopes use cursor measurement bars which are subject to much greater setup error.



**Fig. 40 - The intensified Delta Bar (a) indicates the portion of the trace that is measured by the Delta functions. Use the Delta DC Marker to set the level to be measured by the Delta DC function.**

### Special Notes on the Delta Bar and Delta DC Marker:

1. The SC3100 must be properly triggered for the Delta measurements because each measurement is made on the signal portion that is intensified by the Delta Bar. Unstable triggering conditions will cause unstable Delta readings.
2. The beginning and end of the Delta Bar are timed identically for channel A and B. This allows you to measure the time delay between two signals.
3. The begin and end positions need to be readjusted if the sweep rate is changed. The Delta Bar stays in the same location as you change the HORIZONTAL POSITION or activate the 10X expand.

### Delta Peak-to-Peak

The Delta VPP function measures the amplitude of the waveform portion that is intensified by the Delta Bar. If a dual trace CRT mode is selected, both CRT waveforms will contain a Delta Bar. Use the "CH A  $\Delta$  VPP" and "CH B  $\Delta$  VPP" buttons to select which waveform is measured.

The setting of the VOLTS/DIV control selects the range of the Delta PPV function, the same as it does for the Auto-Tracking™ VPP function. The vertical vernier controls, however, have no effect on the accuracy of the Delta VPP readings.

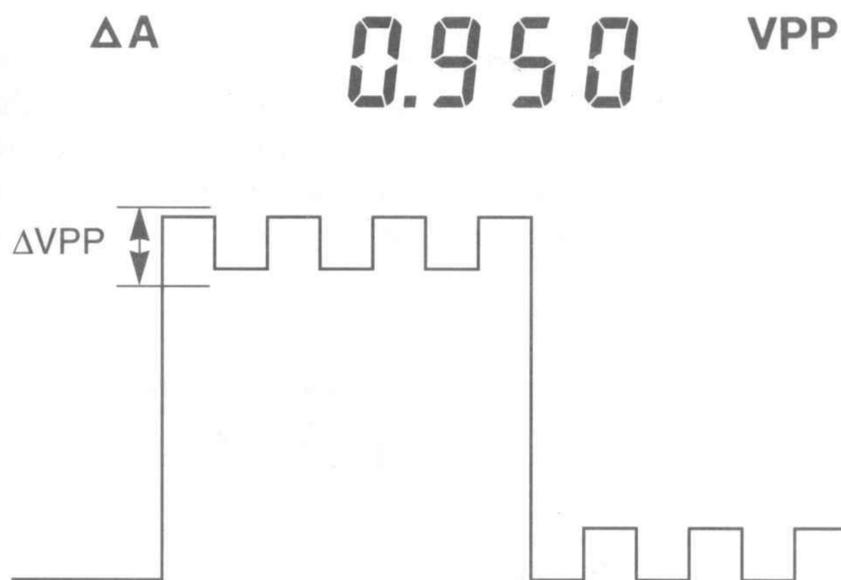


Fig. 41 - The Delta VPP function measures the peak-to-peak voltage of the selected waveform portion.

#### To measure Delta VPP:

1. Press the "CH A  $\Delta$ VPP" or "CH B  $\Delta$ VPP" button.
2. Adjust the INTENSITY control for the desired contrast between the Delta Bar and the trace.

3. Adjust the DELTA MARKER "Begin" and "End" controls until the area to be measured is intensified.
4. Read the amplitude of the intensified area in the digital display.

*NOTE: Delta peak-to-peak measurements on the three slowest sweep speeds require a longer update time than the Auto-Tracking™ PPV measurements.*

### Delta Time

The Delta Time function measures the time duration of the intensified Delta Bar. Use it to make waveform measurements such as pulse width, rise and fall time, time delay, and phase shifts. (Refer to the APPLICATIONS section of this manual for more information on these tests).

The setting of the horizontal timebase, horizontal vernier and 10X expand do not affect the Delta Time readings. The microprocessor automatically selects the proper decimal placement and annunciator display to match these control settings.

#### To measure Delta Time:

1. Press the  $\Delta$ TIME button.
2. Adjust the INTENSITY control for the desired contrast between the Delta Bar and the trace.
3. Adjust the DELTA MARKER "Begin" and "End" controls until the area to be measured is intensified.
4. Read the time in the digital display.

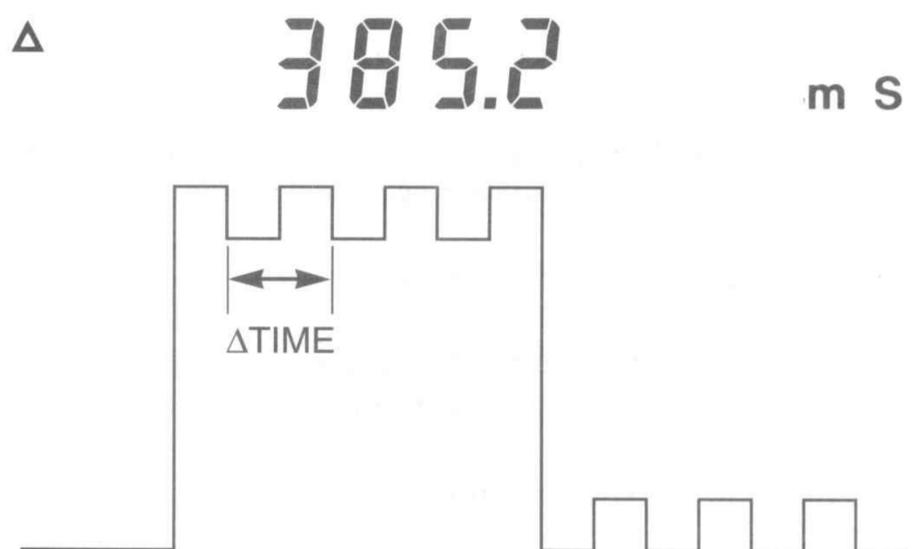


Fig. 42 - The Delta Time function measures the actual time of the intensified waveform portion.

*NOTES: 1) Channel "A" or "B" annunciators are not displayed because the Delta Bar represents the same time interval in both channels.*

2) At lower sweep speeds you may notice a slight delay in the readout update speed because the microprocessor waits for three sweeps to occur before displaying a reading.

## Delta Frequency

The Delta Frequency function provides an approximate equivalent frequency measurement based on the reciprocal of the Delta Time measurement. The main application of the Delta Frequency function is to determine the approximate frequency of a signal that is part of another signal, such as interference riding on top of a square wave. To do this simply highlight 1 cycle of the signal with the Delta Bar.

The Delta Frequency reading is less accurate than the Auto-Tracking™ frequency function because it relies on how closely you set the Delta Bar to one cycle of the waveform and how well you estimate the beginning and ending of one cycle. However, measurements made with the Delta Frequency function are much faster and more accurate than those made using the CRT because there are fewer chances of introducing interpretation error into the calculations.

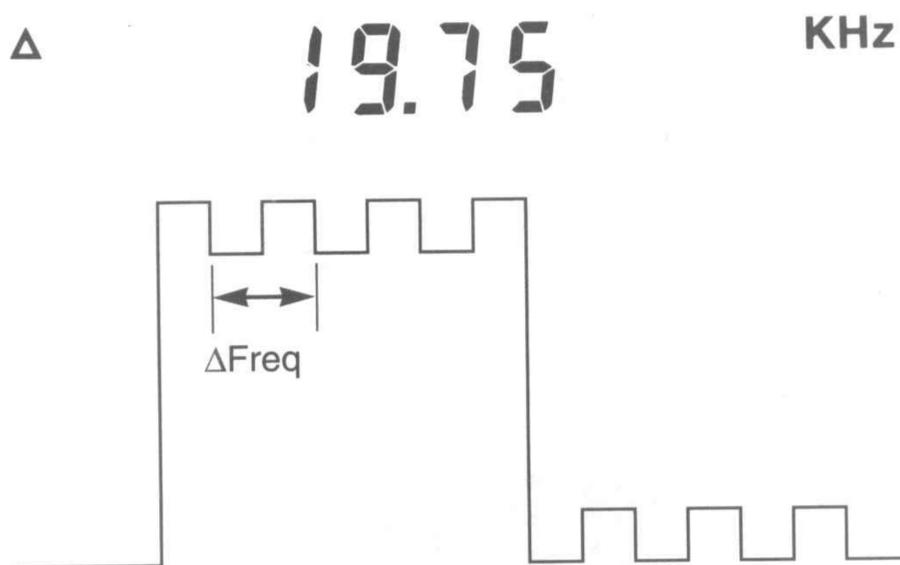


Fig. 43 - The Delta Frequency function converts the actual time of the intensified waveform portion to equivalent frequency.

### To measure Delta Frequency:

1. Expand the waveform until the detail of the signal to be measured can be seen on the CRT.
2. Press the  $\Delta$ FREQ button.
3. Adjust the DELTA MARKER "Begin" and "End" controls until the Delta Bar exactly covers one cycle of the signal.
4. Read the equivalent frequency in the digital display.

## Delta DCV

The Delta DCV function allows you to measure the absolute or instantaneous voltage at any point on a waveform referenced to ground. There is an importance difference between the Delta DC volts function and the Auto-Tracking™ DC voltage function.

The Auto-Tracking DC volts function measures the average DC level of the entire waveform, such as the B<sup>+</sup> or power supply voltage, or the voltage level to which a signal charges a capacitor.

The instantaneous voltage measured by the Delta DCV function is the voltage level that the circuit responds to. Some examples include: "high" and "low" logic levels, sample and hold circuits, SCR and TRIAC "firing" points, and level comparitors.

Refer to the APPLICATION section entitled "Determining Logic Levels" for more information on using the Delta DC Volts function.

When you select the Delta DCV function, the SC3100 automatically locates the ground reference and determines the voltage level on by the Delta DC Marker point on the waveform. You must set the VOLTS/DIV control to a setting **other than "Auto"** when using the Delta DCV function. Otherwise, the SC3100 will not be able to determine the ground reference. The Delta DCV measurement can be made with the INPUT COUPLING switch set to either "DC" or "AC".

The Delta DCV measurements are accurate for signal transitions (rise times) up to 10 MHz because the Delta Marker spreads out. You can make relative measurements on signal transitions faster than 10 MHz depending on how carefully you set the Delta Marker.

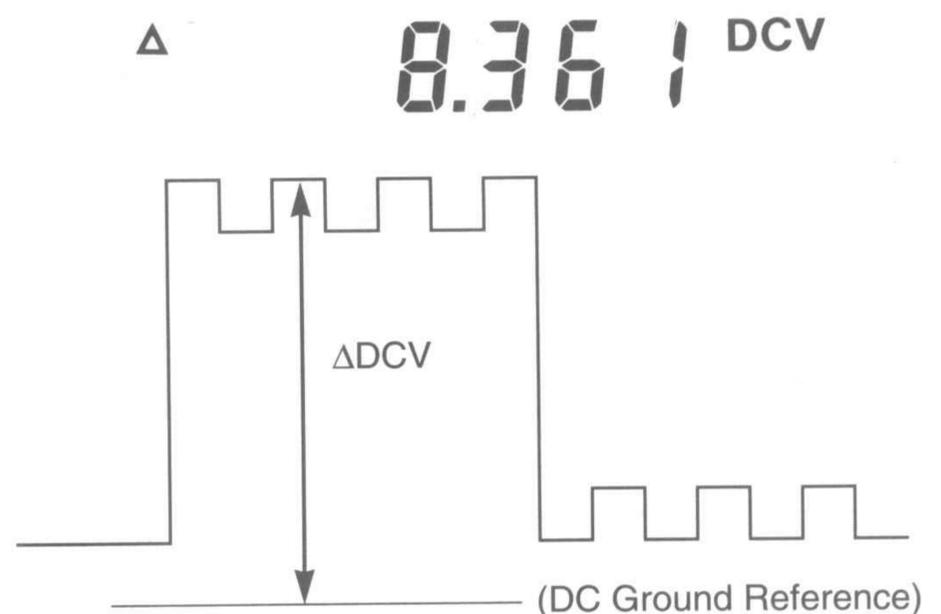


Fig. 44 - Use the Delta DCV function to measure the instantaneous voltage level of a point on a waveform.

**To determine the instantaneous voltage level:**

1. Adjust the VOLTS/DIV control to display the waveform with sufficient vertical detail. Do not use the "Auto" position.
2. Press the "CH A  $\Delta$ DCV" or "CH A  $\Delta$ DCV" button.
3. Adjust the DELTA MARKER "End/ $\Delta$ DCV" control until the Delta Marker is located at the voltage point to be measured.
4. Read the voltage level on the digital display.

# USING THE CIRCUIT PARAMETER TESTS

## Introduction

The SC3100 Waveform & Circuit Analyzer allows you to completely analyze a circuit. In addition to its waveform analyzing functions, the SC3100 includes an ohmmeter, continuity tester, and DC current meter for fast circuit parameter tests.

The circuit parameter tests are made through the OHMS/DC AMPS INPUT Jacks using the supplied DVM TEST LEADS. They are completely separate from the Auto-Tracking test functions, Delta Measurements, and CRT display. The measurements are displayed in the Digital Readout and each function is fully autoranged.

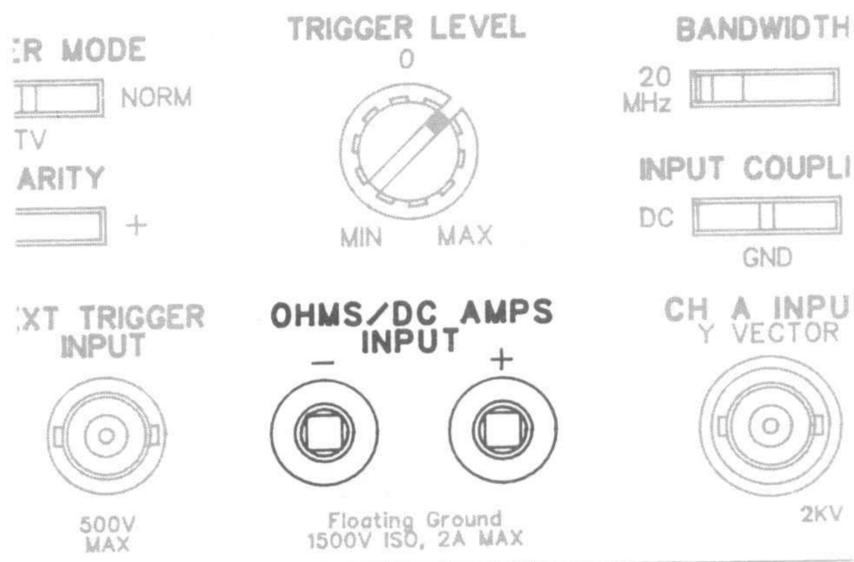


Fig. 45 - Measurements of resistance and DC current are made using the OHMS/DC AMPS INPUT Jacks.

## Ohms Measurements

The Ohms function provides an integrated, fully autoranged ohmmeter that allows you to measure resistance values up to 100 megohms. Resistances less than 210 ohms are displayed with .01  $\Omega$  resolution for accurate measurements. All resistance measurements are made using the supplied DVM TEST LEADS connected to the OHMS/DC AMPS INPUT Jacks. The digital display includes the proper annunciator for  $\Omega$ , k $\Omega$ , or M $\Omega$ .

*Note: The CH A or CH B BNC input jacks are not used for the ohms test.*

The SC3100 automatically selects the applied test current depending on the resistance that is being measured to allow fast tests in or out of circuit. To test diodes simply check for approximately a 10:1 resistance difference when the lead connections to the diode are reversed.

## CAUTION

**Remove power from the circuit before making in-circuit resistance measurements.**

### Ohms Zero

The resistance of the test leads and input circuitry must be subtracted when measuring low resistance values. The SC3100 automatically subtracts the necessary resistance from each measurement once you have "zeroed" the test lead resistance with the OHMS ZERO button.

To zero the test leads, short the ends of the Test Leads together. Then momentarily press the OHMS ZERO button until the display reads zero. The test lead resistance will automatically be subtracted for all ohms and continuity tests. The test lead resistance will remain zeroed while the SC3100 is turned on. You do not need to rezero the test lead unless the POWER has been turned off. Pressing the OHMS ZERO button zeros both the Continuity Test and Ohm measurement functions. The ohms zero may be done with either function selected.

### To measure resistance:

1. Connect the DVM Test Leads to the OHMS/DC AMPS INPUT Jacks.
2. Press the OHMS button.
3. Zero the test leads.
  - a. Short the test leads.
  - b. Press the OHMS ZERO button.
  - c. The test lead resistance is now zeroed for all resistance tests.
4. Connect the unknown resistance to the test leads.
5. Read the resistance directly in the digital display.

### Ohms Protection Fuse

The ohms measuring circuitry is protected from external voltages and current by a fuse. Check the ohms protection fuse if the display overranges when the test leads are shorted together. The fuse is located on the rear panel, as shown in Figure 46. Only replace the ohms protection fuse with a 1/8 amp, 250 volt Fast-Blo, type 3AG.

## WARNING

**Using the wrong fuse may damage the SC3100. Only replace the ohms protection fuse with a 1/8 amp 250 volt Fast-Blo, type 3AG.**

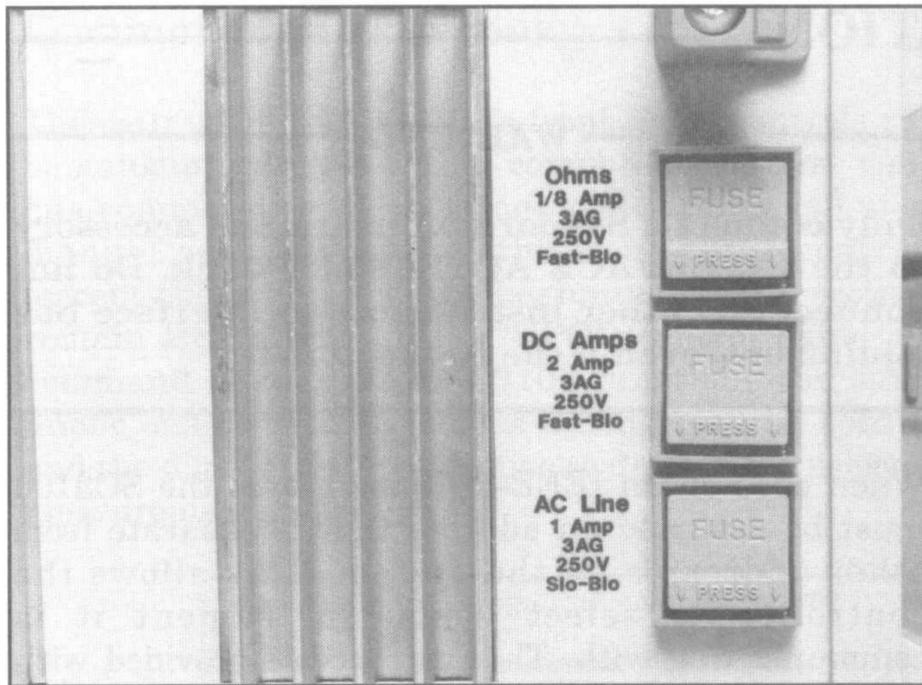


Fig. 46. Protection fuses for the ohms and current functions are located on the rear of the SC3100.

## Continuity Test

The continuity test provides a special, near-instantaneous indication of continuity that is especially useful for quickly determining if a current path is complete or for following circuit traces. An audible tone will sound when the resistance at the test leads is less than approximately 10 to 15 ohms. In addition to the audible tone, the digital readout displays the resistance value up to 210 ohms. Resistances above 210 ohms will overrange. The resistance readings in the Continuity Test are only displayed with 1  $\Omega$  resolution to allow for a fast response time.

*Note: Be sure to zero the test lead resistance before using the Continuity test. Otherwise approximately 8 to 10 ohms will be added to the digital reading and the audible tone turn on point.*

### To use the continuity test:

1. Connect the DVM Test Leads to the OHMS/DC AMPS INPUT Jacks.
2. Press the CONT TEST button.
3. Zero the test leads.
  - a. Short the test leads.
  - b. Press the OHMS ZERO button.
  - c. The test lead resistance is now zeroed for all resistance tests.
4. Connect the test leads to the point to be checked for continuity.
5. Listen for an audible tone.
6. If no tone is heard, read the resistance in the digital display.

## DC Current Measurements

The DC AMP function allows you to measure DC current up to 2 amps. Often current measurements offer valuable troubleshooting clues. At other times current measurements are needed for to make circuit alignments. The SC3100's current readings are fully autoranged and are displayed with an "mA" or "A" annunciator. Connect the supplied DVM TEST LEADS to the OHMS/DC AMPS INPUT Jack. You will need to break the current path and connect the SC3100 in series with the circuit to measure the current.

### DC Current Protection Fuses

The SC3100 current function is protected from overload by a two fuses. A standard, 2 amp Fast-Blo type 3AG protects the unit from overcurrent. This fuse is located on the back panel, as shown in Figure 46. A second internal fuse protects the SC3100 against excessive voltage across the input jacks. This fuse is a special 3 amp, 600 volt fuse. It can be accessed by removing the top case cover. The fuse is located on the DVM board, about 3 inches behind the channel B Auto-Tracking buttons. If all current measurements result in a "0.000 mA" display, check the rear panel fuse first. It will blow under all overload conditions unless more than 2 amps and more than 600 volts is applied to the input. If the rear panel fuse is good, check the internal fuse.

---

### WARNING

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**Using the wrong fuse may damage the SC3100. Only use the following current protection fuses:**

- Rear panel over current fuse:** 2 amp 250 volt Fast-Blo, type 3AG.
  - Internal over voltage fuse:** 3 amp, 600 volt Fast-Blo.
- 

### To measure current:

1. Connect the DVM Test Leads to the OHMS/DC AMPS INPUT Jacks.
2. Press the DC AMPS button.
3. Turn off the power to the circuit to be measured.
4. Open the circuit current path.
5. Connect the DVM test leads in series with the circuit. Connect the "+" lead to the most positive point and the "-" lead to the most negative point of the circuit.

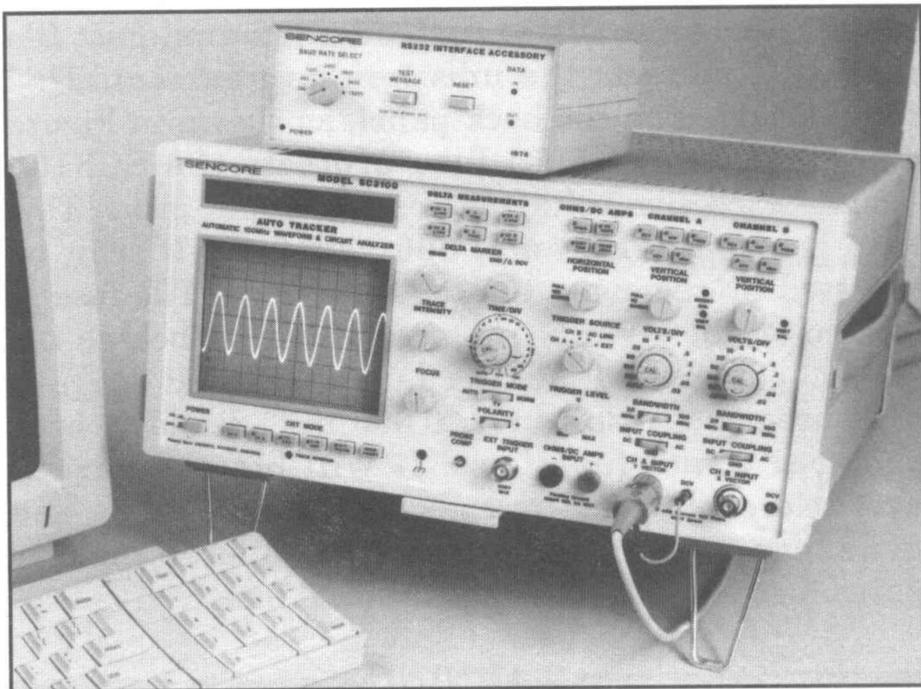
*Note: If you connect the leads backwards the display will show a negative current reading.*

6. Read the current in the digital display.

# COMPUTER AUTOMATED BUS OPERATION

## Introduction

The SC3100 can be used for computer controlled automated testing. Under computer control a program can be developed that automatically sets up any of the front panel measurement controls and reads the digital display. The front panel controls that are not computer controlled are POWER, DELTA MARKERS, FOCUS, INTENSITY, TRIGGER LEVEL, VERTICAL POSITION, VERTICAL VERNIER, HORIZONTAL POSITION and HORIZONTAL VERNIER.



**Figure 47 - The SC3100 can be used for automatic testing by connecting an Interface Accessory and a computer or controller.**

The SC3100 can be used with either IEEE-488 or RS232 control. Use the optional IB72 accessory for IEEE-488 operation and optional IB78 accessory for RS232 control. Both accessories connect to the INTERFACE ACCESSORY Jack located on the rear of the SC3100.

The SC3100 functions as a Talker/Listener. In the listener mode, the computer can set the SC3100's front panel controls via the interface bus. As a Talker the SC3100 sends all of the digital measurements to the controller on command.

## Connecting The SC3100 To The Controller

The signal at the SC3100's INTERFACE ACCESSORY Jack must be translated to the desired standard by a one of the Sencore Interface Accessories. The Interface Accessory is connected between the controller and the SC3100. The Interface Accessory connects to the controller using a standard IEEE-488 or RS232 cable.

## WARNING

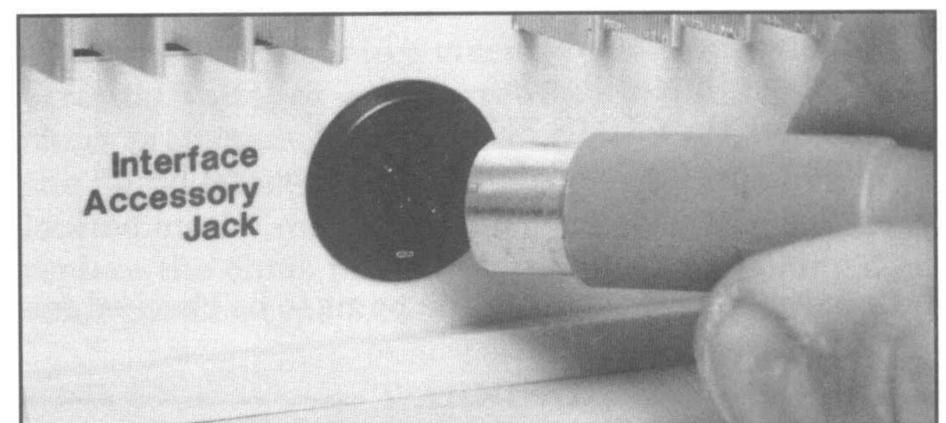
**Only connect a Sencore Interface Bus accessory to the INTERFACE ACCESSORY Jack. Do not connect any other instruments or interface bus equipment, even if the connectors fit.**

When used on an IEEE-488 bus system the SC3100 must be assigned an address that is separate from other addresses on the system. This allows the controller to select which instrument it is communicating with. The instructions provided with the IB72 provide additional connection information and details on setting the address. A special address is not needed when using the IB78 RS232 Interface Bus Accessory.

*Note: When using the SC3100 with the IB72 IEEE-488 Bus Interface, check the version number of IB72's EPROM, IC4. If your IB72 has version 2.0, contact the Sencore Service Department for a replacement.*

## To connect the SC3100 to an automated test system:

1. Remove the power from the SC3100, the Interface Accessory and the computer/controller.
2. Set the slide switches on the rear of the IB72 IEEE-488 Bus Interface Accessory for the desired address. This step is not needed with the IB78.
3. Connect the Interface Accessory's male DIN connector to the INTERFACE ACCESSORY Jack located on the rear of the SC3100.
4. Connect the proper cable from the Interface Accessory to the computer.
5. Supply power to all units in the automated system and verify that all units are on.



**Fig. 48 - Connect The IB72 or IB78 connect to the INTERFACE ACCESSORY Jack on the rear of the SC3100 for computer controlled operation.**

## Command Descriptions

The settings of the SC3100's front panel controls can be automatically set with a computer. The first valid bus command locks the front panel controls out of manual operation. All of the front panel controls (except those noted at the beginning of this section) remain locked out until a "CPO" (control panel on) command is sent. The SC3100 functions the same under bus control as it does during manual control and the digital meter continues to display the selected measurements.

The SC3100 uses a series of commands to control the front panel. Each command consists of a three character code that tells the SC3100 what function to select. Some commands, consist of a three character command plus 1 or 2 digits that give the control setting. The entire command must be sent in order for the SC3100 to respond properly.

Table 2 summarizes the valid commands. They are grouped according to function.

Disable bus control.....	CPO		
<b>Auto-Tracking Digital Measurements</b>			
DC volts, CH A.....	DCA		
DC volts, CH B.....	DCB		
PP Volts, CH A.....	VPA		
PP Volts, CH B.....	VPB		
Frequency, CHA.....	FRA		
Frequency, CHB.....	FRB		
AC volts, CHA.....	ACA		
AC volts, CHB.....	ACB		
dBm, CHA.....	DBA		
dBm, CHB.....	DBB		
<b>DELTA Measuremenets</b>			
Delta Time.....	TIM		
Delta Frequency.....	DFR		
Delta PPV CH A.....	DPA		
Delta PPV CH B.....	DPB		
Delta DCV CH A.....	DDA		
Delta DCV CH B.....	DCB		
<b>Circuit Parameter Measurements</b>			
OHMS.....	OHM		
DC Amps.....	AMP		
Continuity Test.....	CTN		
Ohms Zero.....	OMZ		
<b>BANDWIDTH Switch</b>			
CH A 100 MHz.....	BWA0		
CH A 20 MHz.....	BWA1		
CH B 100 MHz.....	BWB0		
CH B 20 MHz.....	BWB1		
<b>Channel A Invert</b>			
On.....	INV1		
Off.....	INV0		
<b>TRIGGER Controls</b>			
CH A Source.....	TRS0		
CH B Source.....	TRS1		
LINE Source.....	TRS2		
EXT Source.....	TRS3		
TV Mode.....	TRM0		
NORM Mode.....	TRM1		
AUTO Mode.....	TRM2		
"+" Polarity.....	TRP0		
"-" Polarity.....	TRP1		
<b>10X Horizontal Expand</b>			
On.....	X101		
Off.....	X100		
<b>TIME/DIV Control</b>			
TVV.....	TMB00		
AUTO.....	TMB01		
100mS.....	TMB02		
50mS.....	TMB03		
20mS.....	TMB04		
10mS.....	TMB05		
5mS.....	TMB06		
2mS.....	TMB07		
1mS.....	TMB08		
		.5mS.....	TMB09
		.2mS.....	TMB10
		.1mS.....	TMB11
		50uS.....	TMB12
		20uS.....	TMB13
		10uS.....	TMB14
		5uS.....	TMB15
		2uS.....	TMB16
		1uS.....	TMB17
		.5uS.....	TMB18
		.2uS.....	TMB19
		.1uS.....	TMB20
		.05uS.....	TMB21
		.02uS.....	TMB22
		TVH.....	TMB23
<b>CH A VOLTS/DIV Settings</b>			
AUTO.....	VDA00		
200V.....	VDA01		
100v.....	VDA02		
50v.....	VDA03		
20v.....	VDA04		
10v.....	VDA05		
5v.....	VDA06		
2v.....	VDA07		
1v.....	VDA08		
.5v.....	VDA09		
.2v.....	VDA10		
.1v.....	VDA11		
.05v.....	VDA12		
.02v.....	VDA13		
<b>CH B VOLTS/DIV Settings</b>			
AUTO.....	VDB00		
200v.....	VDB01		
100v.....	VDB02		
50v.....	VDB03		
20v.....	VDB04		
10v.....	VDB05		
5v.....	VDB06		
2v.....	VDB07		
1v.....	VDB08		
.5v.....	VDB09		
.2v.....	VDB10		
.1v.....	VDB11		
.05v.....	VDB12		
.02v.....	VDB13		
<b>INPUT COUPLING</b>			
CH A GND.....	ICA0		
CH A AC.....	ICA1		
CH A DC.....	ICA2		
CH B GND.....	ICB0		
CH B AC.....	ICB1		
CH B DC.....	ICB2		
<b>CRT MODE</b>			
CH A.....	CRT0		
CH B.....	CRT1		
CH A & B.....	CRT2		
CH A + B.....	CRT3		
X-Y VECTOR.....	CRT4		
Alternate.....	CRT5		

Table 2 - SC3100 bus commands.

## Data Returned By The SC3100

The SC3100 continually returns the data in the digital display to the computer. The data is in a standard data format, as shown in Table 3. Each data string is 25 characters long and consists of four parts; 1) Header, 2) Numeric Data field, 3) Suffix and 4) End terminator. Each part has the same number of characters for any function so you can use the same subroutines to process any returned data.

- 1) Header: Characters 0-2 identify the test function that is selected. (See Table 3).
- 2) Numeric Data: This field contains the measurement data.
- 3) Suffix: This corresponds to the annunciator that is displayed in the LCD readout
- 4) End Terminator: Character 23 is a carriage return (ASCII decimal 13) and character 24 is a line feed (ASCII decimal 10).

Many computers respond to either end terminator, while others need the line feed. A few computers however, stop accepting data when the carriage return is received. This leaves the SC3100 hung up while it waits to send its last line feed character. If this happens, put an extra GET or INPUT statement into your control program to let the SC3100 send its last character into an unused variable. Table 4 shows a sample of the data returned for each measurement.

Header	Numeric Data	Suffix	End
F R A	_ _ _ _ _ X . X X X X X E ± 0 X	_ _ H z	CR LF
D C A	_ _ _ _ _ ± X . X X X E ± 0 V	_ _ _ _	CR LF
V P A	_ _ _ _ _ X . X X X E ± 0 X	_ V P P	CR LF
A C A	_ _ _ _ _ X . X X X E ± 0 X	_ V _ _	CR LF
D B A	_ _ _ _ _ ± X X . X	_ d B m	CR LF
T I M	_ _ _ _ _ X . X X X E ± 0 X	_ S _ _	CR LF
D F R	_ _ _ _ _ X . X X X E ± 0 X	_ H z _	CR LF
D P A	_ _ _ _ _ X . X X X E ± 0 X	_ V P P	CR LF
D D A	_ _ _ _ _ X . X X X E ± 0 X	_ _ V _	CR LF
O H M	_ _ _ _ _ X . X X X E ± 0 X	_ 0 H M	CR LF
A M P	_ _ _ _ _ X . X X X E ± 0 X	_ A M P	CR LF
C T N	_ _ _ _ _ X . X X X E ± 0 X	_ A M P	CR LF

X = digit, decimal or blank depending on reading  
 E = exponent indicator  
 \_ = place holder space (always blank)  
 +/- = "-" if negative, blank if positive

**Table 3 - Data format returned by the SC3100**

## Error Codes

The SC3100 will return an error code when it receives an invalid command. The error code can be triggered by an invalid 3 character command or control setting.

Table 4 summarizes these error codes.

<b>E1</b>	Invalid bus command or bus command used incorrectly.
<b>E2</b>	Invalid parameter used in command. Possible causes are: <ol style="list-style-type: none"> <li>1) Invalid VOLTS/DIV setting: setting &gt;13, or setting not specified.</li> <li>2) Invalid TIME/DIV setting: setting &gt;23, or setting not specified</li> <li>3) Invalid setting specified for control setting.</li> </ol>

**Table 4 - Error codes returned by the SC3100 during operation.**

# APPLICATIONS

## INTRODUCTION

The applications of a waveform & circuit analyzer/oscilloscope such as the SC3100 "AUTO TRACKER" are limitless. Most alignments and measurements can be made faster and more accurately using the SC3100. This Applications section includes examples of typical applications to provide you with ideas on how to use your SC3100 to its fullest capability. It is divided into Delta Measurement Applications and CRT Applications.

## DELTA MEASUREMENT APPLICATIONS

### Determining Logic Levels

Digital circuits operate with logic high and logic low signal levels. These logic levels must be correct or the circuit will confuse one level for another. You can easily determine if a signal is at the correct logic level by using the Delta DCV function of your SC3100.

A questionable area exists where the digital circuits can not determine if the signal is a high level or a logic low level. This questionable area depends upon the type of logic. Figure 49 shows the logic low, high, and questionable areas for the most common types of logic circuits, TTL and CMOS.

TTL circuits operate with a supply voltage of 5 volts and have a questionable area from 0.8 to 2.8 volts. Levels that are .8 volts or less are a low, while levels 2.8 volts and higher are a high.

CMOS devices operate over a wider range of power supply voltages. Because of this the questionable area for CMOS logic is a percentage of the power supply voltage, rather than a fixed voltage level. The questionable area for CMOS logic is between 20% and 70% of  $V_{cc}$ . If a 10 volt power supply is used, for example, the questionable area would be between 2 volts and 7 volts. A logic high would be 7 volts or higher and a logic low would be 2 volts and less for this example.

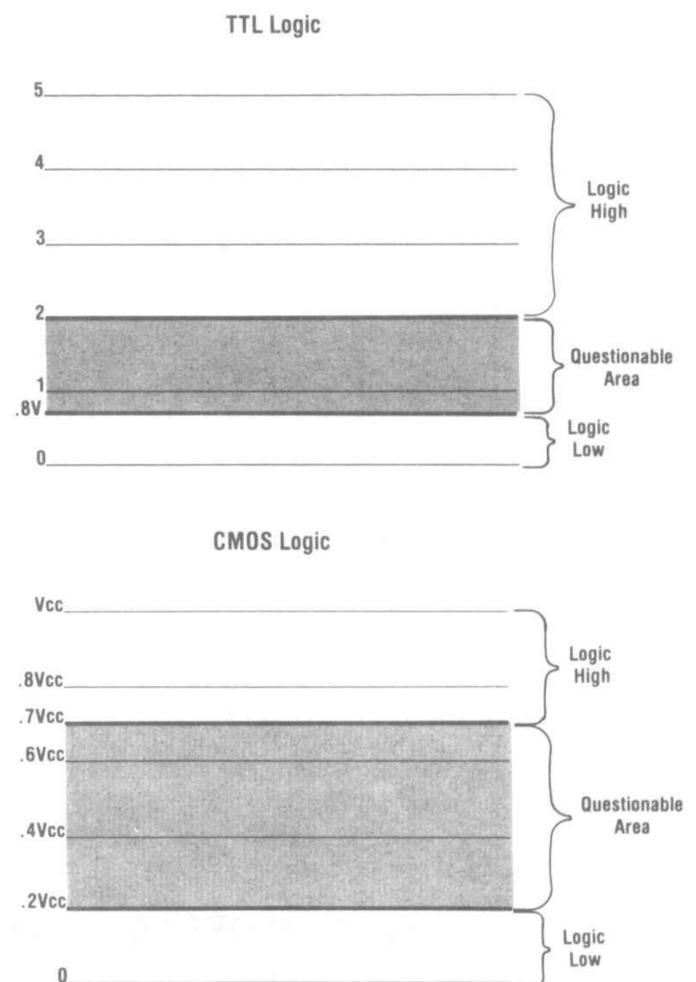


Fig. 49 - Logic high and logic low voltage levels for TTL and CMOS.

### To determine logic levels:

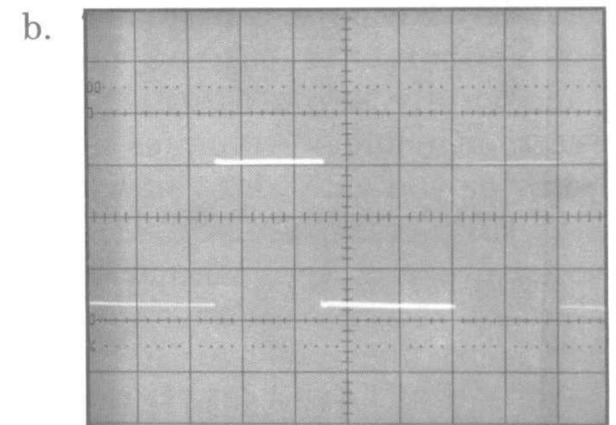
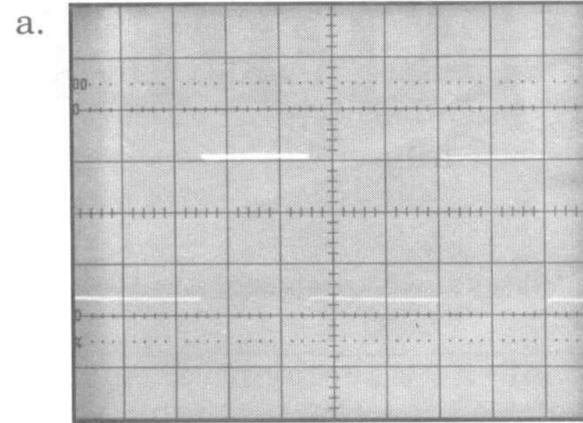
1. Properly lock the waveform on the CRT display.
2. Set the TIME/DIV and VOLTS/DIV controls to display the entire waveform. Use the "Auto" positions if desired.
3. Press the Delta DCV button of the channel corresponding to the signal to be measured.
4. Adjust the "ΔDCV" DELTA MARKER control to position the DC marker at the logic low or logic high point on the waveform.
5. Confirm that the voltage displayed in the digital readout matches the logic level shown in Figure 49.

### Measuring duty cycle

Duty cycle is the ratio of the on time (high level) to the total of one cycle. The SC3100's Delta Time function allows you to accurately make the measurements needed to calculate the duty cycle of a signal.

#### To determine duty cycle:

1. Properly lock the waveform on the CRT display.
2. Set the TIME/DIV and VOLTS/DIV controls to display the entire waveform. Use the "Auto" positions if desired.
4. Press the "ΔTIME" button
5. Adjust the INTENSITY control for good contrast between the DELTA BAR and the remainder of the trace.
6. Adjust the "Begin" and "End" DELTA MARKER controls to intensify the "on" time of the waveform.
7. Read and record the "on" time in the digital display.
8. Adjust the "Begin" and "End" DELTA MARKER controls to intensify one full cycle of the waveform.
9. Read the digital display and record the displayed time.
10. Divide the "on" time by the total time to determine the duty cycle. For example, an on-time of 50  $\mu\text{S}$ , and a total time of 100  $\mu\text{S}$  represents a duty cycle of 50%.



*Fig. 50 - Determine duty cycle by comparing the on time to the total time of one cycle.*

### Measuring Time Delay

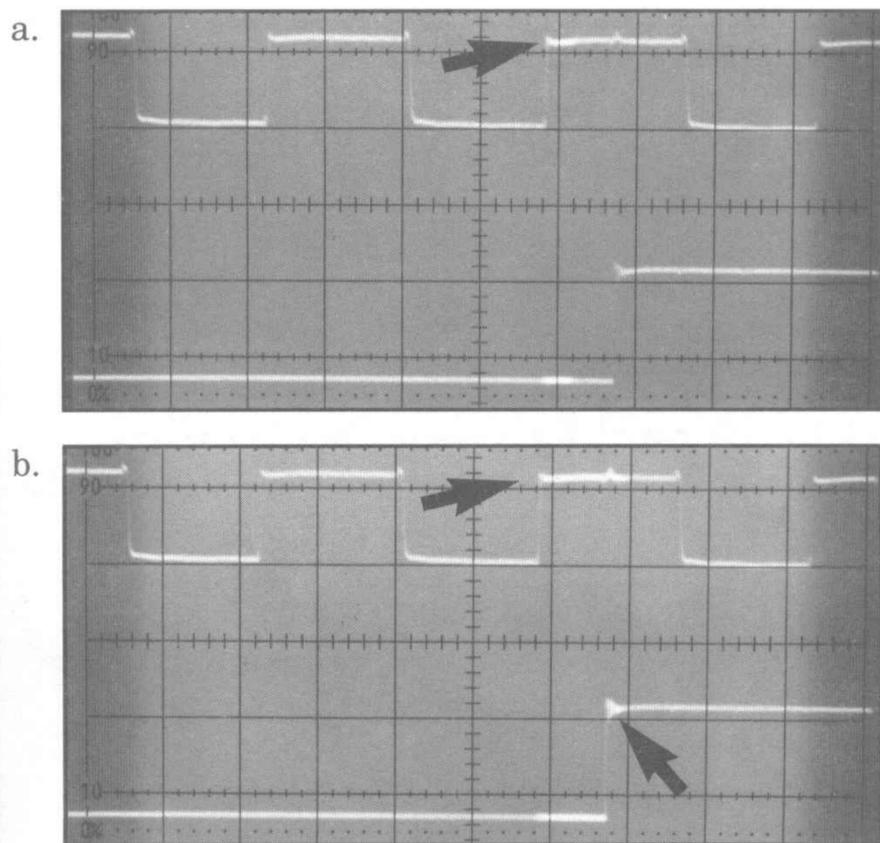
The Delta Time function simplifies measuring the time difference or delay between two signals. Setting the beginning and ending points of the intensified Delta Bar on one trace also sets the beginning and ending points of the Delta Bar on the other trace.

To measure the time delay between two signals you simply set the Delta Bar to highlight the time between the start of one cycle on one channel and the start of the same cycle on the other channel. The digital display shows the time difference of the two points which is the time delay between them.

#### To determine the time delay between two signals:

1. Properly lock the waveforms on the CRT display.
2. Set the TIME/DIV and VOLTS/DIV controls to display both waveforms. Use the "Auto" positions if desired.
3. Position the waveforms so that an identifiable transition, such as the start of a cycle, is visible for both.
4. Press the ΔTIME button.
5. Adjust the INTENSITY control for good contrast between the DELTA BAR and the remainder of the trace.

6. Adjust the "Begin" and "End" DELTA MARKER controls to intensify the on-time of the waveform.
7. Adjust the "Begin" DELTA MARKER control until the start of the Delta Bar is positioned exactly at the selected transition in one of the waveforms.
8. Adjust the "End" DELTA MARKER control until the end of the Delta Bar is positioned exactly at the same transition point in the other waveform.
9. Read the digital display to determine the amount of time delay between the two channels



**Fig. 51 - To measure the delay between signals place the beginning of the Delta Bar on one waveform transition (A). Then set the end of the Delta Bar on the other waveform transition (B).**

### Setting A Desired Time Delay

The above procedure explains how to measure the time delay between two signals. Many adjustments, however, require you to set pulse width time or adjust the time delay between two signals. The Delta Time function can simplify these adjustments.

Use the Delta Bar to "preset" the time window. Then adjust the circuit so that pulse width is the same as the intensified area, or until the required signal transition falls within the intensified area of the Delta Bar.

#### To adjust a circuit to a predetermined time:

1. Properly lock the waveforms on the CRT display.
2. Set the TIME/DIV and VOLTS/DIV controls for the desired waveform display. Use the "Auto" positions if desired.

3. Position the waveform(s) so that the desired interval is visible.
4. Press the "ΔTIME" button.
5. Adjust the INTENSITY control for good contrast between the DELTA BAR and the remainder of the trace.
6. Adjust the "Begin" DELTA MARKER control until the Delta Bar begins at the start of the waveform interval to be adjusted.
7. Adjust the "End" DELTA MARKER control until the digital display reads the desired time.
8. Adjust the circuit until the waveform just fills the area intensified by the Delta Bar, or until the signal transition falls within the intensified area

### Measuring Phase Shift

The Delta Frequency function provides a fast and accurate method for determining the phase between two signals that are the same frequency.

Measuring phase shift is similar to measuring the time delay between two signals. The time delay is converted to the equivalent frequency by pressing the ΔFREQ button. This frequency is then compared to the frequency of one full cycle. The ratio of these two frequencies is the fractional part of 360° represented by the phase shift between channels.

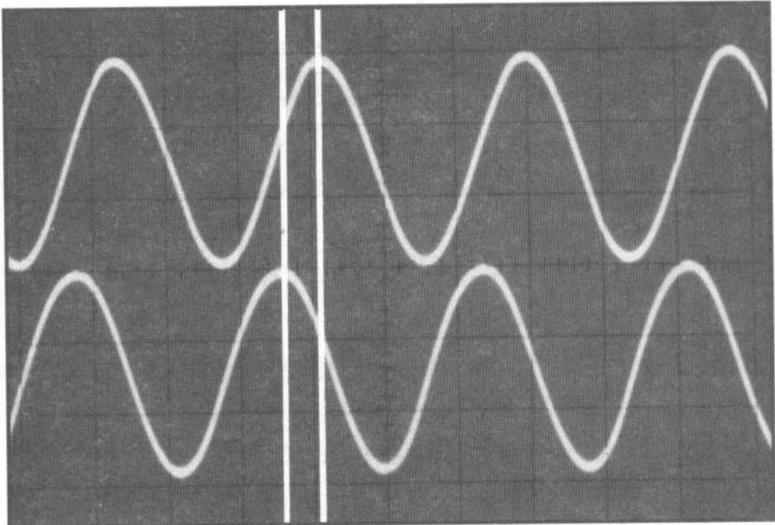
$$\text{The Phase shift equals } \frac{\text{FREQ} \times 360^\circ}{\Delta\text{FREQ}}$$

#### To determine the phase of two signals:

1. Properly lock both waveforms on the CRT display. (Both waveforms must be the same frequency).
2. Set the TIME/DIV control to show 2-3 cycles and the VOLTS/DIV control to show approximately 4 divisions of each signal. Use the "Auto" positions if desired.
3. Press ΔFREQ.
4. Adjust the INTENSITY control for good contrast between the DELTA BAR and the trace.
5. Adjust the "Begin" DELTA MARKER control to position the beginning of the Delta Bar to the very peak of one of the cycles on one of the waveforms.
6. Adjust the "End" DELTA MARKER control so that the Delta Bar end is at very peak of the cycle on the other waveform that is closest to the right of the Delta Bar's beginning point.

7. Read the equivalent frequency in the display.
8. Press the **FREQ** button for either channel A or B (the frequency will be the same for both).
9. Divide the frequency in step 9 by the equivalent frequency in step 8 and multiply the result times  $360^\circ$ .

*Note: You may wish to use the X-Y Vector mode if you only need a very quick visual approximation of phase.*



**Fig. 52 - To measure phase shift intensify the difference of the two signals and read the  $1/\Delta$  Time frequency.**

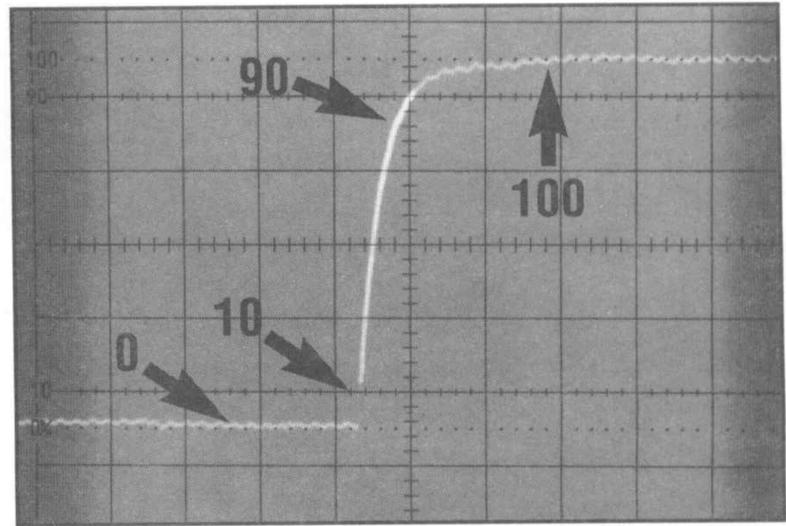
## Measuring Rise and Fall Time

Rise or fall time is how long it takes for the rising or falling edge of a waveform to change from 10% to 90% of its total peak-to-peak amplitude (rise time), or from 90% to 10% (fall time). Some service literature may call this "transition time".

The Delta Time function allows you to make fast and accurate rise and fall time measurements. Special markings on the CRT allow you to quickly determine the 10% and 90% amplitude levels. These markings located on the left edge of the CRT display.

### To measure rise time:

1. Properly lock the waveform on the CRT display.
2. Adjust the **TIME/DIV** and the **HORIZONTAL VERNIER** controls to display one or two cycles of the waveform.



**Fig. 53 - Adjust the amplitude of the waveform between the 0% and 100% markings. Measure the Delta Time between the 10% and 90% points to determine rise or fall time.**

3. Adjust the **VOLTS/DIV** switch, **VERTICAL POSITION**, and **VERTICAL VERNIER** controls to position the entire waveform between the 0% and 100% CRT markings.
4. Press the  **$\Delta$ TIME** button.
5. Adjust the **INTENSITY** control for good contrast between the **DELTA BAR** and the remainder of the trace.
6. Adjust the "Begin" and "End" **DELTA MARKER** controls to position the Delta Bar on the waveform between the 10% and 90% markings on the CRT.
7. Read the rise time on the digital display.

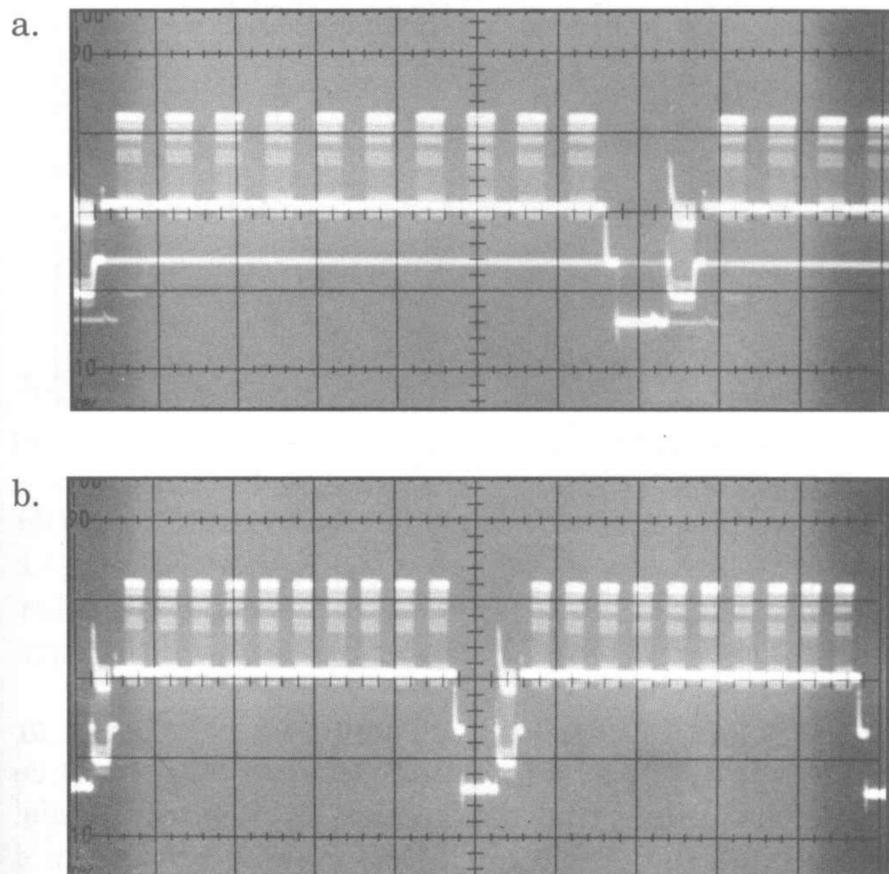
Measure fall time same way, except highlight the falling edge of the signal with the Delta Bar.

## Measuring Delta PPV On Video Signals

Composite video signals contain a complex mixture of frequencies and amplitudes. Because of this you must use the special TV sync separators when making delta readings on composite video waveforms. Select either the "TVV" or "TVH" Preset position of the **TIME/DIV** control, or use the "TV" position of the **TRIGGER MODE** switch. The sync separators eliminate the vertical sync and blanking signal from the waveform when viewing the composite video at the horizontal rate.

Figure 54a shows what happens if the vertical sync is not removed by selecting the sync separators. Notice the faint line running between the two horizontal sync pulses. This is the vertical sync and blanking information. If these vertical signals are not eliminated, they will cause improper Delta PPV readings. The Delta circuits will measure the amplitude from the bottom of the sync pulse (the faint line), rather than from the desired portion of the video signal.

Figure 54b shows the same horizontal waveform, but this time the trigger circuits are set to the "TV" Trigger Mode. The Delta peak-to-peak function now gives the correct reading for any portion of the trace that is intensified by the Delta Bar.



**Fig. 54 - The vertical sync information shows as a faint background trace when the video sync separators are not used or improperly set (a). The sync separator circuits eliminate the vertical sync (b) when viewing video signals for correct Delta P-P readings.**

## Using Delta VPP To Locate Interferences

Sometimes the digital Peak-to-Peak reading is significantly higher than the waveform that is displayed on the CRT. This is an indication that the fast digital peak-to-peak circuits are detecting a noise spike or glitch that is not noticed on the CRT. You can use the Delta VPP function to locate the portion of the waveform that contains the interference, because it only measures the amplitude of the intensified portion of the trace.

### To locate a glitch:

1. Lock in the waveform display on the CRT.
2. Position the Delta Bar to cover a narrow portion of the waveform.
 

The digital display should read very close to the approximate amplitude indicated by the CRT. If it does not, you are already highlighting the portion of the trace that contains the interference.
3. Using the DELTA MARKER controls, slowly widen the area of the trace that is intensified by the Delta Bar while watching the digital display.
4. As soon as the meter reading jumps to a higher voltage you have just highlighted the portion of the trace that contains the noise or glitch.
5. You can now use the CRT controls to expand this portion of the trace to make the interference visible

*Note: Delta VPP readings that randomly change are caused by random noise spikes, or by interference that is not synchronized to the triggered waveform.*

## CRT APPLICATIONS

### Using The A + B Mode To Locate Amplifier Distortion

In a properly operating amplifier, the output waveform should be identical to the input waveform, except that the output will be larger in amplitude. (It may also be inverted 180°). You can use the SC3100 to quickly check for distortion by comparing the input and output waveforms.

The "A + B" and "B - A" CRT display modes make distortion easier to see because they allow the output waveform to be canceled by the input. If the output is not distorted, a straight horizontal line will be produced on the CRT. Any distortion, however, will be visible on the trace. The signal applied to the amplifier input should be a sine wave, but it does not need to have extremely low distortion since signals that are common to the input and output cancel.

Audio amplifier distortion levels as small as approximately .1% can be detected using this method. This is possible because the gain of the vertical amplifiers may be increased (by turning the VOLTS/DIV controls clockwise) beyond the level that would cause full-scale deflection in the normal, non "B-A" mode, while the residual distortion remains relatively small on the CRT.

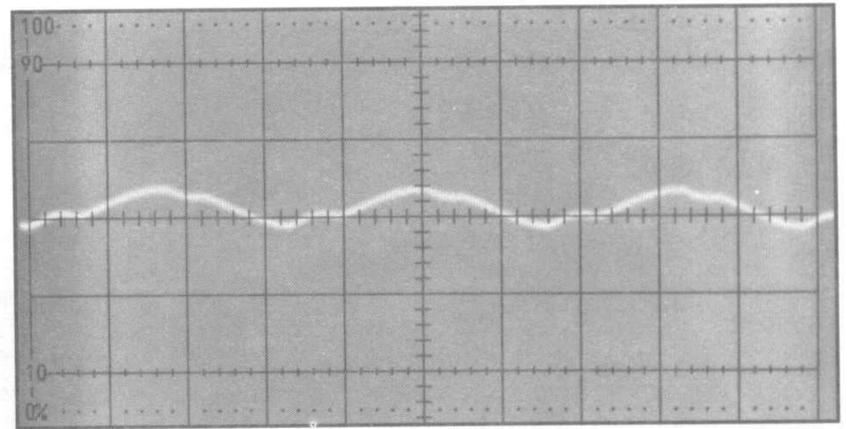
#### To measure amplifier distortion:

1. Connect a sine wave to the amplifier input.
2. Connect the channel A probe to the amplifier input and the channel B probe to the output.
3. Press the "CH A & B" CRT MODE button.
4. Adjust the TIME/DIV and TRIGGER controls to display several cycles of the waveforms.
5. Set the channel A and channel B VOLTS/DIV controls so that both CRT displays are as close to a full scale as possible.
6. Pull the channel A VERTICAL POSITION control to invert the channel A display. If the signals are already 180° out of phase do not invert channel A.
7. Press the "A+B ADD" CRT MODE button.
8. Adjust the VERTICAL VERNIER controls for both channels until the trace is as small as possible.

The signal that cannot be eliminated with step 8 is the distortion added by the amplifier.

A straight line in step 8 indicates there is less than 2% distortion. Your ability to see the distortion may be increased by ten times (20 dB) by increasing the sensitivity of both VOLTS/DIVISION switches by ten times. If, for example, channel A is set to 1 volt per division and channel B is set for 2 volts per division, change them to .1 and .2 respectively.

*Note: The digital VPP function will read the entire amplitude of the signals at the channel A or B inputs, not the canceled signal shown on the CRT.*



**Fig. 55 - The signal that remains after you cancel the input and output signals of an amplifier is the distortion.**

### Using the A+B Mode To Reduce The Level Of Undesired Signals

The A+B mode can also be used to eliminate or reduce the level of some undesirable interference signals that may cause difficulties in viewing signals. For example the 60 Hz hum that may be present in a signal can be reduced to leave only the desired signal on the CRT.

To do this simply apply a sample of the interfering signal to the second SC3100 input. Then subtract the two signals until the interfering signal is fully cancelled.

#### To reduce undesired signal levels:

1. Connect the signal to be measured to the CH B input.
2. Connect a source of the undesirable signal to the CH A input. For example you could use the secondary of an AC power transformer for a sample of 60 Hz hum.
3. Depress the "A&B" CRT display button and set the TIME/DIV and TRIGGER controls to display two or three cycles of the signal.

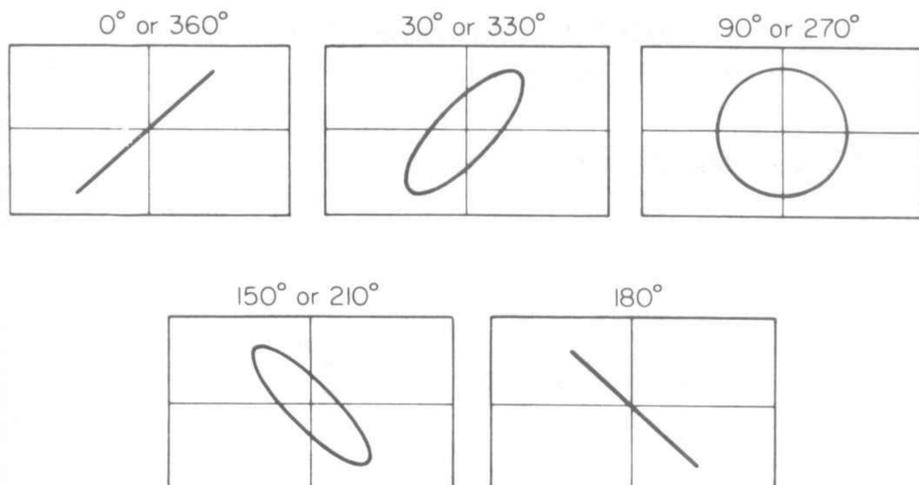
4. Set the VOLTS/DIV controls for both channels to make the undesirable signal displayed by channel A about the same amplitude as the desired signal on channel B.
5. Select the "A+B ADD" CRT MODE button.
6. If the amount of interference doubles, invert the channel A display by pulling the CH A VERTICAL POSITION control.
7. Use the CH A VERTICAL VERNIER control to reduce the undesirable signal to its lowest level.

*Note: The digital VPP function will read the amplitude of the signals at the channel A or B inputs, not the canceled signal shown on the CRT.*

## Using The Vector Mode

While the Delta Frequency function provides a simple, accurate measurement of phase, there are times when you only need to know if two signals are in phase or what their approximate phase is. At these times you will want to use the X-Y VECTOR mode.

In the X-Y Vector mode the signal applied to CH A INPUT produces vertical (Y) CRT deflection and the signal applied to CH B INPUT produces horizontal (X) CRT deflection. The resulting display, called a Lissajous pattern, shows the phase and frequency relationships of the two signals. Figure 56 shows typical phase relationships shown by the vector mode.



**Fig. 56 - The vector mode shows phase relations.**

### Using The X-Y Vector To Align Audio Tape Heads

A practical, typical application of the X-Y vector mode is to check and align the playback/record heads in a stereo tape machine. This alignment procedure involves setting the head for the highest amplitude output and the least amount of phase difference between the left and right channels. The X-Y Vector function allows you to simultaneously monitor both of

these conditions. You can use a similar procedure for checking separation in any system.

The physical position of the record or playback head gap in an audio tape recorder greatly affects the frequency response and output level. The gap must be positioned exactly perpendicular to the edge of the tape for best results. The vector function of the SC3100 allows you to make this adjustment much faster and accurately than any other method.

Decks with two heads (erase and record/playback) only require you to adjust the playback setting. Decks with three heads (erase, record, and playback) require two adjustments: first align the playback head reference tape, then adjust the record head to match the playback head.

*Note: You will need a standard alignment tape to do this procedure.*

### To align the playback head:

1. Connect the Left and Right LINE OUT jacks to the SC3100 inputs.
2. Locate the azimuth adjustment tone on the alignment tape.
3. Press the "A & B" CRT display push button.
4. Play back the alignment tape and adjust the SC3100 controls for about three divisions of signal. Set the VOLTS/DIV controls to the same range (Don't use "Auto"). Set the VERTICAL VERNIERS to "Cal".
5. Rough in the head alignment by adjusting the head azimuth screw for the largest amplitude displays on the CRT.
6. Press the "X-Y VECTOR" CRT MODE button.
7. Adjust the HORIZONTAL and CH A VERTICAL POSITION controls if necessary to center the Lissajous pattern on the CRT. DO NOT readjust any other controls
8. Adjust the azimuth adjustment screw until the vector pattern is as close as possible to a straight line with zero phase shift (45° angle), as shown in Figure 57.

The playback head is now adjusted for optimum performance.

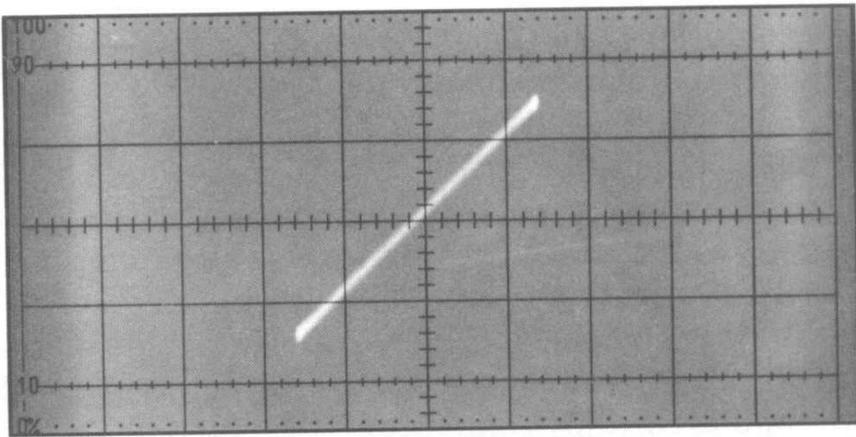


Fig. 57 - A 0° phase shift indicates that both stereo channels are producing the same output.

### To adjust the record head:

1. Align the playback head as explained in steps 1-7 above.
2. Place a blank tape into the recorder.
3. Apply a 1 kHz sine wave to the L and R LINE inputs using a "Y" connector.
4. Adjust the record level and audio generator output controls until both recording VU meters show 0 dB.
5. Place the machine into the record mode.
6. Set the "source/tape" switch to "tape" to monitor the recorded signal from the tape using the playback head.
7. Depress the "CH A&B" CRT MODE button.
8. Adjust the record azimuth adjustment screw until the signal has maximum amplitude.

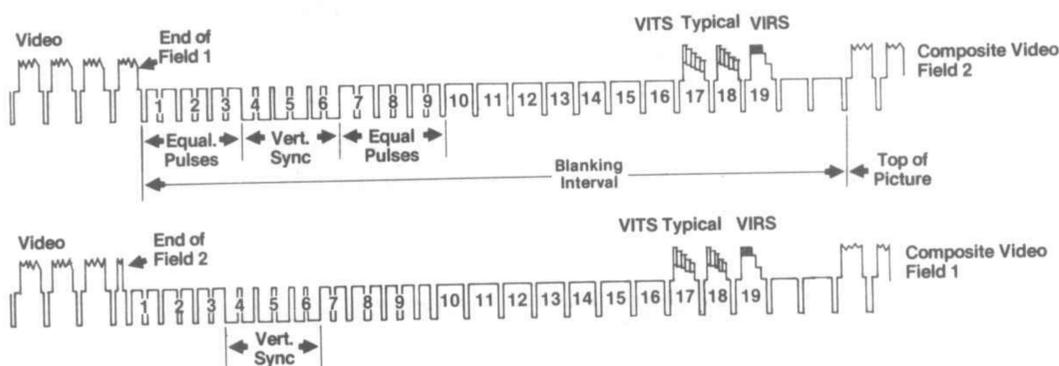


Fig. 58 - The VITS and VIRS signals are located on lines 17, 18, and 19 of the vertical blanking interval.

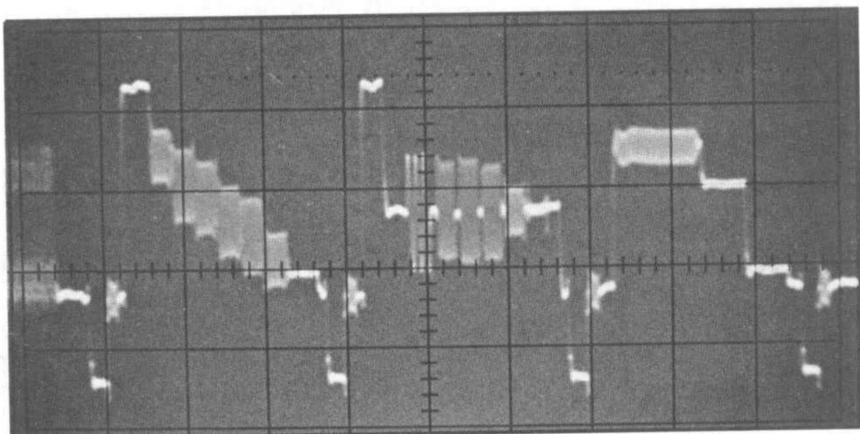


Fig. 59 - The VITS and VIRS signals.

**NOTE:** There may be a short delay between the time the signal is recorded by the record head and picked up by the playback head. Make the adjustment and then wait for the pattern on the SC3100 to stabilize before making additional adjustments.

9. Press the "X-Y VECTOR" CRT MODE button and adjust the record head azimuth until the vector pattern is as close as possible to a straight line with zero phase shift (45° angle), as shown in Figure 57.

### Viewing Video VITS and VIRS

Most TV stations transmit special reference signals during the vertical blanking interval. The two most common signals are the VITS (vertical interval test signal) and VIRS (vertical interval reference signal). These signals may be easily viewed on the SC3100. The SC3100 has special circuits in the sync separators that isolate the two vertical interlaced fields to prevent overlap of the signals from the first and second fields.

#### To view the VITS or VIRS:

1. Set the TIME/DIV to ".1 msec".
2. Set the TRIGGER MODE "TV". Adjust the other trigger adjustments for a properly locked display.
3. Center the VIRS or VITS signal on the horizontal center line.
4. Pull the HORIZONTAL POSITION control to activate the 10X expand.
5. Center the desired signal on the CRT.

## Making Differential Measurements

The CH A and CH B INPUTS of the SC3100 are referenced to earth ground through the AC power cord. This is sometimes called a "single-ended" input and is used by most oscilloscopes. Since most circuits are also referenced to a common ground, this arrangement is ideal for most measurements. A single-ended input offers the advantages of shielding from external noise and safety since the oscilloscope chassis is at earth ground.

A few circuits, however, require a non-grounded or differential measurement since no point in the circuit is referenced to a common reference. Some audio systems, for example, use balanced lines. Connecting a ground will upset these circuits. At other times connecting a ground will short out part of the circuit or power supply.

You can connect the SC3100 to view the signal on the CRT. However, the digital Auto-Tracking and Delta voltage measurements will not be meaningful. (The Delta Time and Delta Frequency measurements will still be correct).

## To make a differential measurement:

1. Connect the CH A and CH B probe ground leads together. Do not connect the grounds to the circuit.
2. Connect the channel A probe to one circuit test point. Connect the channel B probe to the other circuit test point.
3. Press the "A+B ADD" CRT MODE button.
4. Invert the channel A trace by pulling the CH A VERTICAL POSITION control out.
5. Set the VERTICAL VERNIER controls to "CAL".
6. Set both VOLTS/DIV controls to the same position.  
**Do not use the "Auto" position.**

The CRT now shows the difference between the signals applied to the input channels. You can calculate peak-to-peak volts from the CRT by simply multiplying the number of graticules by the VOLTS/DIV setting.

*Note: The triggering may be more touchy when using the SC3100 in the differential mode.*

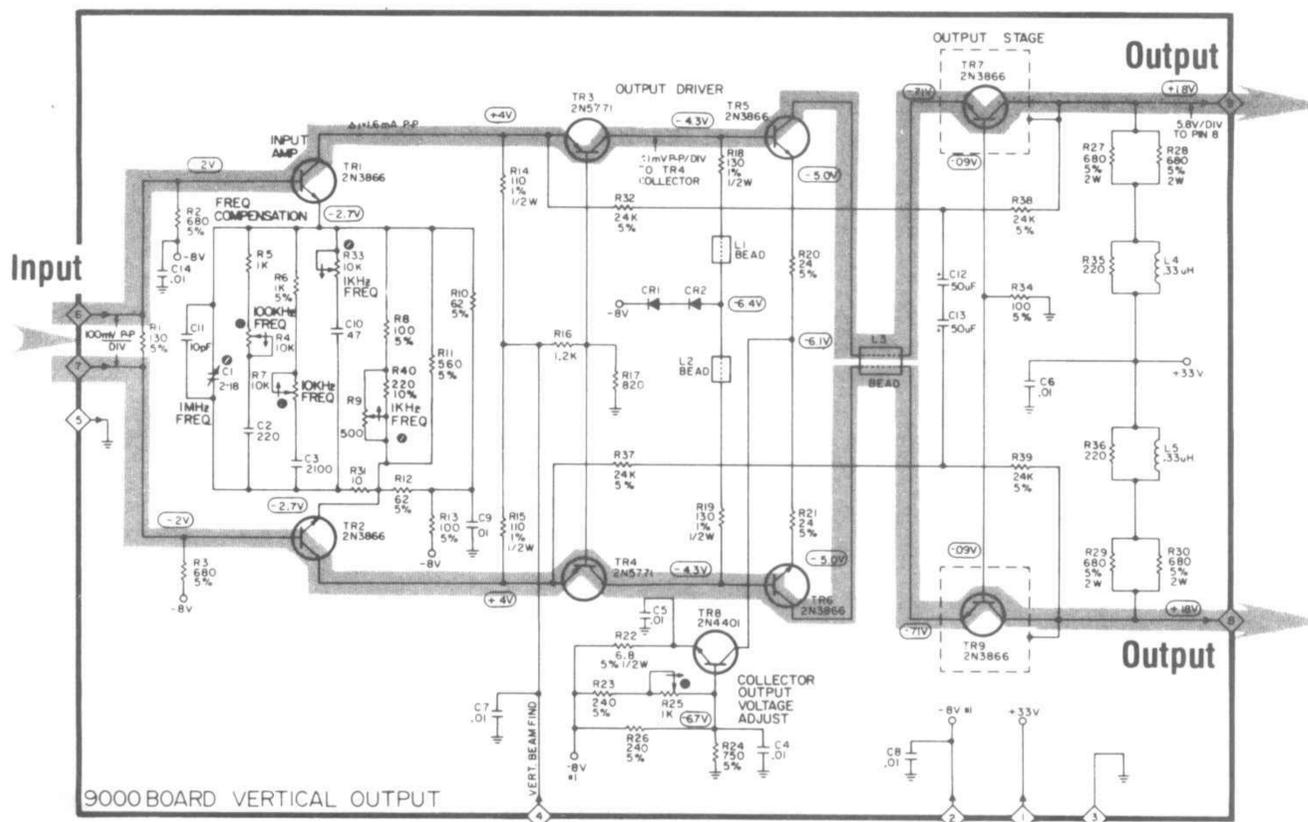


Fig. 60 - A differential measurement is needed when both sides of a circuit are isolated from ground.



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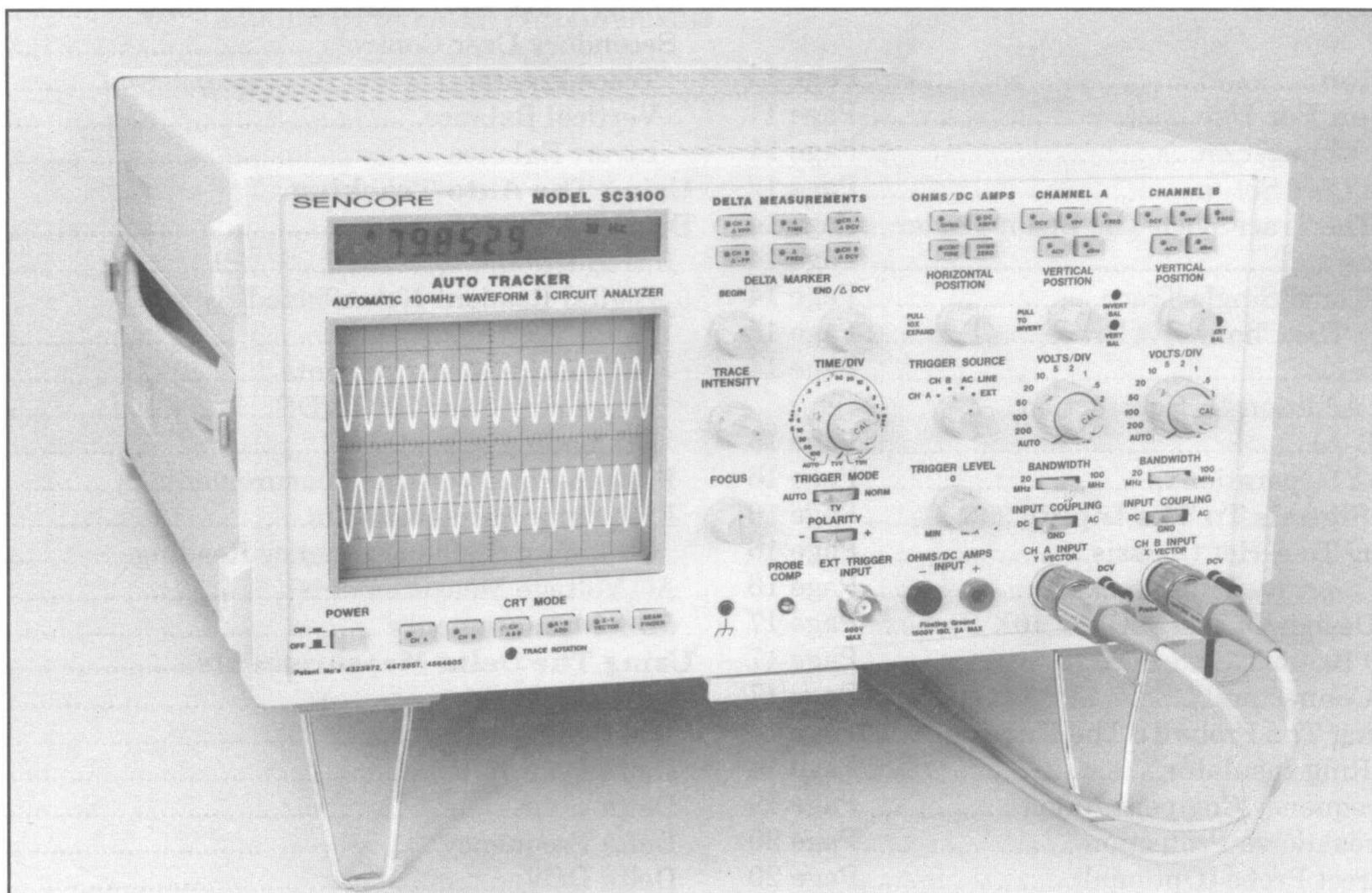
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# SC3100

## "AUTO TRACKER"

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