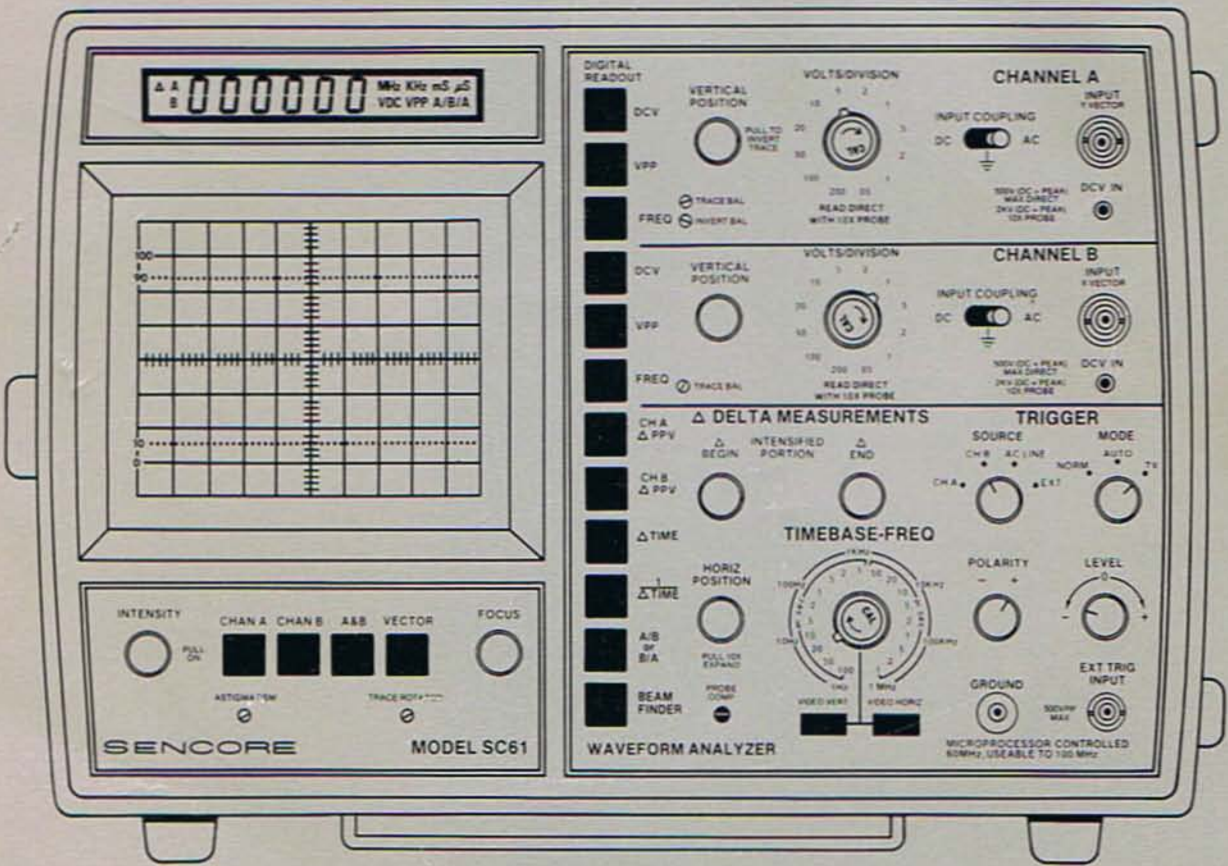
SC61

Waveform Analyzer

Operation, Application, and Maintenance Manual



SENCORE

3200 Sencore Drive, Sioux Falls, South Dakota 57107

W0CCW

WARNING

PLEASE OBSERVE THESE SAFETY PRECAUTIONS

There is always a danger present when testing electronic equipment. Unexpected high voltages can be present at unusual locations in defective equipment. Become familiar with the equipment you're working with, and observe the following safety precautions.

Every precaution has been taken in the design of your instrument to insure that it is as safe as possible. **However, safe operation depends on you, the operator.**

1. **Never exceed the limits of this instrument** as given in the specifications section and the additional special warnings in this manual.

2. **A severe shock hazard can result** if the chassis of the equipment being serviced is tied to the "hot" side of the AC line. An isolation transformer should always be used with this equipment. Also, be sure that the top of your workbench and the floor underneath it are dry and made of non-conductive material.

3. **Remove the circuit power before making connections** to high voltage points. If this cannot be done, be sure to avoid contact with other equipment or metal objects. Place one hand in your pocket and stand on an insulated floor to reduce the possibility of shock.

4. **Discharge filter capacitors** after removing power before connecting to any part of the circuit requiring power to be removed.

5. **Be sure your equipment is in good order.** Broken or frayed test leads can be extremely dangerous and can expose you to dangerous voltages.

6. **Remove the test leads** immediately after the test has been completed to reduce the possibility of shock.

7. **Do not work alone** when working on hazardous circuits. Always have another person close by in case of an accident. Remember, even a minor shock can be the cause of a more serious accident, such as falling against the equipment, or coming in contact with high voltages.

8. **Improper Fuse(s) Void Warranty.** Fuses are for your protection, so always replace fuse with proper type and current rating. The proper fuse type description is marked near the fuse holder and in the manual. Always:
   a. **Be sure you are replacing the right fuse.** On units with more than one fuse, be sure you are placing the proper fuse value in the fuse holder.
   b. **Have the proper size replacement fuse in stock.** With each new instrument, be sure to update your fuse inventory with any special value fuses your instrument may require.

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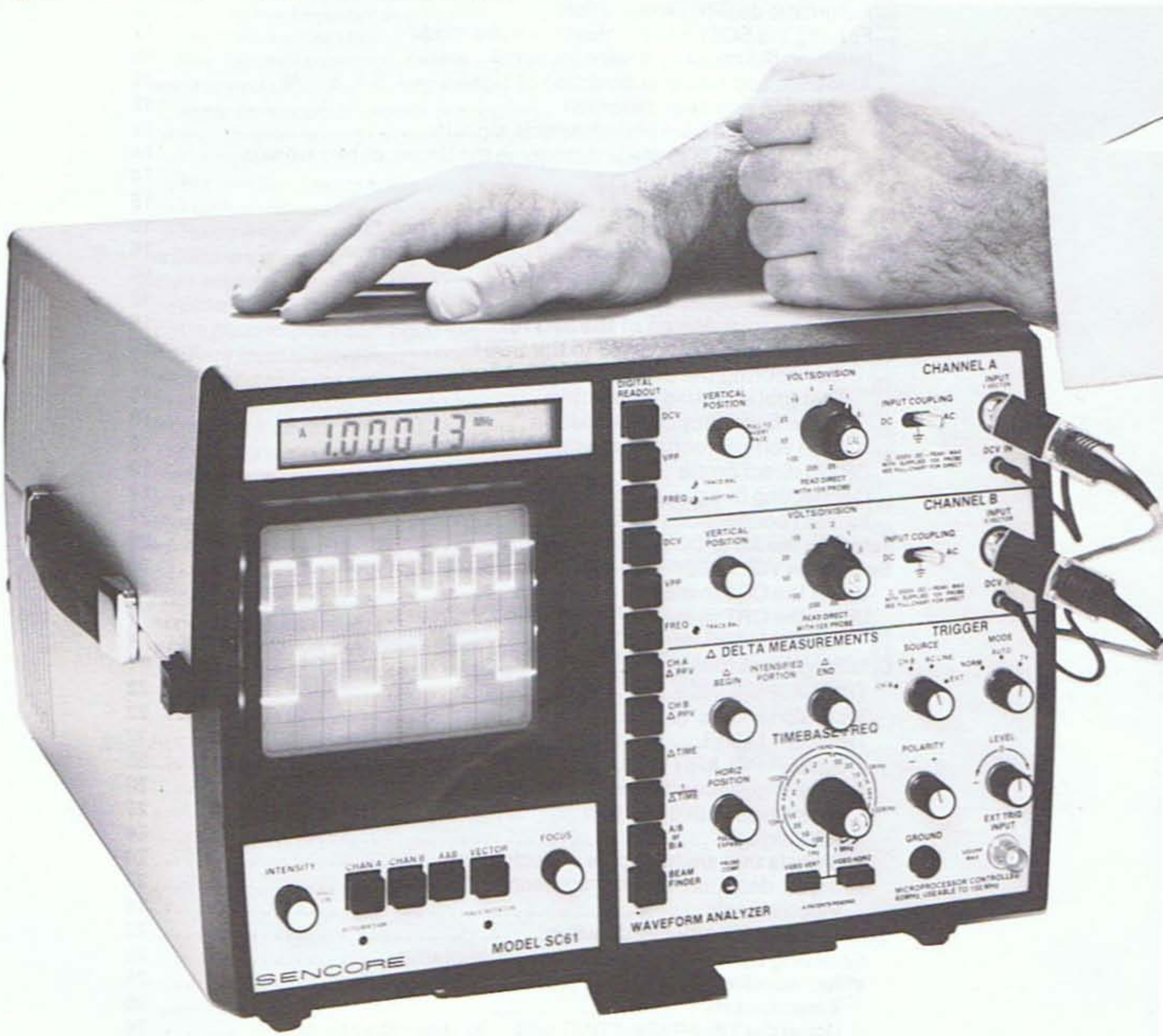

SENCORE

3200 Sencore Drive, Sioux Falls, South Dakota 57107

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DESCRIPTION

Introduction

The SC61 Waveform Analyzer represents the first improvement in waveform measuring techniques since the first oscilloscope was introduced over 50 years ago. Before the SC61, all oscilloscopes were strictly analog devices. Every measurement of peak-to-peak amplitude, time, or frequency required matching the waveform to CRT graticule markings, estimating parts of a CRT division or part of a cycle of the waveform and multiplying the size of the waveform times the setting of the horizontal or vertical switches. The measurements were not very accurate (typical accuracy on an analog scope is ±15% when interpretation error is considered), were time consuming, and were subject to many errors (such as forgetting to turn the vernier to the calibrated position).

The SC61 combines the waveform analyzing capability of a high quality oscilloscope with the speed, accuracy, and freedom from errors of a computer. The SC61 has a microcomputer that monitors the vertical and horizontal circuits at all times. You just push a button when you want to measure all or part of a waveform. The microcomputer determines the reading, automatically sets the decimal, and produces a direct digital readout of the value.

Features

The SC61 Waveform Analyzer starts with a high quality oscilloscope. The CRT display section has a bandwidth of 60 MHz, and is useable to 100 MHz to show the needed detail when analyzing digital signals. Specially designed sync circuits (using differential amplifiers and emitter-coupled logic stages) provide solid triggering with the fewest trigger adjustments possible. The input capabilities extend from 5 millivolts per division all the way to 2000 volts DC or AC peak-to-peak.

Special video circuits simplify analyzing composite video waveforms. Sync separators produce stable triggering on these complex signals. Additional stages eliminate the half-line shift on interlaced signals, while others eliminate veritcal sync from interfering with digital readings of signals displayed at the horizontal sweep rate. Video preset buttons allow pushbutton selection of vertical or horizontal scanning frequencies.

There are two types of digital measurements made through the same probe used for the CRT display. The first three functions for each channel are called the Auto-Tracking™ tests. Auto-Tracking means the microcomputer automatically tracks the CRT display at all times. The three Auto-Tracking functions are DC volts, peak-to-peak volts, and frequency. All three functions measure the entire waveform.

The second group of digital tests are the Delta tests which let you measure part of a waveform. These tests measure the peak-to-peak amplitude, time, or frequency of any part of the waveform shown on the CRT.

Both types of digital tests are unaffected by the vertical or horizontal verniers or position controls, allowing the CRT display to be any size you want without affecting the accuracy of the digital readout. All tests are automatically ranged or directly interfaced to the input attenuators for direct readings.

One final test allows the frequency of the signal applied to channel A to be compared to the frequency of the signal applied to channel B. The digital display shows the ratio of the two frequencies to troubleshoot divider or multiplier stages.

SC61 Specifications

Analog CRT Section

Vertical Amplifiers:

Frequency Response: ±3 dB, DC to 60 MHz, useable to 100 MHz. AC coupled: ±3 dB, 10 Hz to 60 MHz.

Risetime: 6 nanoseconds.

Deflection Factors: 12 calibrated ranges in 1-2-5 sequence calibrated to read direct with supplied 39G183 10X probes. Concentric vernier continuously variable between ranges with detent for calibrated position.

Sensitivity: 50 mV/div. to 200V/div. with supplied 10X probes, 5 mV/div. to 20V/div. direct.

Calibration Accuracy: ±4% from 20° to 30°C (68° to 86°F) for channel A and/or B; ±10% for A+B or B-A modes.

Input Impedance: 10 megohms shunted by 15 pF with 39G183 10X low-capacity probes, 1 megohm shunted by 50 pF direct.

Maximum Input Voltage: 3000 volts (DC + Peak AC) through 39G183 probes, 500 volts (DC + Peak AC) direct. Derated for frequencies above 650 KHz. Protected to 3000 volts (DC + Peak).

Input Coupling: AC, DC, and Ground.

Timing: 70 nS delay line for both channels to show trigger point.

Invert: Available on channel A by pulling vertical position knob.

Display Modes: Channel A, inverted channel A (-A), channel B, dual trace (A&B), algebraic sum (A+B) or difference (B-A), and vector (X-Y).

Dual Trace: Automatically switches between dual-alternate and dual-chopped (approximately 500 KHz chopping frequency) depending on sweep rate when "A&B" button pressed. Forced to dual-alternate for all sweep rates if all CRT display buttons are released to out position.

Vector: Channel A is Y axis, channel B is X axis. Bandwidth: ±3 dB from DC to 4 MHz. Phase shift: ±3° from 10 Hz to 4 MHz.

Sensitivity: Same as vertical amplifiers.

Z-Axis Input: BNC input on rear panel. DC coupled: +5 volts blanks trace. Frequency range: DC to 5 MHz. Protection: 35 volts DC + Peak AC.

Horizontal Sweep:

Timebase: 19 calibrated sweep rates in 1-2-5 sequence. Concentric vernier continuously variable between steps with detent for calibrated position.

Sweep Rates: 100 milliseconds/division to .1 microsecond/division.

Accuracy: ±4% from 20° to 30°C (68° to 86°F).

Video Presets: Activated in 20th switch position. Pushbutton selection of 2 horizontal lines or 2 vertical fields of standard NTSC composite video signal.

10X Expand: Expands horizontal sweep 10 times. Activated by pulling horizontal position control. Accuracy: ±5% except ±8% on .1, .2, and .5 microsecond/division sweep rates.

Trigger Circuits:

Trigger Source: Channel A, channel B, AC power line, or an external source.

Trigger Modes: Norm (only provides trace when trigger circuits have signal), Auto (provides trace at all times), TV (same as "Auto" with sync separators added to use vertical or horizontal sync pulses as trigger reference. TV mode automatically selected by video preset function, no matter where MODE switch set).

Trigger Polarity: Selectable between + and − waveform transition for non-video signals. Selects positive or negative going sync on video signals.

Internal Sensitivity: Normal or Auto mode: AC coupled; .5 divisions of CRT deflection from 10 Hz to 20 MHz, increasing to 1.5 divisions at 60 MHz and 3 divisions (typical) at 100 MHz. TV: 1 division of signal needed. Vertical sync selected for all "msec" sweep rates, horizontal sync selected for all "usec" sweep rates.

External Sensitivity: 100 millivolts to 40 MHz, triggerable to 100 MHz. Maximum input: 500 volts (DC + Peak AC).

CRT:

Size: 96.4 x 120 mm. (approximately 5 inches) rectangular.

Type: Post deflection tube with P31 (blue-green) phosphor.

Model: 140CGB41. Accelerating voltage: 6 KV to match CRT requirements.

Graticule: Internally 8 x 10 division (approx. .9 cm/div.) etched on CRT faceplate to eliminate parallax. Special 0, 10, 90, and 100% markings for rise time measurements.

Beam Finder: Disables trigger and intensity controls, and reduces vertical and horizontal gain to locate beam.

Auto-Tracking™ Digital Tests

DC Volts:

Ranges: 2, automatically selected; 0-20, 20-2000, direct reading with supplied low-capacity probes. Accuracy: ±.5%, ±2 digit including low-capacity probes. No more than .5% between channels.

Input Impedance: 15 megohms through supplied low-capacity probes, 1.5 megohms direct.

Resolution: 3½ digits (2000 counts).

Source: Selected with channel A or B pushbuttons.

Protection: 3000 volts (DC + Peak AC) with supplied low-capacity probes, 500 volts (DC + Peak AC) direct.

Peak-to-Peak Volts:

Ranges: 4, selected by channel A or B input attenuator (unaffected by vertical vernier) ; 0-8, 8-80, 80-800, 800-2000 volts peak-to-peak. Direct reading with supplied 39G183 10X low-capacity probes.

Resolution: 3 4/5 digits (8000 counts).

Accuracy: ±2%, ±5 counts including low-capacity probes. No more than 2% between channels. Calibrated at 1 KHz. Frequency Response: ±.5 dB from 30 Hz to 30 MHz, -3 dB at 60 MHz.

Method (patent pending): DC coupled, microcomputer controlled successive approximation for positive and negative peak, 26 approximations per reading, worst-case.

Source: Channel A or B selected by pushbutton.

Frequency:

Ranges: 7 automatically selected; 1.00 - 9.99 Hz, 10.00 - 99.99 Hz, 100.0 - 999.9 Hz, 1.0000 - 99.9999 KHz, 100.000 - 999.999 KHz, 1.00000 - 9.99999 MHz, 10.0000 - 99.9999 MHz.

Resolution: Up to 6 digits (microcomputer controlled), .01 Hz to 10 KHz depending on input frequency (see "Ranges" above for details). Automatic resolution multiplier used for 1 Hz - 100 KHz to reduce gate time.

Accuracy: ±.001%, ±1 digit from 15° to 35°C (59° to 95°F). Aging less than .001% per year.

Source: Selected with channel A or B pushbutton. Microcomputer automatically selects trigger circuit output or auxiliary counter amplifier depending on trigger source selected.

Sensitivity: Same as internal trigger circuits if reading frequency of channel used as trigger source, 1.5 division of CRT deflection if reading channel other than trigger source.

Read Rate: Automatically selected; <2 second for frequencies between 1 and 10 Hz, <.5 seconds for higher frequencies.

Frequency Ratio:

Method: Calculates ratio of frequencies applied to channel A and B.

Range: 1 to 999,999. A/B or B/A display annunciators indicate which input frequency is greater.

Sensitivity: Same as frequency function.

Accuracy: ±3 digits (percentage does not apply because accuracy of channel A cancels accuracy of channel B).

Response Time: 1 to 4 seconds depending on input frequencies.

Delta Digital Tests

Delta Bar:

Measurement Bar: Intensified area set to any portion of waveform with Delta Begin and Delta End controls; functions of controls automatically reverse if overlapped.

Range: 1 second to 50 nanoseconds.

Setability: ±20 nS typical.

Peak-to-Peak Volts:

Function: Amplitude of intensified area measured.

Range and Specifications: Same as Peak-to-Peak volts above.

Source: Selected with channel A or B pushbutton.

Delta Time:

Function: Actual time of intensified area measured.

Accuracy: Same as frequency function above. Accuracy unaffected by setting of horizontal or vertical controls.

Ranging: Microcomputer automatically places decimal and annunciator reading of mS or uS.

1/Delta Time:

Function: Calculates equivalent frequency of Delta Time reading.

Accuracy: Same as Delta Time.

Ranging: Microcomputer automatically places decimal and annunciator reading of Hz, KHz, or MHz.

Digital Display:

Type: Liquid crystal with high temperature fluid for fast response time and high contrast.

Number of Digits: Six (resolution controlled by microcomputer).

Annunciators: 12 (controlled by microcomputer) Δ, A, B, MHz, KHz, Hz, uS, mS, VDC, VPP, A/B, and B/A.

General

Warm Up Time: Unit completely operable as soon as CRT trace appears. For maximum accuracy of frequency measurements, unit should operate for at least 30 minutes at room temperature.

Construction: Vinyl-clad aluminum case, fully EMI shielded, with Cycolac* bezel

Storage Compartment: Located in rear for storage of probes and other small accessories.

Size: 9.5" x 12" x 17" HWD (21.6 x 30.5 x 43.2 cm.)

Weight: 31 lbs. (14.1 Kg.)

Power: 105 - 130 VAC 50/60 Hz as delivered from factory. Field convertible to 210 to 250 VAC 50/60 Hz operation.

Power Consumption: 90 watts maximum.

* Cycolac is a registered trademark of Borg-Warner.

Accessories

Supplied:

2 ea: 39G183 low-capacity probes with isolated DC volts connector.

1 ea: 39G157 DC voltage probe with multiplier resistor.

1 ea: 66K28 color TV vector graticule overlay.

1 ea: 48" ground lead.

1 ea: Instruction/Operation Manual.

1 ea: Schematic/Parts List

Optional:

- DP226: 1:1 Direct Probe for measuring signals in the 5 to 50 mV range.
- PC227: Protective Cover to protect front-panel in portable applications.
- 39G81: 250 MHz Demodulator Probe to show the modulation envelope of AM signals.
- PR47: 600 MHz UHF Frequency Prescaler for measuring frequencies over 100 MHz.
- PL207: RF Pickup Loop for inductive pickup of signals in high impedance or high voltage circuits.
- HP200: 50 KV High Voltage Probe to extend the DC input range to 50,000 volts.
- TP212: 10 KV Transient Protector Probe to extend the DC input range to 10,000 volts or to increase the DC input impedance to 150 megohms for lower circuit loading.

"Numerous Patents Pending"

"Specifications subject to change without notice."

Controls

Fold out for descriptions

Fold Back

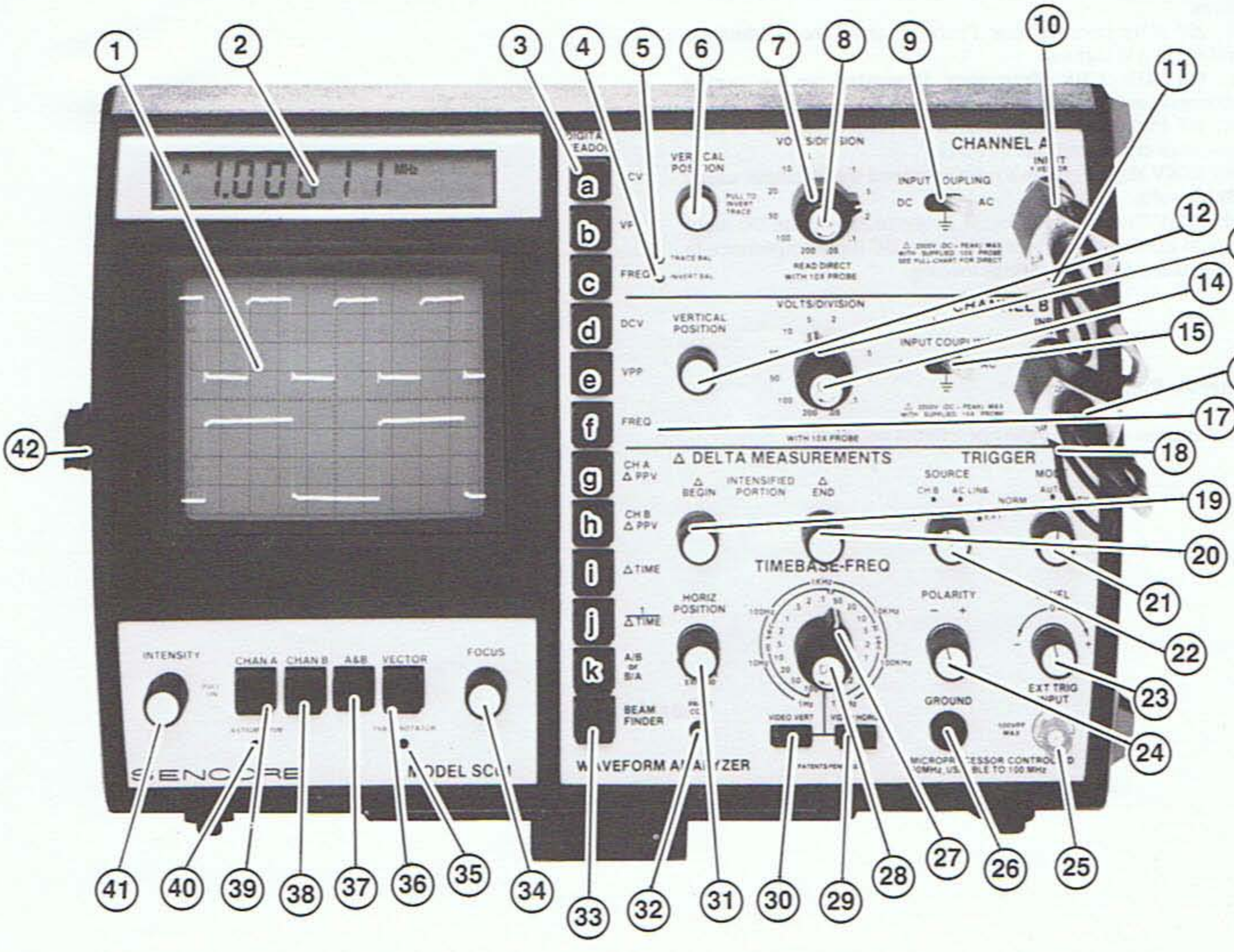


Fig. 1A — Front panel controls and features.

Controls

1. **CRT DISPLAY.**

2. **DIGITAL READOUT** — Provides direct readings of any function selected with the DIGITAL READOUT selector buttons (3a - k). The internal microcomputer selects the correct number of digits, places the decimal, and turns on the annunciators to indicate the channel, function, and range.

3 **(a-k) DIGITAL READOUT selector buttons.**

3a. **DCV** — Measures the DC voltage applied to the CHANNEL A DCV IN jack (11) and displays it on the DIGITAL READOUT (2).

3b. **VPP** — Measures the peak-to-peak voltage applied to the CHANNEL A INPUT jack (10) and displays it on the DIGITAL READOUT (2).

3c. **FREQ** — Measures the frequency of the signal applied to CHANNEL A INPUT jack (10) and displays it on the DIGITAL READOUT (2).

3d. **DCV** — Measures the DC voltage applied to the CHANNEL B DCV IN jack (18) and displays it on the DIGITAL READOUT (2).

3e. **VPP** — Measures the peak-to-peak voltage applied to the CHANNEL B INPUT jack (16) and displays it on the DIGITAL READOUT (2).

3f. FREQ — Measures the frequency of the signal applied to the CHANNEL B INPUT jack (16) and displays it on the DIGITAL READOUT (2).

The following four buttons measure only that part of the waveform intensified by the Delta Measurement Bar. The position of the Delta Bar is controlled with the ΔBEGIN control (19) and ΔEND control (20).

3g. CH A ΔPPV — Measures the peak-to-peak voltage of the part of the channel A trace intensified by the Delta Bar and displays the value on the DIGITAL READOUT (2).

3h. CH B ΔPPV — Measures the peak-to-peak voltage of the part of the channel B trace intensified by the Delta Bar and displays the value on the DIGITAL READOUT (2).

3i. ΔTIME — Measures the time duration of the Delta Bar and displays the results on the DIGITAL READOUT (2).

NOTE: Only one button is needed for both channels because the Delta Bar is positioned identically in both channels. The channel A or B DIGITAL READOUT annunciators are not activated.

3j. 1/Δ TIME — Measures the time duration of the Delta Bar and inverts it to show the approximate frequency of the Delta Bar on the DIGITAL READOUT (2). When the Delta Bar is set to intensify one cycle of a signal, the frequency reading will be approximately equal to the frequency of the signal.

3k. A/B or B/A — Compares the frequencies of channel A and channel B and displays the ratio on the DIGITAL READOUT (2).

Channel A Input Controls

4. INVERT BAL — Compensation control allows calibration of the inverting amplifier to assure that DC reference levels are the same for an inverted or non-inverted display.

5. TRACE BAL — Compensation control allows calibration of input circuits to assure that DC reference levels are the same from one setting of the VOLTS/DIVISION switch (7) to another.

6. VERTICAL POSITION/INVERT — Determines vertical position of Channel A trace. Pull knob to invert polarity of Channel A trace.

7. VOLTS/DIVISION — Allows direct CRT reading of peak-to-peak signal levels when Channel A vernier is rotated fully clockwise. Calibration is for 10:1 low-capacity probe. Divide readings by 10 if direct probe is used. Provides correct range for channel A digital peak-to-peak readings.

8. VERTICAL VERNIER — Allows gain of Channel A vertical amplifier to be varied for special tests. Must be turned fully clockwise for calibrated CRT measurements. *Does not affect digital tests.*

9. INPUT COUPLING SWITCH — Selects DC or AC input coupling or ground reference.

10. CHANNEL A INPUT jack — Supplies signals for all channel A tests, except DCV.

11. CHANNEL A DC VOLTS input jack routes DC signals around INPUT COUPLING SWITCH (9) to allow DC measurements when CRT is AC coupled.

Channel B Input Controls

12. VERTICAL POSITION — Determines vertical position of Channel B trace. *Channel B does not have an invert function.*

13. VOLTS/DIVISION — Allows direct CRT reading of peak-to-peak signal levels when Chan B vernier (14) is rotated fully clockwise. Calibration is for 10:1 low-capacity probe. Divide readings by 10 if direct probe is used. Provides correct range for channel B digital peak-to-peak readings.

14. VERTICAL VERNIER — Allows gain of Channel B vertical amplifier to be varied for special tests. Must be turned fully clockwise for calibrated CRT measurements. *Does not affect digital tests.*

15. INPUT COUPLING SWITCH — Selects DC or AC input coupling or ground reference.

16. CHANNEL B INPUT jack supplies signals for all channel B tests, except DCV.

17. TRACE BAL — Compensation control allows calibration of input circuits to assure that DC reference levels are the same from one setting of the VOLTS/DIVISION (13) to another.

18. CHANNEL B DC VOLTS input jack routes DC signals around INPUT COUPLING SWITCH (15) to allow DC measurements when CRT is AC coupled.

19, 20. ΔBEGIN and ΔEND — Positions the intensified Delta Measurement Bar anywhere on the waveform. The microcomputer automatically exchanges the function of the two controls if the end of the Delta Bar is positioned before the beginning to allow measurements with the bar in either direction. The intensified area is the only part of the waveform measured when any of the four Delta functions are selected with buttons 3g-j.

Horizontal and Triggering Controls

21. TRIGGER MODE: Selects three different triggering options:

NORM — Only shows a trace when the triggering circuits are fully locked to the incoming signal selected by the TRIGGER SOURCE switch (22).

AUTO — Shows a trace whether the triggering circuits are locked or not.

TV — Switches in special sync-separators to trigger on the sync pulses of a composite video signal. Automatically switched between vertical sync for sweep speeds in the msec range of the TIMEBASE-FREQ switch (27) or horizontal sync when in the usec range. NOTE: MODE switch does not need to be in the TV position if the VIDEO PRESET buttons (29 or 30) are used.

22. TRIGGER SOURCE — Selects signal to be used to trigger sweep circuits.

CH A — Selects signal from Channel A vertical amplifier.

CH B — Selects signal from Channel B vertical amplifier.

AC LINE — Locks triggering circuit to 60 Hertz AC line.

EXT — Selects signal applied to EXT TRIGGER jack (25).

23. **TRIGGER LEVEL** — Determines amplitude of input signal selected by TRIGGER SOURCE switch (22) that will cause trigger circuits to operate. Scope will trigger at center of symmetrical waveform when set to zero position. The "+" and "−" areas indicate amplitude change only, not triggering polarity.

24. **TRIGGER POLARITY** — Determines whether trace will start on positive (+) or negative (−) transition of incoming signal when TRIGGER MODE switch (21) is in NORM or AUTO mode. When TRIGGER MODE switch (21) is in TV position, or VIDEO PRESET BUTTONS (29 or 30) are used, polarity refers to polarity of sync pulses; "+" for positive going sync and "−" for negative going sync.

25. **EXTERNAL TRIGGER Input** — Allows external triggering signal to be injected when TRIGGER SOURCE switch (22) is in EXT position.

26. **GROUND Jack.**

27. **TIMEBASE-FREQ** — Determines horizontal sweep rate. Used for determining frequency or time of displayed waveform on CRT when HORIZONTAL VERNIER (28) is rotated fully clockwise. Does not effect digital frequency measurements.

28. **HORIZONTAL VERNIER** — Allows sweep speed to be varied for special tests. Must be turned fully clockwise for calibrated time or frequency measurements on CRT. *Does not affect accuracy of digital tests.*

29. **VIDEO HORIZ** — Displays two or more horizontal lines of composite video information, depending on setting of HORIZONTAL VERNIER (28) when TIMEBASE-FREQ switch (27) is set to "Video Preset" position. Also automatically selects video sync separators regardless of setting of TRIGGER MODE switch (21).

30. **VIDEO VERT** — Displays two more more vertical fields of composite video information, depending on setting of HORIZONTAL VERNIER (28) when TIMEBASE-FREQ switch (27) is set to "Video Preset" position. Also automatically selects video sync separators regardless of setting of TRIGGER MODE switch (21).

31. **HORIZ POS./10X EXPAND** — Determines horizontal position of trace. Pull knob to expand trace horizontally by a factor of 10.

32. **PROBE COMP** — Provides a square wave signal for adjustment of the low capacity scope probes to match the input amplifiers.

33. **BEAM FINDER** — Press to locate position of traces. When this button is pressed, the vertical and horizontal gain is reduced to display the relative position of both channel A and B traces. This button also bypasses the INTENSITY control (41) and the triggering circuits to aid in locating trace.

Display Pushbuttons and Controls

34. **FOCUS** — Electrically focuses electron beam for clear trace.

35. **TRACE ROTATOR** — Allows trace to be electrically rotated to compensate for different magnetic field conditions.

36. **VECTOR** — Selects "X-Y" operation with channel A input providing vertical deflection and channel B input providing horizontal deflection.

37. **A & B** — Selects dual trace operation using both channel A and channel B vertical input circuits. Dual trace display mode is automatically determined by setting of TIMEBASE-FREQ switch (27) with dual chopped operation between 100 and .1 msec, and dual alternate between 50 and .1 usec. Dual alternate may be manually selected for slower sweep rates for special applications by releasing all DISPLAY PUSHBUTTONS (36 through 39) to the "out" position.

38. **CHAN B** — Selects single trace operation using channel B input circuit only, or allows channel A and channel B to be added when pressed simultaneously with CHAN A selector button (39).

39. **CHAN A** — Selects single trace operation using channel A input circuits only, or allows channel A and channel B to be added when pressed simultaneously with CHAN B selector button (38).

40. **ASTIGMATISM** — Establishes focusing range to assure that FOCUS control (34) operates properly at different settings of INTENSITY control (41).

41. **INTENSITY/PULL ON** — Determines brightness of trace. Pull knob to apply AC power to unit.

42. **COVER LATCH** — Latches the optional scope cover, PC227, to the case of the SC61.

Rear Panel Features

43. CORD WRAPPERS — Holds AC line cord.

44. STORAGE COMPARTMENT — Holds probes and small accessories.

45. Z AXIS INPUT JACK — Signal applied to modulate intensity of CRT trace; +5 volts blanks trace.

46. ACCESSORY JACK — Supplies 12-15 VDC at 100 mA to power accessories such as the PR47 600 MHz Prescaler.

47. HIGH VOLTAGE FUSE — Protects low voltage supply in case troubles develop in high voltage supply. **Replace only with ¼ amp, slo-blo, type 3AG fuse.**

48. AC LINE FUSE — Protects against possible fire hazard in case of internal troubles. **Replace only with 1 amp, slo-blo, type 3AG fuse.**

49. AC POWER CORD.

Supplied Accessories

50. VECTOR GRATICULE — Marked with phase angles for analyzing color outputs of TV receiver.

51. GROUND LEAD.

52. 39G183 LOW CAPACITY PROBES — 2 supplied for direct readings on CRT or digital readout. Includes special isolated DC lead to connect to DCV IN jacks (11 and 18) to bypass INPUT COUPLING switches (9 and 15).

53. 39G157 DCV PROBE — Allows DC voltages to be measured when 39G183 probes (51) not used.

Optional Accessories

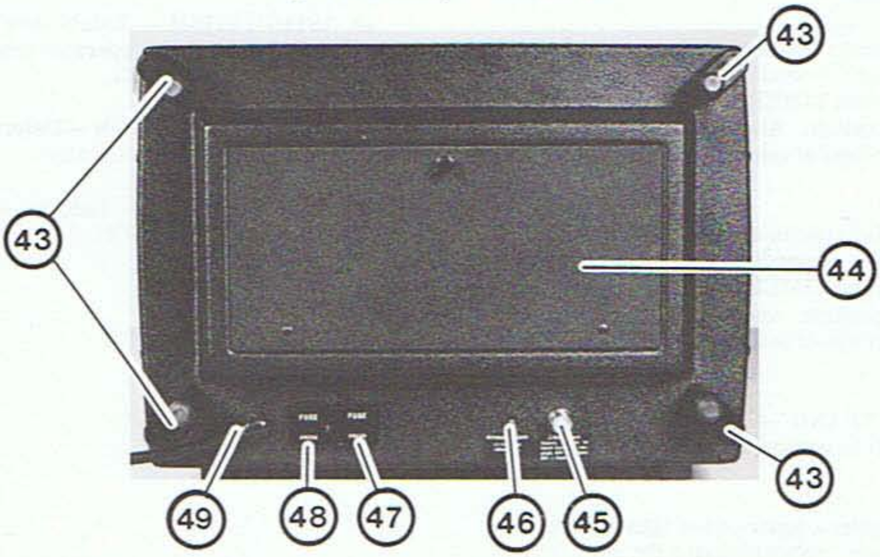
54. PC227 Protective Cover — Protects front panel for portable applications.

55. PL207 RF PICKUP LOOP — Used for inductive pickup of signals in high impedance or high voltage circuits when peak-to-peak voltage is not important. Shows waveshape, frequency, and time relationships.

56. DP226 1:1 DIRECT PROBE — Provides direct input for measuring signals in the 5 to 50 millivolt range to 15 MHz.

57. 39G81A 250 MHz DEMODULATOR PROBE — Shows AM modulation envelope for general troubleshooting of AM systems to 250 MHz.

Fig. 1B — Rear panel features.



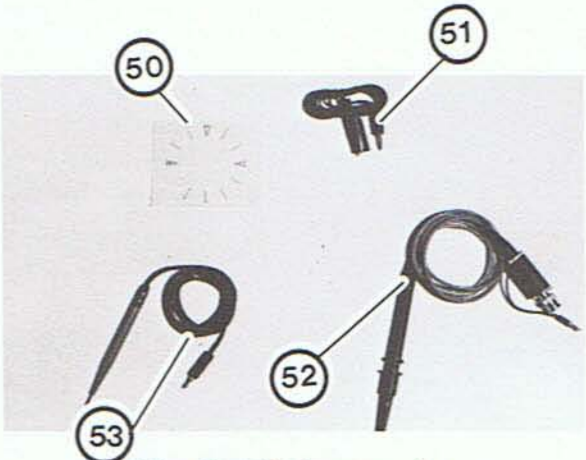


Fig. 1C — Supplied accessories.

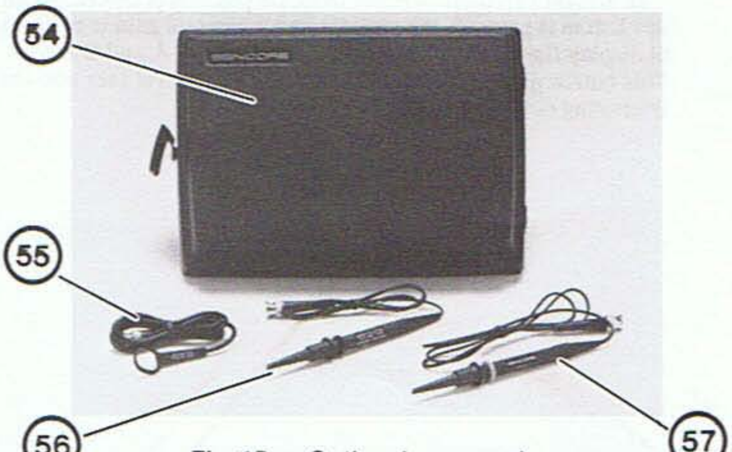


Fig. 1D — Optional accessories.

Notes

OPERATION

Introduction

The operating instructions are broken into three sections; the CRT display, the Auto-Tracking™ digital functions, and the Delta measurements. Operation of the CRT display is identical to that of a standard analog oscilloscope. The vertical and horizontal controls are calibrated to allow analog measurements of signals when desired. Most measurements, however, are made with the digital readout. These special digital functions give results that are faster, more accurate, and subject to less operator error than conventional analog oscilloscope measurements.

AC Power Connection

WARNING

The SC61 must be used with a properly grounded 3-wire AC system for safe operation and minimum pickup of external interference. Always use an isolation transformer on any piece of equipment (such as a TV receiver or radio) 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.

The SC61 is wired for use on a 105-130 VAC, 50 or 60 Hz AC line when shipped from the factory. The SC61 may be converted for 210-250 VAC operation by changing the wiring of the primary of the power supply transformer. Details on converting the operating voltage are found in the Maintenance section of this manual.

It is important that the SC61 be connected to a properly grounded AC outlet. The ground connection insures safe operation in the event of a circuit failure inside the SC61, or if the ground of the SC61 is connected to a test point that has a potentially dangerous voltage. In either case, the ground connection insures that the metal parts of the SC61 do not become a source of a shock hazard.

Extra care must be taken when working on a device, such as a TV receiver or radio, that does not have an internal isolation transformer. Such devices must be connected to an isolation transformer, such as the Sencore PR57 AC POWERITE® . **The isolation transformer must be connected to the device being tested, not the SC61.** The isolation transformer breaks the circuit path formed by the 3-wire ground system to allow the "hot chassis" to float in reference to earth ground.

The ground connection on the SC61 also provides a return path for interference when the unit is used in electrically noisy environments. This is especially important when the SC61 is used close to a high power RF transmitter.

Setting up the waveform, a simplified approach

The fastest way to learn the SC61 is to use the same procedure to set up every waveform. The front panel has all controls grouped by function to allow you to move clockwise around the panel as you apply the signals, adjust the trigger circuits, and then adjust the horizontal sweep circuits. Always start from the same point when you apply a new signal or experience difficulty in locking the waveform.

Use the following procedures as a "checklist" to follow as you learn to use the SC61. Each of these simplified procedures is covered in detail in other sections of this manual. Be sure to read all the following sections to fully understand the effects each control has on the waveform. Then, use these simplified instructions (or the ones in the *Simplified SC61 Operating Instructions* located in the pocket on the bottom of the SC61) as a reminder of the steps needed to obtain a trace.

To set up any waveform:

1. Pull INTENSITY control outward to apply power to the SC61.

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

3. Apply the signal(s) to the vertical input(s).

a. Make sure the INPUT COUPLING switch is **not** set to the "ground" position. It should be in the "AC" position for most measurements.

b. Set the VOLTS/DIVISION switch to a position that is one-half to one-eighth the amplitude of the input signal. *NOTE: Remember the VOLTS/DIVISION switches are calibrated to read directly when using the supplied low capacity probes; it is not necessary to multiply times ten.*

4. Adjust the four TRIGGER controls to lock the signal:

a. Set the TRIGGER SOURCE switch to the signal you want to use as your reference; "CH A" will trigger on a sample of the signal applied to the Channel A input, "CH B" will trigger on a sample of the Channel B input, "AC LINE" will trigger on a sample of the AC Line, "EXT" will trigger on the signal applied to the EXT TRIG INPUT jack.

b. Set the TRIGGER MODE switch to the desired position; "Auto" will be used for most signals, "TV" is used for composite video signals, or "Norm" is used for special triggering conditions.

c. Set the TRIGGER POLARITY switch for the desired starting point. The polarity is often unimportant. When using the "TV" position of the TRIGGER MODE switch, however, the TRIGGER POLARITY switch must be set to the polarity of **the sync pulses.**

d. Adjust the TRIGGER LEVEL control until the trace is properly locked on the CRT.

5. Adjust the TIMEBASE-FREQ switch for the desired number of waveforms across the CRT. Remember to use the frequency markings on the outside ring as a guide when the frequency of the signal is known. Use the position with a marked frequency that is **lower** than the frequency of the applied signal.

6. Adjust the VERTICAL POSITION, HORIZ POSITION, FOCUS, and INTENSITY controls as desired for the best waveform.

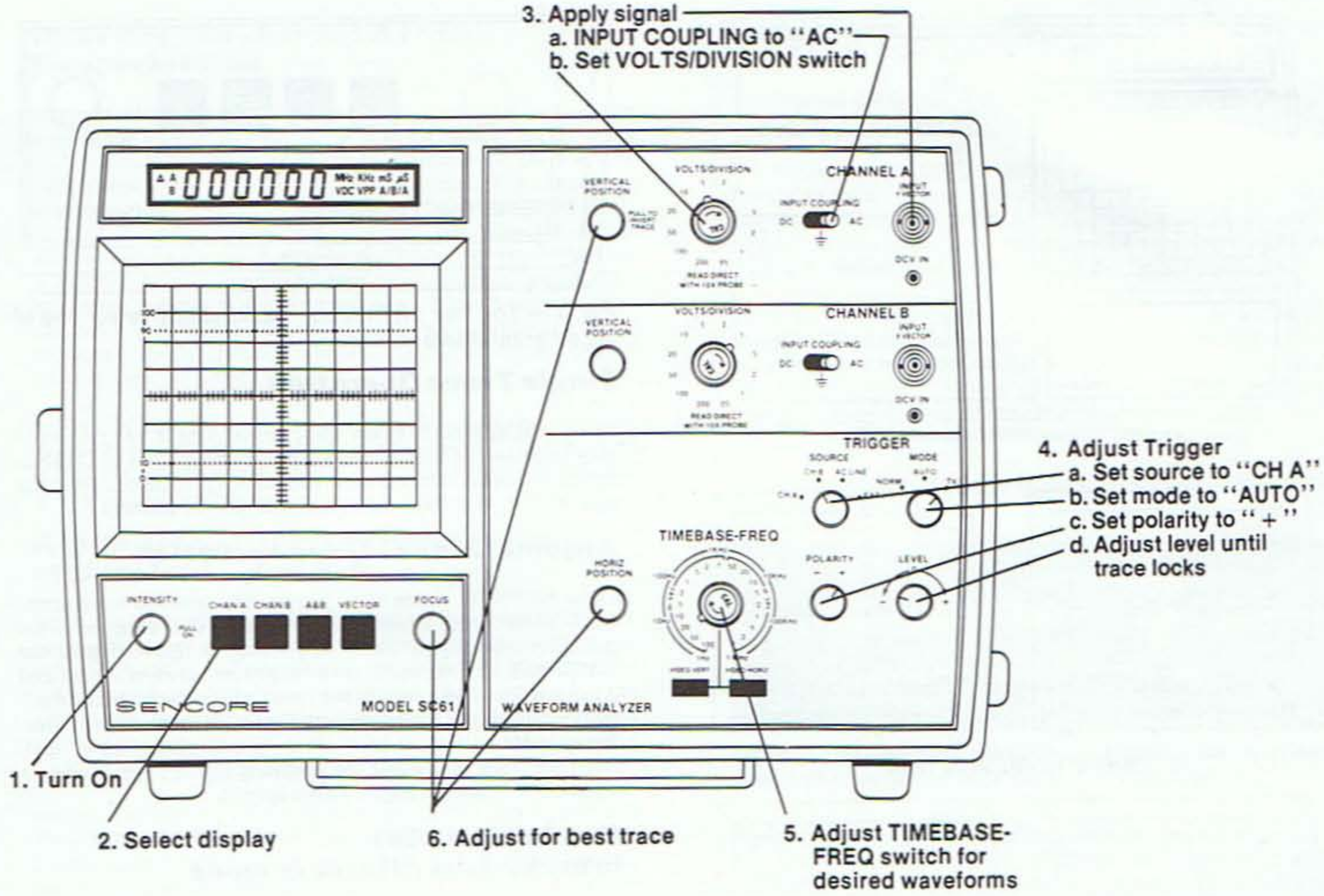


Fig. 2 — Follow this sequence to get a trace on the SC61. Note that the trigger controls are marked for a channel A signal.

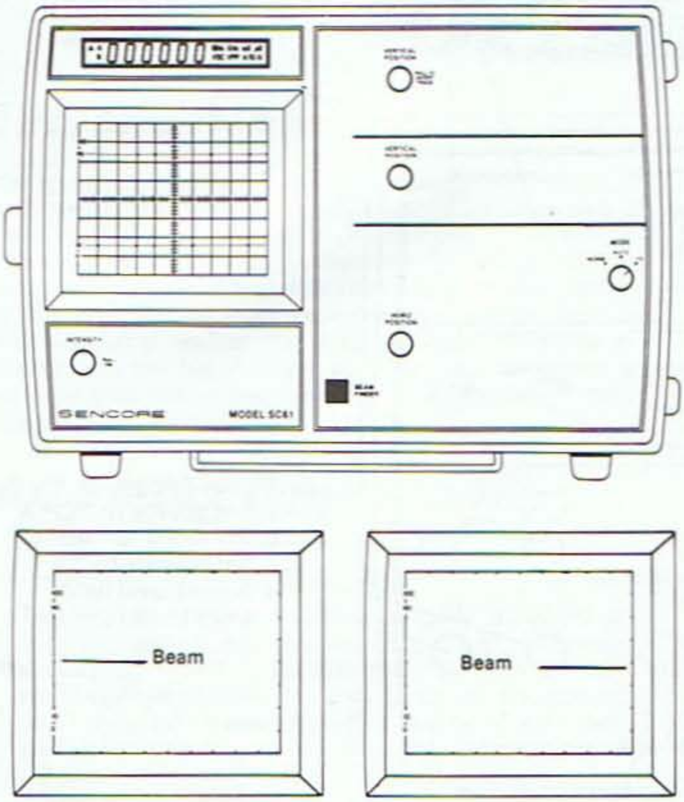
Locating the trace with the BEAM FINDER

You may occasionally lose the trace because one or more of the CRT controls is improperly set. Pressing the BEAM FINDER button overrides several internal circuits to force the trace back onto the screen. The position of the traces with the BEAM FINDER button pressed indicates what steps are necessary to obtain a properly centered trace.

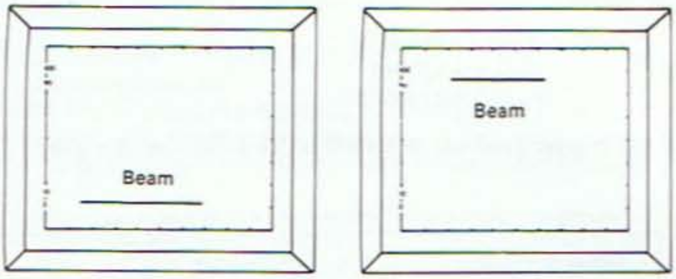
The BEAM FINDER overrides four circuits when the button is pressed: 1. The INTENSITY control is bypassed to show the trace position when the intensity is reduced, 2. The trigger circuits are disabled to produce a trace if "normal" triggering is selected with the TRIGGER MODE switch, 3. The gain of the 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 to force the trace onto the CRT horizontally. These four conditions will force the trace onto the screen for any combination of control settings.

The following table shows how to interpret the CRT trace when using the BEAM FINDER. Remember that one or two traces will appear, depending on which CRT display mode is selected with the CRT selector pushbuttons. You may wish to locate one trace at a time by selecting the CHAN A and then CHAN B button.

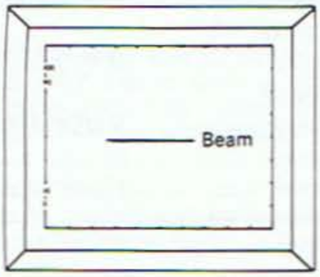
What Appears on Screen (with BEAM FINDER pressed)	Control(s) to Check (after releasing BEAM FINDER)
Beam at center of screen	Intensity/Trigger Mode
Beam above or below center	Vertical Position
Beam at left or right of center	Horizontal Position



Adjust HORIZ POSITION



Adjust VERTICAL POSITION



Adjust INTENSITY or TRIGGER MODE

Fig. 3 — The BEAM FINDER forces the trace onto the CRT for any control setup.

Selecting the proper CRT display pushbutton

The SC61 has six different CRT display modes selected by the four CRT display pushbuttons located immediately below the CRT. The display options break into single-trace, dual-trace, or vector (X-Y) modes. The following paragraphs describe the six different options available.

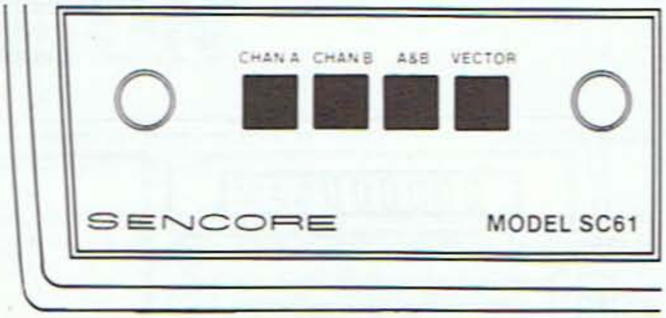


Fig. 4 — The four CRT display pushbuttons select one of six different display modes.

Single Trace Operation

The signal applied to either the channel A or B vertical input may be displayed independently. Press the CHAN A or CHAN B button to display either trace. A signal may be connected to the second channel without affecting the displayed channel.

Automatic dual-trace operation

Press the "A&B" button when you want to view two waveforms. The SC61 automatically selects between the dual-chopped or the dual-alternate display mode, depending on the setting of the TIMEBASE-FREQ switch. All sweep rates between 100 mS and .1 mS (enclosed with the "m sec" bar) will be shown in the dual-chopped display mode to prevent flicker on lower sweep rates. Sweep rates in the "u sec" range are displayed as a dual-alternate trace to prevent the chopping signal from causing a segmented display on higher sweep speeds.

Forcing the SC61 into the dual-alternate mode

There may be times when the chopping oscillator causes interference in the trace when the "A&B" mode is used on sweep rates in the "m sec" range of the TIMEBASE-FREQ switch. This interference is common on all dual-trace scopes and is caused by the 500 KHz signal that quickly moves the CRT beam between the channel A and B signal. The interference only becomes noticeable when the chopping frequency is an exact multiple of the input frequency. Fig. 5 shows an example of chopping interference.

The SC61 may be forced into the dual-alternate display mode by releasing all four display pushbuttons to their "out" positions. Simply press lightly on any of the buttons that is not depressed until the switch mechanism releases all of the buttons. The SC61 may be returned to its automatic dual-trace mode at any time by depressing the "A&B" pushbutton.

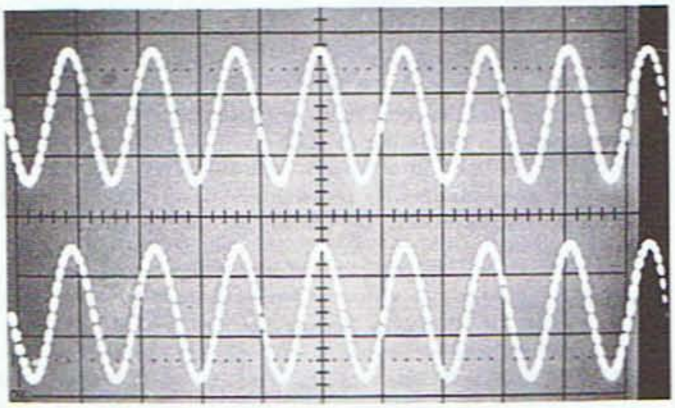


Fig. 5 — Releasing all four CRT display buttons forces the SC61 into the dual-alternate mode and eliminates this type of interference.

Inverting the channel A trace for special tests

Some waveforms are easier to interpret if inverted. One example is using the dual-trace mode of the SC61 for comparing the input and output of an inverting stage to determine if the stage is adding distortion or phase shift to the signal. The channel A trace may be inverted by pulling the channel A VERTICAL POSITION control to the "out" position. **The inversion circuit affects only the displayed waveform.** This is important when the A channel signal is used to trigger the horizontal circuits. The triggering polarity of the inverted signal will not change when channel A is inverted, allowing the triggering circuits to be set one time while the channel A trace is alternately displayed as an inverted or non-inverted signal.

NOTE: Be sure the inversion switch is set to the non-inverting mode when making standard measurements. Confusion in waveform interpretation may result if the channel A trace is unintentionally inverted.

Algebraic addition or subtraction of signals (A+B or B-A)

Some applications require two signals to be added to form a composite signal or subtracted to display the difference of two signals. The SC61 will add the two signals (A+B) when both the CHAN A and CHAN B display pushbuttons are depressed at the same time. Subtraction occurs when both buttons are pressed and the channel A signal is inverted by pulling the channel A VERTICAL POSITION control.

Remember that the phase relationships of the two signals will determine whether the two signals actually increase when added or cancel when subtracted. If both signals are of the same phase, for example, adding the signals will cause the size of the displayed waveform to increase. Subtracting two signals of the same phase will cause a decrease in the size of the display waveform or total cancellation. But, if the two signals are 180° out of phase, the opposite will occur. Adding out-of-phase signals results in cancellation, and subtracting causes an increase in waveform size. Any phase shift besides 0° and 180° will result in the instantaneous sum or difference of the signals to be displayed.

Locating amplifier distortion

The "A + B" and "B - A" display modes may be used to isolate audio amplifier stages that are causing distortion. The SC61 is connected to the input and output of a single stage and then set to cancel the output signal with the input signal. The resulting display is the distortion added by the tested stage. The audio signal source used should be a sine wave, but does not need to have extremely low distortion levels because any distortion in the test signal will be present at the output of the stage being tested, resulting in cancellation of the signal source distortion. It is possible to isolate distortion as small as .1% using this method because the gain of the SC61 channels may be increased beyond the level that would cause full-scale deflection, if channel A and B were displayed normally, while the residual distortion part of the signal will remain relatively small on the CRT display.

To display the distortion produced by a single stage:

1. Connect an audio oscillator to the amplifier input.

2. Connect the channel A probe to the input of the stage to be tested, and the channel B probe to the stage output.

3. Set the VOLTS/DIVISION switch for both channels to produce a full-scale signal.

4. Confirm that the phase of the channel B signal is *opposite* that of the channel A signal. If they are the same phase, pull the channel A VERTICAL POSITION control to invert channel A.

5. Depress the CHAN A and CHAN B display pushbuttons at the same time to produce an "A + B" display.

6. Adjust the VERNIER control of either channel until the trace is as small as possible vertically. This step balances the amplitude of the two traces for full cancellation of the input signal. The resulting signal, that cannot be eliminated with this step, is the distortion added by the channel being tested.

7. If the result of step 6 is a straight line, there is less than 2% distortion in the measured signal. The distortion resolution 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.

8. Repeat this test, stage-by-stage, until the stage causing the distortion is located.

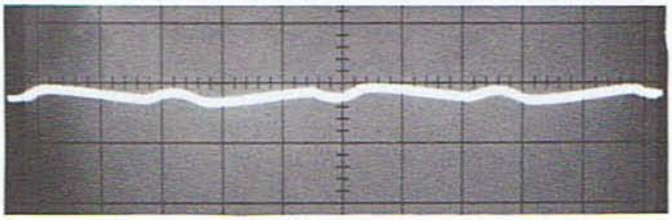


Fig. 6 — The distortion remains after nulling the input and output of an amplifier with the A + B function.

Reducing the level of undesirable signals

The A + B mode can be used to eliminate or reduce the level of some undesirable interference signals that may cause difficulties in viewing the signal containing the interference. For example, the 60 Hertz hum that may be present in a signal can be reduced so that just the signal is present on the CRT. A sample of the interfering signal is simply injected into the second SC61 input and the two signals are algebraically subtracted until the interfering signal is fully cancelled.

To reduce the undesirable signal level:

1. Connect the signal to be measured to the channel B input.

2. Connect a source of the undesirable signal to the channel A input, for example, the secondary of the AC power transformer for 60 Hertz hum.

3. Depress the A & B display pushbutton and set the TIME-BASE-FREQ switch and TRIGGER controls to lock in two or three cycles of the signal to be viewed.

4. Set the VOLTS/DIVISION switches for both channels so that the undesirable signal in channel A is about the same amplitude as the undesirable signal in channel B.

5. Depress both CHAN A and CHAN B display pushbuttons at the same time to obtain the A + B mode. If the amount of interference doubles, reverse the phase of the interfering signal by pulling the INVERT switch in the channel A VERTICAL POSITION control.

6. Use the channel A vernier control to reduce the undesirable signal to its lowest level.

NOTE: The channel A VOLTS/DIVISION vernier control must be changed if the channel B signal is changed or there is a change in the amount of interfering signal.

Using the A + B mode to determine the timing of two signals

The "A + B" display mode may be often used to simplify the comparison of the timing of two signals. Common applications include the time difference between two pulses or square waves or the comparison of a triggering pulse compared to an analog signal, such as a ramp. Combining the two traces into one trace eliminates the need of resetting the VERTICAL position controls if the amplitude of either of the two traces changes. Either the channel A or B VERTICAL POSITION control may be used to place the desired part of the waveform on the calibrated center graticule line, saving additional measurement time.

To determine the time relationship of two signals:

1. Connect the two signals to the channel A and B inputs, using channel A as a reference.

2. Set the TIMEBASE-FREQ switch and TRIGGER controls to view two or three locked-in cycles of the reference signal.

3. Depress the "A & B" display pushbutton and adjust the VOLTS/DIVISION switches until both signals are about the same amplitude on the CRT screen and occupy less than four vertical divisions.

4. Depress both the CHAN A and CHAN B display pushbuttons at the same time to obtain the "A + B" mode. The two signals are now algebraically added on the CRT.

5. Use analog procedures or the Delta Time digital function to determine the time delay between the two signals.

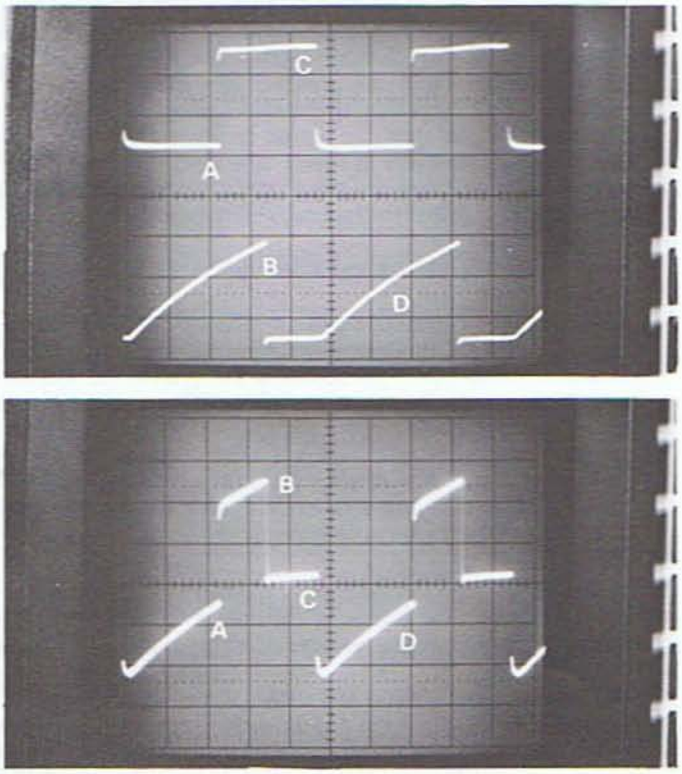


Fig. 7 — The two waveforms in the top photo are added with the A + B function to compare the timing in the bottom photo.

Vector (X-Y) operation

The SC61 may be used as a vector (sometimes called "X-Y") scope by pressing the VECTOR display button. The signal applied to channel A causes vertical (Y) deflection, and the signal applied to channel B causes horizontal (X) deflection. The resulting Lissajous (liss-a-jew) pattern compares the phase and frequency relationships of the two signals. The special design of the SC61 provides accurate phase comparisons to 4 MHz with less than 3° of phase shift between channels.

The vertical gain is controlled by the channel A VOLTS/DIVISION switch. The channel A VERTICAL POSITION control adjusts the pattern's vertical position. The channel B VOLTS/DIVISION switch controls the amount of horizontal gain. The horizontal position is adjusted by the HORIZ POSITION control (the channel B VERTICAL POSITION control has no effect on the trace when the vector function is selected).

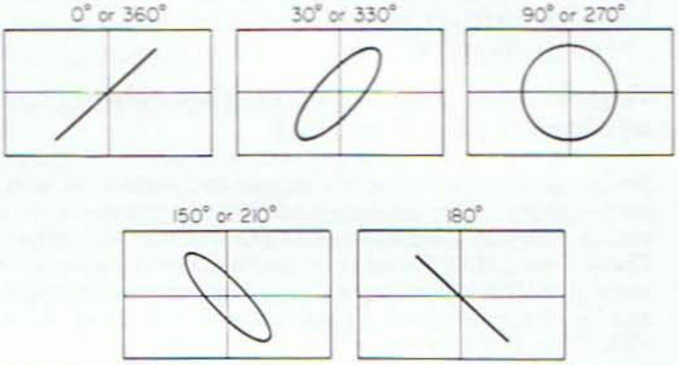


Fig. 8 — Phase relations are represented in the vector mode with different shapes and orientations.

Fig. 8 shows typical phase relationships as shown in the vector mode. The following procedure may be used to calculate phase angle. A simplified method of measuring phase is covered in the digital display instructions on page 40.

To measure the phase difference using the VECTOR mode:

1. Apply the signals to the two SC61 inputs.

2. Depress the VECTOR display pushbutton.

3. Set the channel B INPUT COUPLING switch to the "ground" position and the channel A INPUT COUPLING switch to the "AC" position.

4. Adjust the channel A VOLTS/DIVISION and VERNIER control for 4 divisions of display.

5. Set the channel A INPUT COUPLING switch to the "ground" and the channel B INPUT COUPLING switch to "AC".

6. Adjust the channel B VOLTS/DIVISION switch and VERNIER control for exactly 4 divisions of display along the horizontal axis.

7. Return the channel A INPUT COUPLING switch to the "AC" position.

8. Use the channel A VERTICAL POSITION control and the HORIZ POS. control to center the displayed pattern around the center of the graticule.

9. Measure the number of divisions between the points where the oval touches the vertical graticule line and divide this figure by "4" (the total number of divisions of the outside oval) as

shown. The result is the sine of the phase angle. Use a scientific calculator or trig table to determine the phase angle.

$$\text{Sine of the phase angle} = \frac{\text{Divisions inside of the oval}}{\text{Divisions outside of the oval}}$$

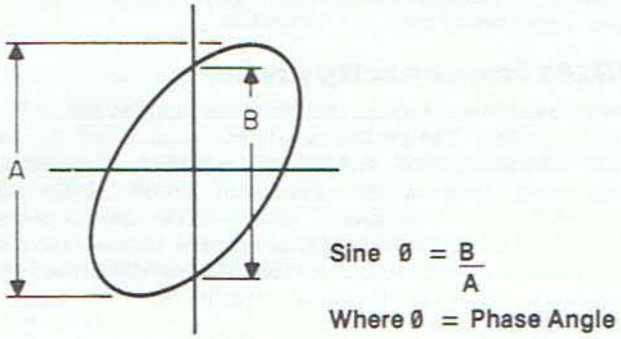


Fig. 9 — Calculation of phase angle using a Lissajous pattern (VECTOR).

Vector graticule

A special graticule overlay is included to use when analyzing color TV receiver circuits with the vector function. The graticule is made of a special plastic that will cling to the CRT face without the need of adhesive. Simply place the center circle of the special graticule over the center of the CRT with the lettering facing the correct direction; the "burst" marking on the left, the "R-Y" marking at the top, and the "B-Y" marking at the right. Rub your hand over the overlay to make it stick. Save the backing paper to store the graticule overlay when not in use.

When making vector tests in a TV receiver, the channel A probe should be connected to the R-Y output and the channel B probe to the B-Y output. Both vertical attenuators should be set for the same gain and the vernier controls to the "Cal" position for proper vector shaping.

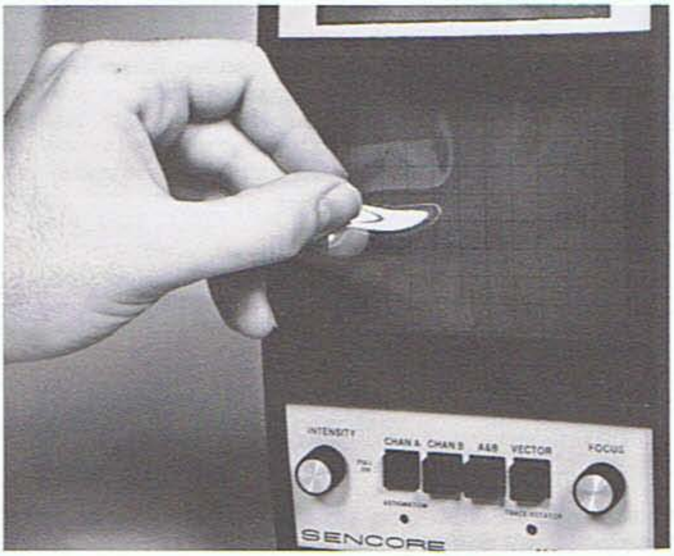
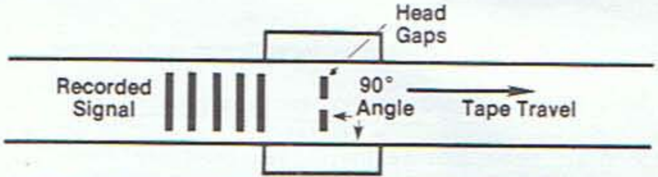


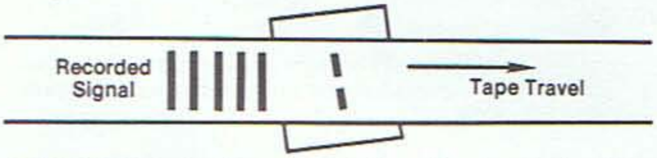
Fig. 10 — A special graticule is included for TV vector service. The graticule is placed over the front of the CRT and rubbed gently to make it stick in place.

Using the vector mode to align audio tape heads

The mechanical position of the "gap" of the record or playback head in a tape recorder has a great effect on both the frequency response and the output level of the head. The gap must be positioned exactly perpendicular to the edge of the tape (as shown in Fig. 11) for best results. The vector function of the SC61 provides a method of setting this adjustment much faster and much more accurately than any other method. The procedure requires a standard test alignment tape, available from many electronics parts distributors, or audio supply houses. You should have a tape for each type of tape deck you service: reel-to-reel, 8-track cartridge, or cassette.



a. The head gaps should be exactly perpendicular to the edge of the tape.



b. Azimuth error (greatly exaggerated) results when the head is not properly adjusted.

Fig. 11 — An improper azimuth setting causes the recorded signal to cross the left and right head-gap at a different time, causing a phase shift.

The alignment procedure involves setting the head for the highest amplitude output and the least amount of phase difference between the left and right channel. Decks with two heads (erase and record/playback) only require a playback setting. A separate record adjustment is not necessary because the same head-gap is used for both recording and playback. Decks with three heads (erase, record, and playback) require the playback head to be adjusted to the reference tape, and the record head is then adjusted to match the playback head.

To set the playback head on a three-head machine, or the record/playback head on a two-head machine:

1. Connect the left tape deck output to either SC61 input and the right tape deck output to the second input.

NOTE: Be sure to clean and demagnetize the heads of the machine before loading the alignment tape to prevent partial erasure of the reference signals.

2. Load the alignment tape on the machine and locate the azimuth adjustment tone.

3. Press the "A & B" display pushbutton on the SC61.

4. Play back the tone and adjust the SC61 vertical inputs to show about three divisions of deflection. Both vertical input switches should be set to the same range and the vertical verniers set to the "Cal" position.

5. Rough in the alignment by adjusting the tape head azimuth adjustment screw for the largest amplitude signal on the CRT.

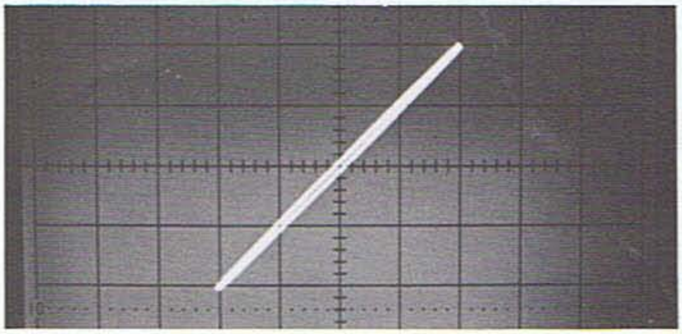


Fig. 12 — The azimuth setting is correct when the vector pattern shows a 0° phase shift.

6. Press the "VECTOR" display pushbutton.

7. 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 Fig. 12.

The playback head is now adjusted for optimum performance.

To adjust the record head on a three-head machine:

1. Perform the alignment of the playback head listed above.

2. Remove the alignment tape from the machine and load a blank tape.

3. Apply a 1 KHz sinewave to both the left and right inputs. Use a "Y" connector so the same signal is applied to both channels with no phase shift.

4. Adjust the recording level controls until both recording VU meters are showing 0 dB levels.

5. Place the machine in the "record" mode.

6. Set the "source/tape" switch to the "tape" position to monitor the recorded signal from the tape using the playback head.

7. Depress the "A & B" display pushbutton the SC61.

8. Adjust the record azimuth adjustment screw until the signal played back has the highest possible amplitude.

NOTE: There will be a delay of about ½ second 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 SC61 to stabilize before making additional adjustments.

9. Press the "VECTOR" display pushbutton on the SC61 and adjust the record head azimuth adjustment until the vector pattern is as close as possible to a straight line with zero phase shift (45° angle) as shown in Fig. 12.

The recording head is now properly set. The recording azimuth adjustment has been referenced to the standard alignment tape since the playback head was set to this standard before the recording head was adjusted.

Using the SC61 with sweep generators or curve tracers

The vector mode eliminates the need for a separate horizontal input jack for special tests. Most sweep generators and curve tracers, for example, require a horizontal input to reference the CRT display to the special tester. Connect the vertical output of the device to the channel A input, and horizontal output to the channel B input and press the VECTOR button. The channel B VOLTS/DIVISION switch provides complete control of the horizontal gain. Either AC or DC coupling may be used on both channels, as required for some tests.

NOTE: If a sweep generator uses intensity markers, connect the intensity output of the generator to the Z AXIS INPUT jack on the rear of the SC61. A positive-going marker signal causes a dark spot on the trace.

Applying signals to the vertical inputs

Signals may be supplied to the SC61 in several ways. Each method has certain advantages and disadvantages that should be considered before making a connection.

39G183 low-capacity probes

Most measurements require the use of the supplied 39G183 low-capacity probes. The probes isolate the capacity of the test leads, CRT input circuits, and DC input circuits from the circuit being tested, reducing the chances of circuit loading and measuring errors. The special design of the 39G183 probes protects the SC61 to 3000 volts DC or AC peak-to-peak, allowing measurements in high voltage circuits. The 39G183 probes also provide a separate isolated circuit for DC voltage measurements.

Reduced sensitivity is the only disadvantage of using the low-capacity probes. The probes divide the amplitude of all signals by ten before reaching the SC61 input jacks. The probes allow measurement of signals as small as 25 millivolts (.025 volts), which is adequate for most circuit tests.

Both the CRT display and digital tests read direct with the 39G183 probes. Keep this in mind if you use competitive scopes that require multiplying by ten for the low-capacity probes. You **do not** need to multiply readings by ten when using the SC61 with 10X probes.

A special resistance wire between the probe and connector prevents waveform distortion caused by signal reflections inside the coaxial cable. **Do not replace this wire with any other type, as waveform distortion will occur.** The tiny center conductor requires special connection techniques. Send defective probes to the Sencore Service Department if service is ever required.

A special high temperature covering protects the resistance wire from heat damage, such as contact with a soldering iron. Both ends have extensive strain relief to protect the cable from damage during normal use. The 39G183 probes will give years of reliable use with reasonable care. Avoid excessive mechanical stresses on the special cable. Keep the probes out of the way of heavy objects and off the floor when not in use, or breakage of the probe tip or body is possible.

The special design of the 39G183

The SC61 digital readout presented a special design problem that was overcome with the 39G183 probe. The DC signal had to

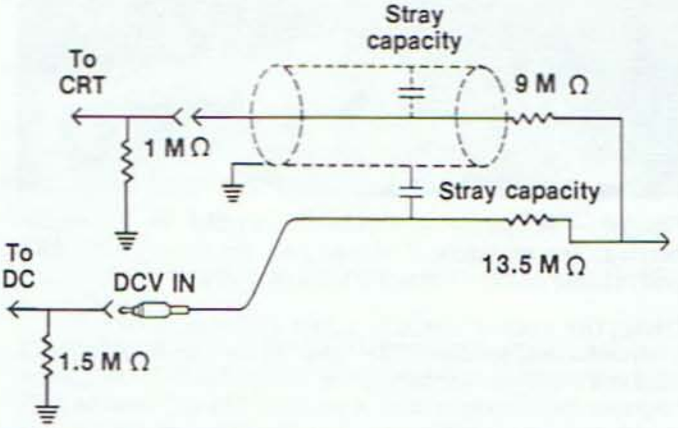


Fig. 13 — Separate isolated paths for the AC and DC signals prevent the stray test lead capacity from loading high frequency circuits.

be routed separately from the signal used to drive the CRT, digital peak-to-peak function, and digital frequency function. If all signals had been routed in one path, it would have been necessary to have the INPUT COUPLING switch in the "DC" position to measure DC voltage with the digital display. This, however, was not convenient because most waveform measurements are easier to make with the CRT input in the AC coupled mode.

Simply connecting the DC lead to the scope probe ahead of the scope isolation network, however, leads to loading problems. The DC lead acts like a capacitor placed in parallel with the isolated scope probe, causing problems in high impedance or high frequency circuits. The solution was to add a second isolation network inside the probe. The 39G183 probe serves as both a 10:1 DC divider and a 10:1 AC divider. The DC lead is resistively isolated from the circuit, just like the AC path.

The input impedance of the CRT circuits at the input jack is 1 megohm when DC coupled, or 2 megohms when AC coupled. The impedance of the DC input is 1.5 megohms. The series isolation inside the probe increases both values to ten times the direct input, or 10 megohms for the AC path and 15 megohms for the DC path. The two measuring paths are usually in parallel for a total DC impedance of about 6 megohms. While this is a somewhat lower impedance than most scopes, there are very few circuits affected by the slightly lower impedance. If DC loading is ever a problem, simply disconnect the DCV IN lead from the SC61. The input impedance with the DC path disconnected is 10 megohms when DC coupled or 11 megohms when AC coupled.

Connecting the 39G183 to the SC61

The separate AC and DC paths require two connectors for each probe. Connect the BNC connector first to hold the assembly in place while connecting the DCV IN lead.

Connect the probe with the blue ring on each end to the channel A input to tell which probe is which without tracing the wires from the probe back to the SC61. The probes work equally well if the blue-coded probe is connected to channel B, but you lose the convenience of color-coded probes.

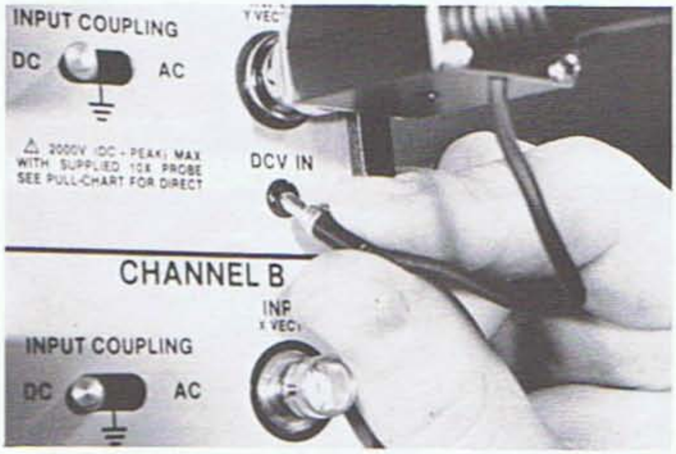


Fig. 14 — The small banana plug must be connected to the DCV IN jack to read DC volts through the low-capacity probe.

The SC61 includes a special DC voltage probe in addition to the two 39G183 low-capacity probes. The 39G157 DCV probe contains the 10:1 divider resistor needed for direct readings. Unplug the 39G183 DCV IN connector from channel A or B and replace it with the 39G157 plug when you want to make DC measurements without using the 39G183 probes. Press the channel A or B DCV DIGITAL READOUT button for the channel that has the DCV probe connected to read the voltage applied to the 39G157 input.

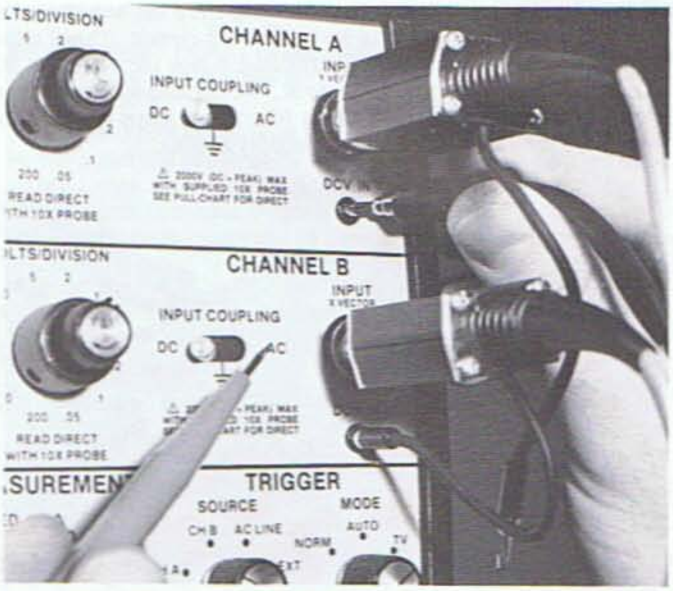


Fig. 15 — The 39G157 DC voltage probe provides DC voltage measurements separate from the normal low-capacity probes. The 39G157 has a multiplier resistor so all readings are direct.

Connecting the 39G183 to the circuit

The 39G183 may be used in either of two ways to make circuit connections; with a retractable hook tip, or with a needle-type connector. To use the retractable tip, simply pull back on the collar (see Fig. 16) to expose the connecting hook. Slip the hook over the component lead or test point, and release the collar. The sleeve will then slide forward to hold the probe in place.

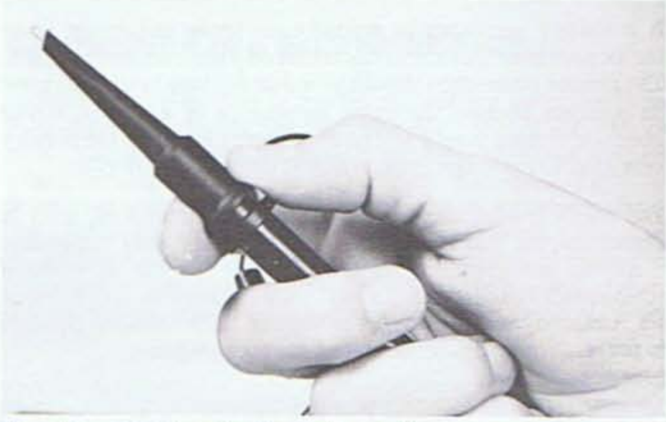


Fig. 16 — Pulling back on the collar exposes the metal hook that is connected to the circuit.

The pointed tip is exposed by unscrewing and removing the retractable tip. The tip is made of hardened steel to insure solid connections to circuits that may have an oxide coating that prevents reliable electrical contact.

Fig. 17 — Unscrew the probe tip to expose a sharpened steel probing tip.

It may be necessary to use a special clip (like the one shown in Fig. 18) when connecting to an integrated circuit. These clips are available in a variety of sizes and styles for different IC packages. Pomona and E-Z Hook, for example, have clips designed for 14, 16, 24, and 40 pin ICs. These clips are usually available through local electronic supply houses.

Fig. 18 — IC test clips provide secure connections to IC pins with little chance of shorting adjacent connections.

Test probe ground connectors

Each 39G183 comes with two ground leads and a ground clip. It is very important that you use the shortest possible ground connector when working in high frequency circuit or circuits that produce square-wave signals with fast risetime. The inductance of extra ground lead length will cause distortion in these signals. The long (12") ground lead must only be used when measuring low frequency signals.

It is always necessary to ground each probe to prevent interference or other waveform distortion on high frequency signals. The ground connection should be made as close to the test point as possible because the extra inductance of a printed circuit board or chassis wiring will have the same effect on the displayed signal as the longer ground leads; waveform distortion.

The small ground clip should be used when making tests in digital stages. The small size is designed for easy connection when the spring-loaded tip is removed. The clip is made of spring steel to allow connections to the closely spaced pins of an IC. And, above all, the length of the clip is the smallest possible to prevent signal distortion on fast rise-time signals.

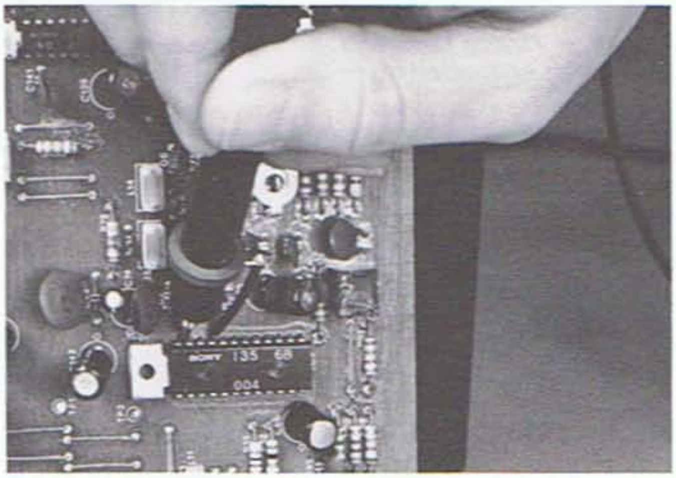


Fig. 19 — The ground clip provides the shortest possible ground connection and a convenient way to connect to IC pins.

Use care when removing a ground lead from the probe. The plastic strain-relief collar surrounding the probe ground connection rotates, and must be set to center the ground connector in the rectangular slot before attempting to remove the connector. Failure to center the connector in the slot before pulling the connector may result in a broken ground lead or plastic strain-relief collar.

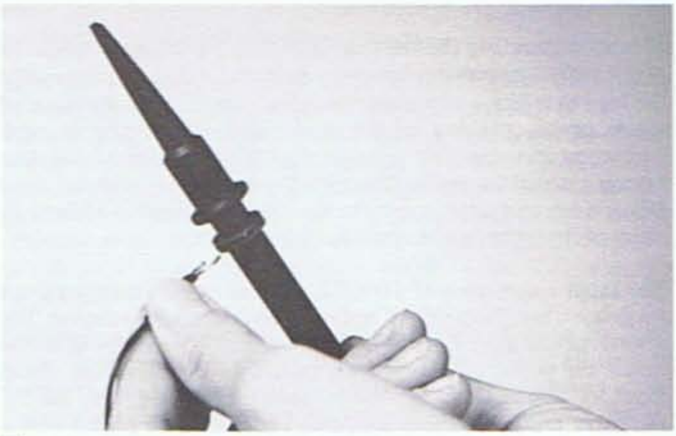


Fig. 20 — Make sure the ground clip is centered in the strain relief hole before trying to remove the clip.

Probe frequency compensation

Each 39G183 probe has a special compensation capacitor built into the BNC connector body. This capacitor matches the capacity of the probe and connecting cable to the input of the SC61 for flat frequency response. The compensation should be checked periodically to insure both probes are properly matched to the SC61 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.

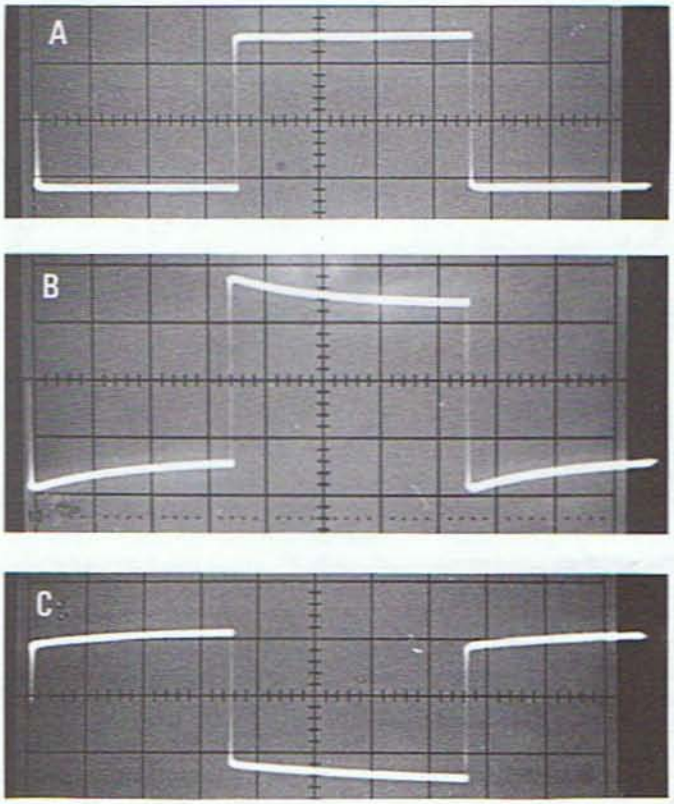


Fig. 21 — The signal from the PROBE COMP jack should be square, as in the top photo. Overshoot (B) or rounding (C) indicate the capacitor in the probe needs adjustment.

Check the probes' compensation by connecting them to the PROBE COMP jack on the front panel. The resulting CRT display should have a flat top and bottom with square corners. The capacitor should be adjusted if there is any overshoot or rounding.

NOTE: The probe comp signal has square edges, but may not be an exactly symmetrical square wave. The duty cycle, exact frequency or amplitude is not important in its application of testing probe compensation.

To compensate the probes:

1. Connect the two probes to the PROBE COMP jack.
2. Set the channel A and B VOLTS/DIVISION switches to the ".5" position.
3. Lock in the waveform with the trigger adjustments.
4. Set the TIMEBASE-FREQ switch to the .1 m sec position.
5. Select the CHAN A CRT display pushbutton.
6. Adjust the small trimmer capacitor in the probe connector body for the best square wave signal possible.
7. Repeat the adjustments on the channel B probe.

3000 volt protection extends to 650 KHz

The voltage rating of all high frequency low-capacity probes drops as frequency increases. The capacitive reactance at higher frequencies decrease, causing higher power dissipation in the probe components and connecting cable. There are very few applications requiring a higher voltage rating of the 39G183 probes. The graph in Fig. 22 shows the protection limits for high frequency applications. The optional PL207 RF Pickup Loop may be used for relative measurements of high voltage/high frequency signals. The PL207 is covered in a later section of this manual.

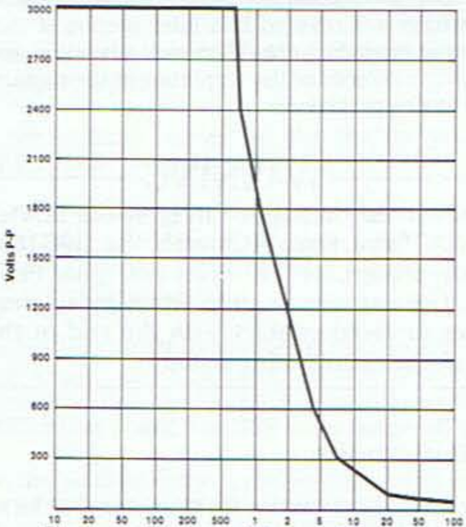


Fig. 22 — The voltage rating of the 39G183 probes reduce for frequencies above 1 MHz.

DP226 Direct Probe

Measuring extremely small signals (in the 5 to 50 mV region) requires the use of the optional DP226 Direct Probe. The direct probe results in ten times more vertical sensitivity than the low-capacity probe. There are, however, several disadvantages to using a direct probe. These disadvantages are related to all direct probes, not only the DP226.

First, the direct probe does not isolate the capacity of the input circuits and the probe cable from the circuit. This added capacitance may cause some circuits to change operating points. Second, the DC input impedance of the measuring system is reduced from 10 megohms to 1 megohm, which may load some high impedance DC circuits. Third, the frequency response is limited to 15 MHz. This third point may require a bit more explanation.

It would seem that a direct probe would be no more than a piece of coaxial cable with a connector on one end and a probe tip on the other end. This, however, does not work well because the one megohm impedance of the SC61 input does not terminate the characteristic impedance of the cable, resulting in standing waves on signals with fast risetimes. The standing waves add to the measured signal, causing ringing and other waveform distortion. High quality direct probes, such as the DP226, use a special resistance wire (with several ohms per foot of DC resistance) as the center conductor of the coaxial cable. The resistance damps the standing waves to eliminate the ringing. The resistance, however, also reduces the usable frequency response because the resistance of the wire is in series with the input capacitance of the scope.

The direct probe, therefore, is useful in applications requiring added sensitivity on signals below 15 MHz. It should not, however, be used for most measurements.

Finally, remember that the SC61 CRT and digital display are both calibrated for a 10X low-capacity probe. **The readings must be divided by 10 when used with a direct probe.**

Connecting to a generator output

A direct connection may be made from a signal generator to the SC61 input when testing the generator itself or recalibrating the SC61. Remember that the cable must be terminated with the characteristic impedance of the generator and connecting cable to prevent standing waves which may cause waveform distortion. Terminate the cable with a feed-through terminator, such as the one shown in Fig. 23. The terminator must be connected on the end of the cable closest to the SC61 (not the end next to the generator) because its main purpose is to quiet the interconnecting cable.

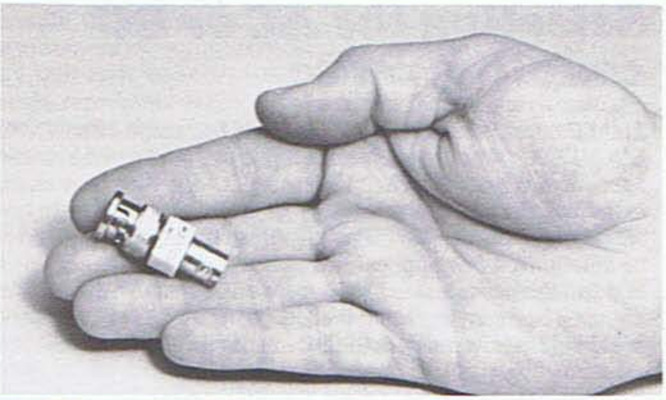


Fig. 23 — A 50 or 75 ohm terminator must be used at the SC61 input when viewing the output of high frequency generators to prevent the interconnecting cable from ringing.

Indirect connections with the PL207

The 39G183 probes provide low capacitive loading and high voltage protection adequate for most measurements. The measuring capabilities of the SC61 may be extended even further by using inductive pickup of signals with the PL207 RF Pickup Loop. Peak-to-peak readings made with the PL207 are relative. You can confirm a signal is present, its waveshape and frequency as well as whether the amplitude is increasing or decreasing.

The DC or capacitive loading of any oscilloscope probe may affect some high impedance/high frequency circuits, such as oscillators. Simply connect the PL207 in place of the 39G183 probe and position the loop close to a coil or capacitor in the circuit. Move the loop near 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 shock hazard or direct contact between the PL207 and a high voltage point. Hold the PL207 several inches from the signal's source. The PL207 acts like an antenna to pick up the signal and supply it to the SC61 input.

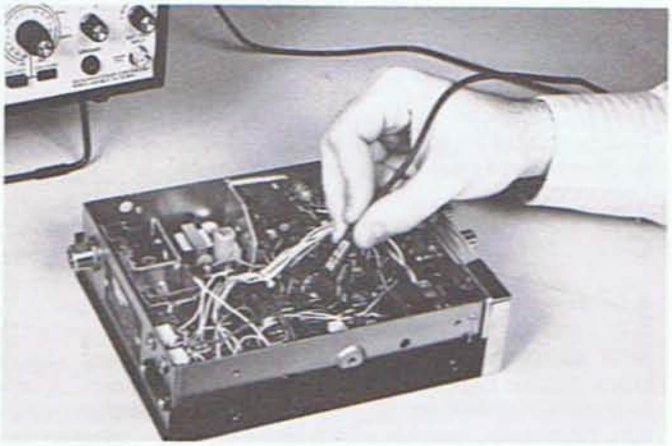


Fig. 24 — The PL207 RF Pickup Loop allows inductive pickup of signals in high impedance or high voltage circuits.

Selecting the AC or DC coupling mode

The SC61 may be used as an AC or DC scope. The INPUT COUPLING switch (next to each input jack) selects the mode of operation. When the switch is in the "DC" position, any change in the average DC level at a test point will cause the trace to move vertically by an amount proportional to the DC voltage. This can be helpful in a few applications that require the sum of the AC and DC components of a signal to be measured. The trace shifting may be annoying when the DC component is not of interest or is being monitored with the DC function of the digital readout.

Most tests require AC coupling. The AC mode places a capacitor in series with the input circuits to block DC. The capacitor causes the trace to return to the same vertical position as the amount of DC voltage at a test point changes, or as the probe is moved from a test point with one DC level to another point with a different DC level.

The INPUT COUPLING switch may be in any position when using the digital readout to measure DC volts. This is especially helpful when making tests in power supplies, as the CRT shows the ripple (with the INPUT COUPLING switch set to "AC") while the digital display monitors the DC level. This is possible because the DC signal is routed to the digital circuits through a separate path.

The design of the CRT input circuits prevents possible damage to solid-state components when moving from a point with a high DC voltage (such as the plate of a tube in a hybrid circuit) to the input of a solid-state device. The blocking capacitor of other oscilloscopes holds the DC level from the previous measurement until it is discharged back through the probe. Conventional oscilloscopes require grounding the probe to the scope ground to discharge capacitor when moving from a high voltage point to a solid-state device. The SC61 automatically discharges the blocking capacitor when the probe is removed from the circuit. The capacitor discharges in about .2 seconds.

Setting the VOLTS/ DIVISION switch

The VOLTS/DIVISION switch may be used in two different ways, depending on whether peak-to-peak measurements are being made with the CRT or the digital readout. The variable vernier control does not need to be in the "calibrated" position when the digital display is used because the signal is routed to the digital circuits ahead of the vernier or vertical position controls. **The vernier must be calibrated when using the CRT to determine peak-to-peak amplitude.**

Both the digital display and the CRT controls are calibrated for direct readings when using the supplied 39G183 10X low-capacity probes. This is different than most other oscilloscopes that are calibrated for a direct (1:1) probe. Most scopes require multiplying all readings by 10 when the low-capacity probe is used.

Using the CRT to measure P-P volts

The instructions for using the digital readout to measure peak-to-peak voltage are covered in a later section of this manual. The following procedure should be used when it is necessary to use the CRT to determine the amplitude of the signal using conventional analog procedures:

WARNING

Do not exceed the input rating of the SC61; 3000 volts (DC plus Peak AC) with the 39G183 low-capacity probes, or 500 volts (DC plus Peak AC) direct. Use extreme caution when measuring high voltages to avoid contact with the end of the test probe or the circuit being tested.

1. Apply the signal to the SC61 and lock it on the CRT with the TRIGGER adjustments.

2. Turn the vertical vernier for the channel to be measured, fully clockwise to the "CAL" position.

3. Set the VOLTS/DIVISION switch until the waveform is between two and four divisions tall on the CRT.

4. Adjust the VERTICAL POSITION control until the bottom of the waveform is lined up with one of the horizontal lines on the CRT graticule (it does not matter which line is used).

5. Adjust the HORIZ POSITION control until the highest point of the waveform is on the middle CRT graticule line.

6. Count the number of divisions occupied by the waveform. Remember that each minor mark on the graticule represents .2 major divisions.

7. Multiply the total number of major divisions and parts of a division by the setting of the VOLTS/DIVISION switch to determine the total peak-to-peak amplitude of the signal. Remember that it is not necessary to move the decimal if the supplied 10X low-capacity probes are used. If the DP226 Direct Probe is used, divide the resulting number by ten (move the decimal one place to the left).

Using the CRT to measure DC levels

The digital readout should always be used to determine the average DC level at any test point. The digital section of the SC61 provides results that are approximately 60 times more accurate than using the CRT display. The digital DCV circuits automatically determine the average level of the AC component of a signal and add this level to the DC bias. These readings agree with the DC voltages shown on schematics.

There are times when you need to know the DC level of a portion of a waveform, such as the "on" or "off" level of a digital signal. These measurements are sometimes called the "absolute value" or the "DC plus Peak AC" value of the signal. These measurements must be made with the CRT because the digital test shows the average DC level.

The following procedure should be used to determine the absolute value of any part of a waveform:

WARNING

Do not exceed the input rating of the SC61; 3000 volts (DC plus Peak AC) with the 39G183 low-capacity probes, or 500 volts (DC plus Peak AC) direct. Observe extreme caution when measuring high voltages to avoid contact with the end of the test probe or the circuit being tested.

1. Apply the signal to the SC61 and lock it on the CRT with the TRIGGER adjustments.

2. Turn the vertical vernier for the channel you wish to measure, fully clockwise to the "CAL" position.

3. Set the VOLTS/DIVISION switch to a marked position that is between one-half to one-eighth the expected DC level. If, for example, the expected voltage is 10 volts, the switch should be set to the "2" or "5" position.

4. Set the INPUT COUPLING switch to the "ground" position to establish a zero reference point. *(NOTE: The TRIGGER MODE switch must be in the "Auto" position in order to produce a trace with no input signal.)*

5. Adjust the position of the trace (with the input grounded) using the VERTICAL POSITION control until it is on any of the CRT graticule lines. This is your zero reference line.

6. Move the INPUT COUPLING switch to the "DC" position.

7. Decide what part of the waveform should be measured (the TRIGGER adjustments and TIMEBASE-FREQ switch may need to be adjusted to show the necessary detail) and use the HORIZ POSITION control to place that part of the waveform on the center CRT line. **Do not move the VERTICAL POSITION control, as this will change your zero reference.**

8. Count the number of divisions from the zero reference line (step 5) to the point you want to measure on the waveform. Remember that each minor mark on the graticule represents .2 major divisions.

9. Multiply the total number of major divisions and parts of a division by the setting of the VOLTS/DIVISION switch to determine the absolute value. Remember that it is not necessary to move the decimal if the supplied 10X low-capacity probes are used. If the DP226 Direct Probe is used, divide the resulting number by ten (move the decimal one place to the left).

Tips on measuring DC volts

1. Any graticule line may be used as the zero reference point. The second vertical input channel may be used to "mark" the zero point when you are only using one of the channels. Simply press the A&B CRT display button and ground both inputs with the INPUT COUPLING switches. Set both traces to the same line. Then, leave the unused input set to the "ground" position when the measured channel is set to the "DC" position. The grounded channel trace will remain at the zero reference while the measured channel moves the correct amount to represent the DC level.

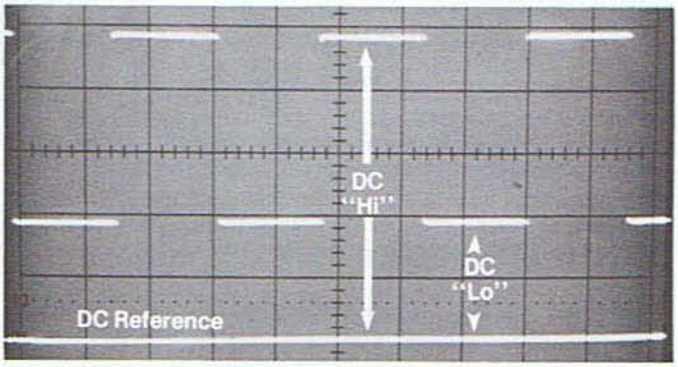


Fig. 25 — The second channel may be used to mark the zero reference point by grounding the input and pressing the "A&B" CRT display selector.

2. The zero reference point does not need to be reset when changing the VOLTS/DIVISION switch if the TRACE BAL control is properly set. Move the VOLTS/DIVISION switch to a larger number if the trace moves off the CRT, or to a smaller number if you want more detail.

3. All direct-coupled oscilloscopes show a slight drift when the trace moves a full 8 divisions on a DC measurement. If, for example, the zero reference is set at the bottom of the CRT, and the measured DC voltage causes full-screen deflection, the trace may shift up to one minor division after about 15 seconds. This change represents only a 2% change in the measured voltage, which should not affect most readings. The drift is minimized when six or fewer divisions of deflection are used.

Obtaining a locked-in trace

The TRIGGER circuits reference the horizontal sweep circuits to the waveform to provide a stable trace. The trace is stable when the horizontal sweep starts at the same point on the input signal at the beginning of each sweep of the electron beam across the CRT. The waveform may jitter or run freely if the TRIGGER adjustments are improperly set. There are only four adjustments needed to obtain a stable trace on the SC61. The following section describes the effects of each adjustment on the waveform.

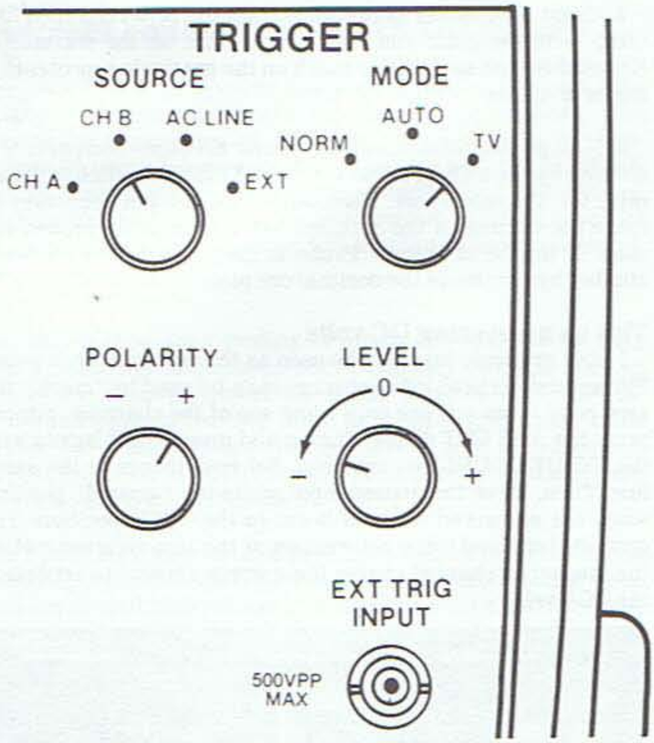


Fig. 26 — The four trigger adjustments allow a wide assortment of reference signals to lock the trace.

TRIGGER SOURCE

The CRT display may be referenced to any of four signal sources. Most tests use a sample of the signal applied to the vertical amplifiers to reference the trigger circuits. A few special tests require referencing the sweep circuits to the AC line frequency or to an external signal.

The CH A and CH B positions of the TRIGGER SOURCE switch reference the sweep circuits to the signal applied to the channel A or B inputs. These two positions are used for most waveform measurements. There are two general rules to follow when using the internal trigger references:

1. When viewing one trace, set the TRIGGER SOURCE switch to agree with the channel being viewed.

2. When using the dual-trace display mode, set the TRIGGER SOURCE switch to the channel that gives the most stable reference.

There are exceptions to these rules covered in the section of this manual entitled, "Special Triggering Conditions". Be sure to review these special conditions so you know when a special condition is encountered.

The "AC Line" position of the TRIGGER SOURCE switch locks the sweep circuits to the 60 Hz AC line signal. AC line triggering simplifies power supply troubleshooting or isolating power supply ripple. If, for example, you suspect a test point contains power supply ripple, set the TRIGGER SOURCE switch to the "AC Line" position and set the TIMEBASE-FREQ switch to the "1 m sec" position. Ripple will remain stationary on the CRT while all other signals at the test point are out of sync. If the signal is not locked on the CRT, you know that the interference is coming from some circuit other than the power supply.

NOTE: The "AC Line" position of the TRIGGER SOURCE switch should not be used to reference the sweep circuits when viewing video signals. The vertical video sweep rate is not referenced to the AC line. The actual vertical rate for TV signals is 59.94 Hz for interlaced signals or 60.05 Hz for non-interlace signals.

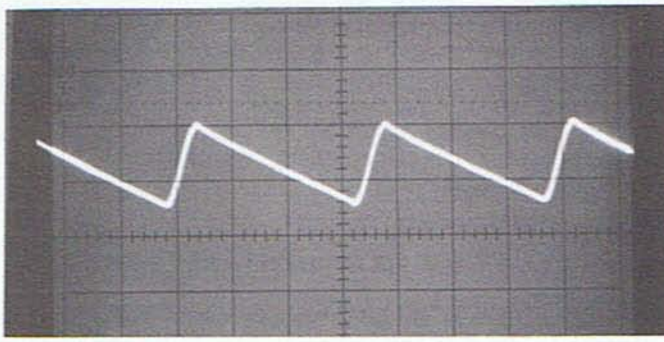


Fig. 27 — The "AC Line" trigger source helps isolat power supply problems because the ripple is automatically locked no matter what other signals are present.

The EXT position of the TRIGGER SOURCE switch reference the sweep circuits to a signal applied to the EXT TRIG INPU jack in the lower right hand corner of the SC61. This allows bot of the CRT traces to be referenced to a third signal.

NOTE: The three signals must be derived from the sam master source, or the SC61 will appear to be out of sync whe using the EXT function.

TRIGGER MODE

The TRIGGER MODE switch selects one of three types of triggering. Most measurements will be made with the switch in th "Auto" position. The "Norm" and "TV" positions provid stable triggering for special signal applications.

The "Norm" position only shows a trace when the trigge circuits receive a signal large enough to produce a trigger output. The CRT remains blank until a trigger pulse arrives. Ther are two general uses for normal triggering; triggering o complex signals and triggering on signals that have long period with no signal between trigger references. Both applications ar described in more detail in the "Special Triggering Conditions section of this manual.

The "Auto" position provides a trace whether or not the trigge circuits have a reference signal. This mode shows the trac location at all times to simplify setting up a fully locked trace.

The "TV" position switches special sync separators into th trigger circuits for stable triggering on composite video signal The TIMEBASE-FREQ switch automatically selects betwee the vertical or horizontal sync separator mode. All sweep speed in the "m sec" range use the vertical sync separator, and a sweep speeds in the "u sec" use the horizontal sync separato The TRIGGER POLARITY switch must always be properly se when triggering on video signals, as explained in a later section

NOTE: It is not necessary to have the TRIGGER MODE witc in the "TV" position when using the video preset position of th TIMEBASE-FREQ switch. The preset mode automaticall selects TV triggering when the TRIGGER MODE switch is i the "Norm" or "Auto" position.

TRIGGER LEVEL

The TRIGGER LEVEL control adjusts the sensitivity of th trigger amplifiers. Fig. 28 shows the effects of this control. Fi 28A shows the TRIGGER LEVEL control set to "0" with a sin wave input. Notice that the trace starts near the midpoint of the waveform. Fig. 28B shows the same signal with the TRIGGER LEVEL control turned towards the "+" marking. Notice that the trace starts at a higher amplitude on the signal. Fig. 28C shows that the waveform starts at a lower point when the TRIGGER LEVEL control is turned towards the "−" marking.

NOTE: The "+" and "−" markings of the TRIGGER LEVEL control refer to the position the trace begins relative to the top and bottom of the CRT. This is still true when the TRIGGER POLARITY switch is in the "−" position. The effect will appear to be reversed if the channel A signal is inverted and the SC61 is triggering from channel A because the inversion of the signal takes place after the trigger take-off point.

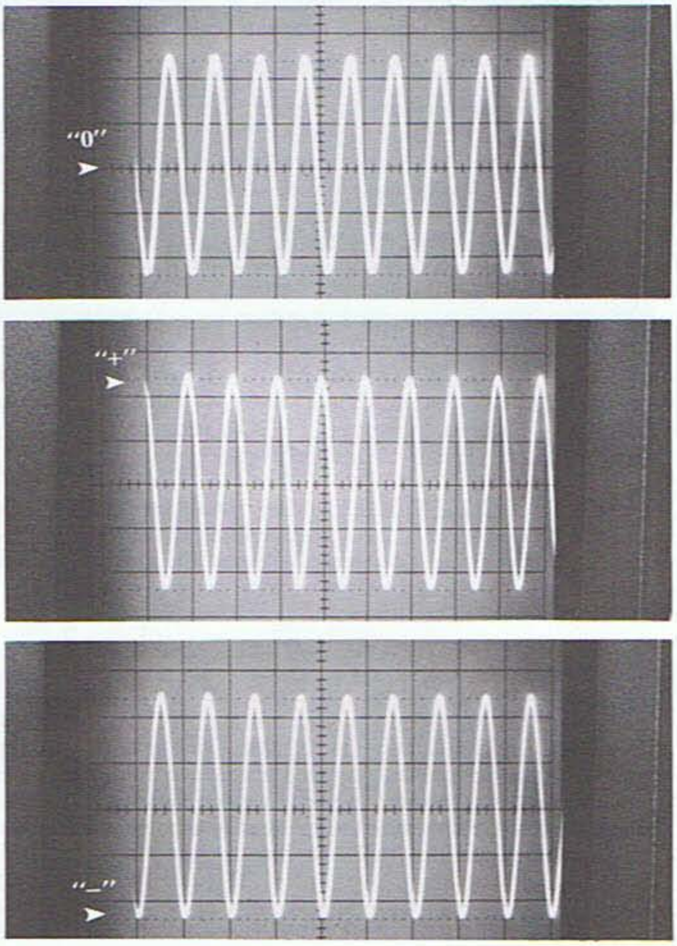


Fig. 28 — (A) The trigger point is in the middle of the waveform with the TRIGGER LEVEL control at zero. (B) Turning the control in the "+" direction causes the starting point to move up. (C) Moving the control towards "−" causes the opposite effect.

TRIGGER POLARITY

The TRIGGER POLARITY switch determines whether the trigger circuits respond to a positive or negative transition in the incoming signal. Most applications work equally well with either polarity. When polarity is important, the "+" position starts the trace on the part of the signal increasing in amplitude, and the "−" position starts the trace on the part of the signal decreasing in amplitude.

The TRIGGER POLARITY switch must be in the correct position when triggering the SC61 from a composite video signal. The sync separators must be told whether the sync pulses (needed for stable triggering) are positive or negative-going so the sync separators can properly isolate the sync pulses from the video information. The TRIGGER POLARITY switch must be set to the "+" position if the sync pulses are positive (pointing up)) or to the "−" position if they are negative. Selecting the wrong polarity may result in an unstable trace, and will always give incorrect peak-to-peak readings when the Delta peak-to-peak function of the digital readout is used.

NOTE: The TRIGGER POLARITY switch will appear to work backwards if the channel A trace is inverted and the SC61 is triggering from channel A. The trigger signal is taken from the channel A amplifier before the inverting amplifier.

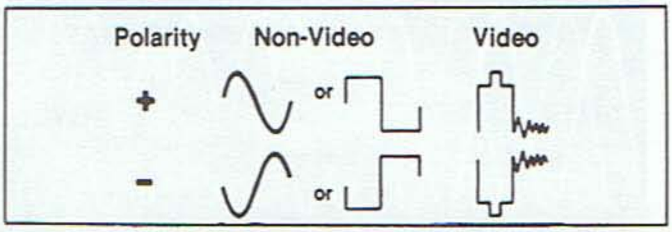


Fig. 29 — The TRIGGER POLARITY affects the starting point of a non-video signal, or references the sync polarity on a composite video waveform.

Special triggering conditions

Most signals require no special adjustments for stable triggering. Simply adjust the TRIGGER LEVEL control until the trace locks. There are a few signals that may appear to give false triggering. The SC61 is actually triggering properly, in these cases, but special parts of the signal may cause the trigger circuits to begin at different points on the waveform on successive sweeps, causing an unstable trace.

Sinewaves with distortion

Low frequency sinewave signals often contain distortion or interference that may cause unstable waveforms. An audio generator or amplifier, for example, may have crossover distortion may make the SC61 appear to "double-trigger" when the TRIGGER LEVEL control is adjusted to trigger at the point on the waveform that contains the distortion. Fig. 30 shows an enlarged view of crossover distortion. Notice that there are two points with the same amplitude. The trigger circuits alternately trigger on both points, resulting in the double pattern. The SC61 TRIGGER LEVEL control should simply be reset slightly to reference the trigger circuits above or below the crossover point.

At other times, audio signals may contain a small amount of a higher frequency signal that may cause the SC61 to appear to trigger erratically. Two common examples of signals of this type are the output of an FM receiver that contains a small amount of the 19 KHz stereo pilot signal or the output of an audio stage near a radio transmitter that may be acting as an antenna and feeding the RF signal through the vertical amplifiers. The solution, in either case, is the same. Simply adjust the TRIGGER LEVEL control until the SC61 is triggering properly. In the case of severe interference, it may be necessary to trigger from the very top or bottom of the waveform to prevent the false triggering.

The "Norm" position of the TRIGGER MODE switch simplifies setting the trigger circuits to the edge of the signal. The circuits are simply adjusted until the trace just appears on the CRT, insuring the TRIGGER LEVEL control is set for the highest amplitude signal.

To use the "Norm" mode to trigger a signal:

1. Set the TRIGGER MODE switch to the "Norm" position.

2. Adjust the TRIGGER LEVEL control fully clockwise.
NOTE: The CRT should be blank.

3. Slowly adjust the TRIGGER LEVEL control in the counter-clockwise direction until a trace just appears on the CRT.

NOTE: After the proper trigger level has been established, the TRIGGER MODE switch may be returned to the "Auto" position without affecting the trigger point on the signal.

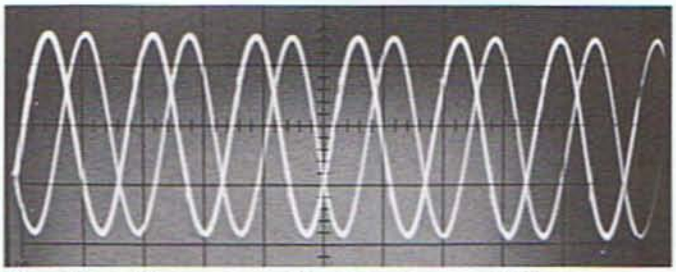


Fig. 30 — Sinewaves with distortion or high frequency interference may appear to mistrigger. Readjust the TRIGGER LEVEL control to lock the waveform.

A.M. signals

Amplitude modulated signals are especially difficult to lock because the high frequency trigger circuits of the SC61 will tend to lock to the carrier frequency when the modulating signal is usually the signal you want to view. There are two ways to obtain a stable trace on AM signals. First, the TRIGGER LEVEL control may be set to trigger from the highest peak modulation as explained in the previous section. This should provide acceptable triggering as long as the peak modulation amplitude remains constant. Any change in amplitude, however, will require readjustment of the TRIGGER LEVEL control to establish a new triggering point.

Triggering is much simpler when the audio signal used to modulate the carrier is available separately. The modulation signal may then be fed to either the external trigger input or the second vertical input as a reference for the trigger circuits. For example, if you are using channel A to view the modulation, feed the modulating signal to channel B and select the CH B TRIGGER SOURCE. Adjust the TRIGGER LEVEL control until the SC61 is solidly locked to the modulating signal and then press the CHAN A CRT display pushbutton. The SC61 will remain triggered, even if the amount of RF carrier or modulation changes during the measurement.

Signals that are multiples of each other

The SC61 may appear to mistrigger on one signal when viewing two signals that are multiples of each other. A digital flip-flop, for example, produces an output that is half the frequency of the input. Or, a frequency doubler is used in many FM receivers to step the 19 KHz pilot signal (sent from the station) up to the 38 KHz needed to separate the left and right audio information. The TRIGGER SOURCE switch should always be set to trigger from the lower of the two frequencies. If it is set to trigger from the higher frequency, the second channel will be randomly displayed because the trigger circuits cannot tell where the lower frequency is in relationship to the higher frequency.

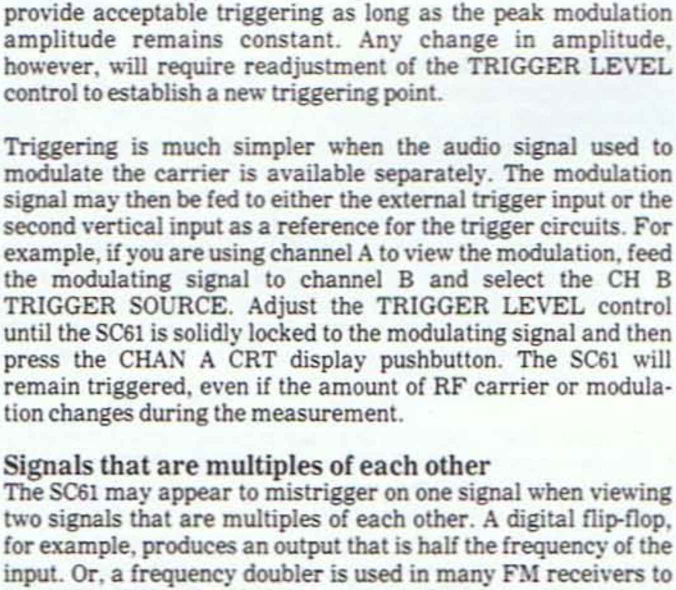


Fig. 31 — Always trigger from the lower frequency signal, when two signals are multiples of each other, to prevent the lower frequency signal from double triggering.

Digital data from microprocessors

Analyzing the inputs or outputs of a microprocessor based system with any oscilloscope requires the system to be placed into a loop that repeats the same data on a continuous basis. Attempting to view a waveform with the system in full operation results in a blur of data because the data (and resulting waveform) will be different every time the electron beam sweeps across the CRT screen. At times, this is not a problem because you may only be interested in learning whether the signal is "toggling" (moving between highs and lows) rather than viewing a specific set of data instructions.

The service literature for the system should explain how to place the system into a loop for special tests. Sometimes, this is a special set of instructions designed for troubleshooting only. The special loop may require adjusting internal switches or jumpers to place the system into the loop. At other times, the loop may be produced by selecting a standard function that forces the system to repeat the same information over and over, such as a reset function.

After the loop has been established, the SC61 needs a reference signal to insure that the trace begins its sweep at the same point in the digital data for each trace sweep. A "reset" or "enable" pulse may be used to trigger the SC61 through the external trigger input or through the second vertical input.

Finally, the TRIGGER MODE switch should be in the "Norm" position. This prevents the auto-baseline circuit from causing the horizontal circuits to sweep between the starting signals. The SC61 will wait any period of time necessary for the next starting pulse when the normal trigger mode is used.

Video signals

The video sync separators (switched into the trigger circuits when the TRIGGER MODE switch is in the "TV" position, or the TIMEBASE-FREQ switch is in the video preset position) provide stable triggering on composite video waveforms. The sync separators are most important when viewing waveforms at the vertical rate because the vertical sync pulse requires both level detection and integration for proper triggering.

The SC61 may trigger with high stability at the video horizontal rate because the TRIGGER LEVEL control will allow the horizontal sync to be isolated from the composite video. **The sync separators must be used, however, for accurate readings of the Delta peak-to-peak function.** The sync separators eliminate the vertical sync and blanking signal from the waveform. If these vertical signals are not eliminated, they will cause improper Delta readings if the amplitude of any part of the composite waveform, except the sync pulse, is measured. The Delta circuits will measure the amplitude from the bottom of the sync pulse, rather than the desired video signal.

The CRT shows when the trigger circuits are improperly set. Fig. 32 shows what to look for. Notice the faint line running between the two horizontal sync pulses in Fig. 32. The faint line is the vertical sync and blanking. The line is faint because it is present for only 1/525th the time of horizontal sync. Fig. 33, on the other hand, shows a horizontal waveform when the video triggering circuits have been properly set and the vertical information is eliminated from the trace. The Delta peak-to-peak function will now give the correct reading for any portion of the trace intensified by the Delta Measurement Bar.

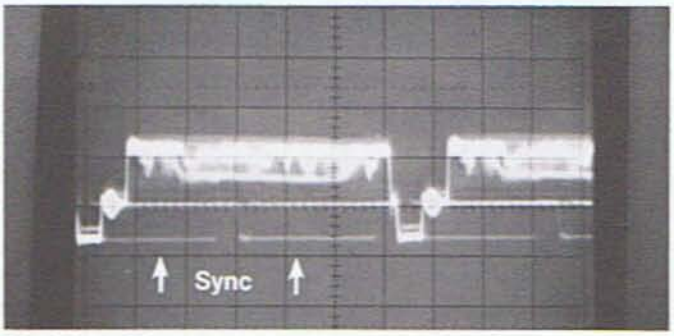


Fig. 32 — The vertical sync information shows as a faint background trace when the video sync separators are not used or improperly set.

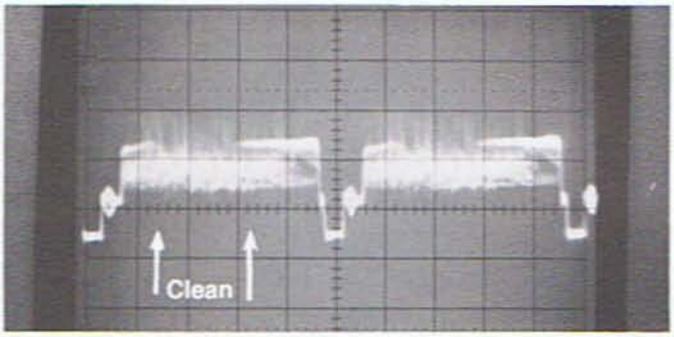


Fig. 33 — The SC61 has special circuits that eliminate the vertical sync when viewing video signals at the horizontal rate for correct Delta P-P readings.

There is one other condition unique to video signals. Many test points in a TV receiver or video monitor contain the vertical and horizontal sync pulses needed by the SC61 for proper triggering. A few points, however, do not have sync. One example is the output of the chroma bandpass amplifiers. The low frequency sync pulses are removed by the filtering action of these stages. Signals without sync information may not lock solidly on the SC61. Trigger the SC61 from another test point, such as the video detector or sync separator, to provide a stable trigger reference. The second trigger source may be fed to the external trigger input or to the second vertical channel.

Setting the TIMEBASE-FREQ switch

The TIMEBASE-FREQ switch plays a much less important role in most SC61 measurements compared to an analog oscilloscope. The digital display provides a direct readout of time or frequency for most measurements, eliminating the need for analog readings. The TIMEBASE-FREQ switch, and its associated vernier control, are simply adjusted to show as much or as little detail in the waveform as desired.

The TIMEBASE-FREQ switch is fully calibrated, allowing the SC61 to be used as an analog oscilloscope if desired. The main use of the frequency markings, however, will be to set the TIMEBASE-FREQ switch to the correct sweep rate to display a signal with a known frequency. The following sections cover the procedures for displaying a waveform, followed by procedures for making analog measurements of time and frequency.

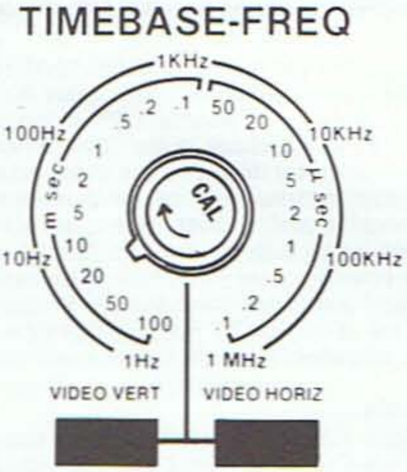


Fig. 34 — The outside calibrations simplify setting the TIMEBASE-FREQ switch when the frequency of the signal is known, or for measuring an unknown frequency with analog methods. The inside calibrations are for measuring time. The bottom position activates the video preset buttons.

Selecting the sweep rate for a known frequency

The frequency markings on the ring surrounding the TIMEBASE-FREQ switch represent the frequency of the SC61 horizontal oscillator when the vernier control is in the "Cal" position. These markings simplify setting the horizontal sweep circuits to show a waveform when the frequency of the signal is known. The frequency markings eliminate the need to relate time/division calibration to frequency. The SC61 digital frequency function may be used to determine the frequency of the signal, if it is not given elsewhere, as the frequency function gives correct readings for any setting of the TIMEBASE-FREQ switch.

To set the TIMEBASE-FREQ switch:

1. If the schematic does not show the frequency:

a. Press the "Freq" DIGITAL READOUT button for the channel used as the trigger source.

b. If the digital display reads all zeros, the trigger circuits are not locked to the incoming signal. Adjust the INPUT COUPLING switch, the VOLTS/DIVISION switch, and the TRIGGER LEVEL control until you get a frequency reading.

2. Using the frequency from the schematic or from the previous test as a reference, set the TIMEBASE-FREQ switch to the position marked with a frequency that is lower than the frequency of the signal.

NOTE: The horizontal vernier does not have to be in the "Cal" position for this test.

3. There will be between 2 and 20 cycles of the signal displayed when the switch is set in step 2, which gets the TIMEBASE-FREQ switch close to the desired setting.

4. Adjust the TIMEBASE-FREQ switch to expand or reduce the waveform as desired.

Video waveforms

The SC61 displays composite video signals in either of two ways. The first procedure is the faster of the two because preset buttons select the vertical or horizontal video sweep rate. The second procedure allows the composite video signal to be expanded to see more detail near the back porch of the vertical or horizontal sync information.

It is normal for the waveform at the video detector of a television receiver to appear thicker on any wideband scope than on a lower frequency oscilloscope. The wide frequency response of the vertical amplifiers of the SC61 will respond to the 45.75 MHz IF carrier passing through the detector. This IF signal will not appear on a lower frequency oscilloscope because the oscilloscope's vertical amplifiers filter out the IF carrier. The IF signal does not affect the TV receiver's picture because the limited video amplifier frequency response removes the signal.

Video presets

The TIMEBASE-FREQ switch activates the two video preset pushbuttons when set to the video preset (bottom) position. The SC61 displays two cycles of the vertical field rate or two cycles of the horizontal line rate with the VIDEO VERT or VIDEO HORIZ button depressed and the vernier calibrated. Rotating the vernier counterclockwise displays more cycles. Pulling the HORIZ POSITION control expands any part of the signal ten times.

The video preset position of the TIMEBASE-FREQ switch automatically selects the "TV" trigger mode, no matter where the TRIGGER MODE switch is set. This simplifies trigger setup when it is necessary to alternately measure video and non-video signals as the TRIGGER MODE switch may be left in the "Auto" or the "Norm" position for the video and non-video signals. Moving the TIMEBASE-FREQ switch to the video preset position automatically overrides the TRIGGER MODE switch to select the "TV" trigger mode. Switching the TIMEBASE-FREQ switch out of the video preset position automatically returns the control of the trigger circuits to the TRIGGER MODE switch.

To view composite video signals:

1. Apply the desired signal(s) to the vertical input(s) and select the desired display pushbuttons.

2. Set the TIMEBASE-FREQ switch to the "VIDEO PRESET" position.

3. Select the desired TRIGGER SOURCE switch position.

4. Set the TRIGGER POLARITY switch to the correct position to agree with the direction of the sync pulse, "+" for positive-going sync or "−" for negative-going sync.

5. Press the VIDEO VERT pushbutton to view signals at the vertical rate, or the VIDEO HORIZ pushbutton to view signals at the horizontal rate.

Using the TIMEBASE-FREQ switch to view video signals

The video sync separators may be used with any of the calibrated sweep positions of the TIMEBASE-FREQ switch by switching the TRIGGER MODE switch to the "TV" position. The TIMEBASE-FREQ switch is generally used when time measurements must be made on a portion of the composite video signal, or when the area following vertical or horizontal sync must be expanded to view detail in the blanking intervals. This feature allows the VIRS or VITS signal (in the vertical blanking interval) or the color burst signal (in the horizontal blanking interval) to be expanded.

The selection of the vertical or horizontal sync separators is automatically made by the TIMEBASE-FREQ switch. All sweep speeds in the "m sec" range use the vertical sync separator, and all sweep speeds in the "u sec" range use the horizontal sync separator.

To view composite video signals:

1. Apply the desired signal(s) to the vertical input(s) and select the desired display pushbuttons.

2. Set the TRIGGER MODE switch to the "TV" position.

3. Select the desired TRIGGER SOURCE switch position.

4. Set the TRIGGER POLARITY switch to the correct position to agree with the direction of the sync pulse "+" for positive-going sync or "−" for negative-going sync.

5. Select the desired sweep speed, remembering that the vertical sync separator is used in all sweep speeds marked "m sec" and the horizontal sync separator is used for all sweep speeds marked "u sec".

NOTE: The TRIGGER LEVEL control should usually be set to the "zero" position. If the trace is not fully triggered, adjust the TRIGGER LEVEL control for best triggering.

Viewing 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 viewed on the SC61 without the need for delayed sweep. The SC61 has special

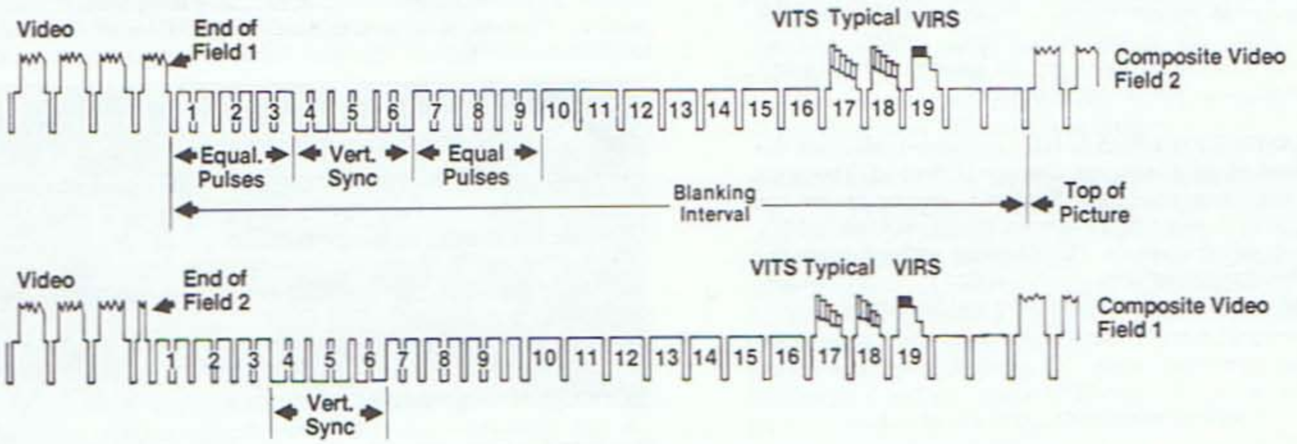


Fig. 35 — VITS and VIRS are located on lines 17, 18, and 19 of the vertical blanking interval.

circuits in the sync separators that isolate the two vertical interlaced fields to prevent overlap of the signals from the first and second fields.

The signals are displayed by setting the TIMEBASE-FREQ switch to the .1 m sec position, the trigger mode to "TV", and expanding the waveform ten times. The special sync separators result in a stable trace.

To view the VITS or VIRS:

1. Set the TIMEBASE-FREQ switch to the .1 m sec position.

2. Set the TRIGGER MODE switch to the "TV" position and adjust the other trigger adjustments for a properly locked signal.

3. Center the VIRS or VITS signal on the horizontal center line.

4. Activate the 10X expand mode by pulling the HORIZ POSITION control.

5. Center the desired signal on the CRT.

NOTE: The VIRS or VITS signals are present for only one line out of the 525 lines of video information. Any oscilloscope shows a great reduction in CRT intensity when viewing signals with duty cycles this low. You may need to turn the INTENSITY control fully clockwise to view the signal. Some competitive oscilloscopes may appear brighter than the SC61 when viewing these signals, but this is usually because they do not have the special circuits that eliminate the overlap between the two vertical fields. The result is a trace that appears twice as bright, but has two waveforms with a half-line shift super-imposed on each other.

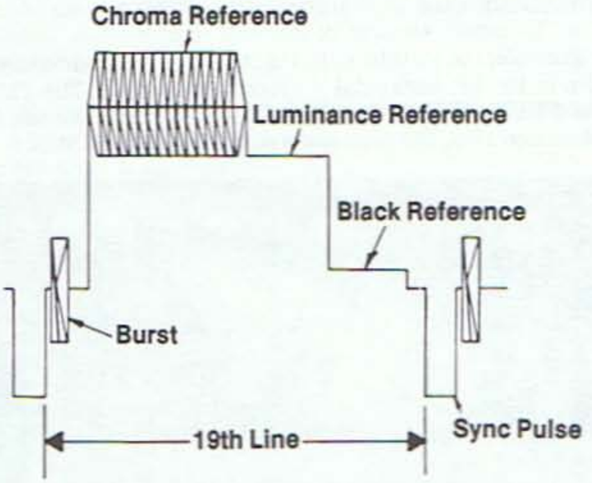


Fig. 36 — The VIRS consists of a chroma reference, a luminance reference, and a black reference.

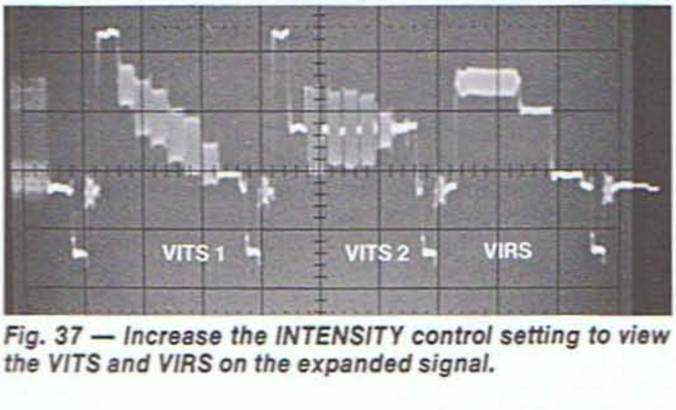


Fig. 37 — Increase the INTENSITY control setting to view the VITS and VIRS on the expanded signal.

Measuring time with the TIMEBASE-FREQ switch

The digital Delta Time function eliminates analog time measurements for most applications. A few applications, however, may require the use of the CRT because the time period is too short to accurately set the DELTA BEGIN and DELTA END controls.

There are two sets of markings around the TIMEBASE-FREQ switch. Use the inside numbers to measure time. The numbers represents the amount of time needed for the trace to move horizontally **one major division** on the CRT screen. The horizontal vernier control must be set to the fully clockwise "Cal" position for accurate results.

To measure the time period of any signal:

1. Set the horizontal vernier to the fully clockwise "Cal" position.

2. Adjust the TIMEBASE-FREQ switch until sufficient detail is shown on the CRT to view the part of the waveform to be measured. Use the 10X expand feature, if necessary, on fast signals.

3. Adjust the VERTICAL POSITION control until the part of the waveform to be analyzed is on the center horizontal graticule line.

4. Adjust the HORIZ POSITION control until the beginning of the part of the waveform to be analyzed is lined up with a vertical CRT graticule line (it does not matter which one).

5. Count the number of divisions occupied by the part of the waveform that must be measured. Remember that each minor division represents .2 major divisions.

6. Multiply the number of divisions times the setting of the TIMEBASE-FREQ switch. The sweep rate is one-tenth the marked time if the 10X expand feature is used.

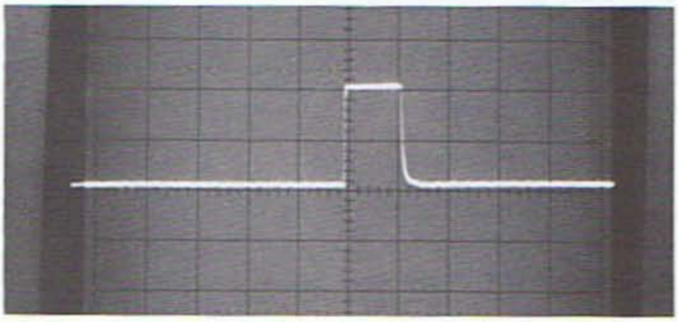


Fig. 38 — The number of divisions occupied by the waveform are counted and multiplied by the setting of the TIMEBASE-FREQ switch. This pulse is 1.3 divisions wide (each minor division is .2 major divisions).

Rise time measurement

Rise time is that time between the 10% and 90% points of the leading edge of a square wave or pulse waveform. This is also called "transition time" in some literature.

To measure rise time:

1. Connect the SC61 to the desired signal source and use the TRIGGER controls to lock the signal on the CRT.

2. Adjust the TIMEBASE-FREQ switch so that only one or two cycles of the waveform are on the screen.

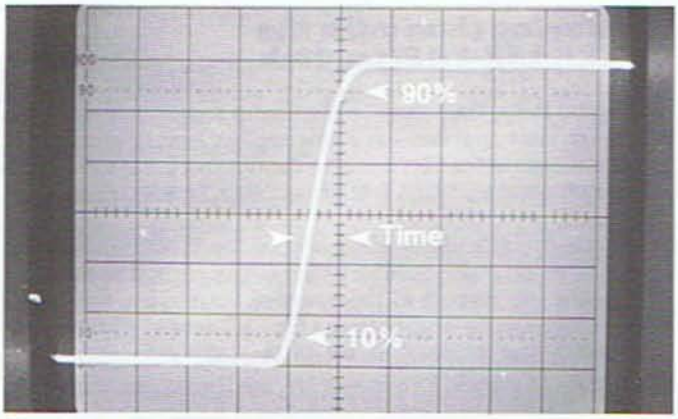


Fig. 39 — Risetime is measured between the 10 and 90 marks after adjusting the waveform to extend from 0 to 100.

3. Set the HORIZONTAL VERNIER control to the fully clockwise "calibrated" position.

4. Adjust the VOLTS/DIVISION switch and vernier control so that the waveform fills the 6 divisions on the graticule, between the "0" and "100" marks. Use the VERTICAL POSITION control to place the two extremes of the waveform at these points.

5. Measure the number of divisions on the horizontal axis that the trace occupies between the 10% and 90% points. The number of divisions is then multiplied by the setting of the TIMEBASE-FREQ switch setting.

NOTE: If the rise time is too small to be seen with the normal setting of the TIMEBASE-FREQ switch, pull the 10X EXPAND switch and measure the number of divisions. Multiply number of horizontal divisions the trace occupies by the setting of the TIMEBASE-FREQ switch and divide the result by 10 to get the actual rise time.

Fall time measurement

Fall time is that time between the 90% and 10% points on the trailing edge of a square wave or pulse. It is measured in the same way that the rise time is measured.

Determining frequency with the TIMEBASE-FREQ switch

The digital circuits provide fast and accurate tests of frequency of either an entire waveform or part of one. The TIMEBASE-FREQ switch may be used to determine the approximate frequency of an unknown signal, however, for special applications.

The frequency markings of the TIMEBASE-FREQ switch simplify frequency calculations. These markings represent the frequency of a signal that displays exactly one cycle across the 10 full horizontal CRT divisions. *NOTE: Remember that Sencore oscilloscopes, marked with frequency, have two different methods of calibrating the horizontal control. The frequency markings represent the full 10 divisions, while the time markings represent the time for one major CRT division.*

Frequency calculation involves setting the TIMEBASE-FREQ switch to one of the seven settings marked with a frequency, counting the number of cycles of the unknown signal in all ten horizontal CRT divisions, and multiplying the number of cycles times the marked frequency.

To determine the frequency of the input signal:

1. Set the horizontal vernier to the fully clockwise "Cal" position.

2. Adjust the TIMEBASE-FREQ switch until more than one cycle of the waveform is shown on the CRT and the switch is in one of the seven positions marked with a frequency. The 10X expand may be activated by pulling the HORIZ POSITION control for signals over 10 MHz.

NOTE: Any number of cycles may be used. The highest accuracy, however, results when fewer than 10 cycles are shown across the full width of the CRT. Using the fewest number of cycles possible reduces interpretation error when estimating the partial cycle in the last CRT division.

3. Adjust the VERTICAL POSITION control until the waveform is centered on the center horizontal graticule line.

4. Adjust the HORIZ POSITION control until the beginning of one complete cycle lines up with the left-most line on the graticule and (at the same time) the waveform extends to the right-most graticule line.

5. Count the number of **complete cycles** displayed in the ten horizontal CRT divisions. If the last cycle does not end exactly on the right-hand graticule mark, estimate what fraction of the last cycle is present at the right-hand line.

Multiply the number of whole and fractional cycles in the ten horizontal divisions times the setting of the TIMEBASE-FREQ switch.

NOTE: Multiply the frequency times ten if the 10X expand function is activated.

For example, the waveform in Fig. 40 shows approximately 9.4 cycles in the ten horizontal divisions of the CRT. The TIMEBASE-FREQ switch is in the 1 MHz position without the 10X expand activated. The resulting frequency is then 9.4 MHz.

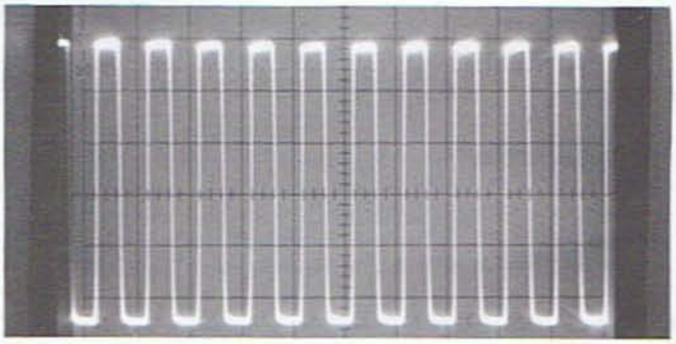


Fig. 40 — Count the number of full and partial cycles in the 10 horizontal divisions when making analog frequency measurements. Here are 9.4 cycles.

Secondary user controls

There are five secondary adjustments accessible through small holes in the front panel. Use a small screwdriver to adjust these controls. These controls require only occasional adjustment to compensate for slight drift in the internal circuits. The following instructions explain how to test or adjust each of the secondary controls.

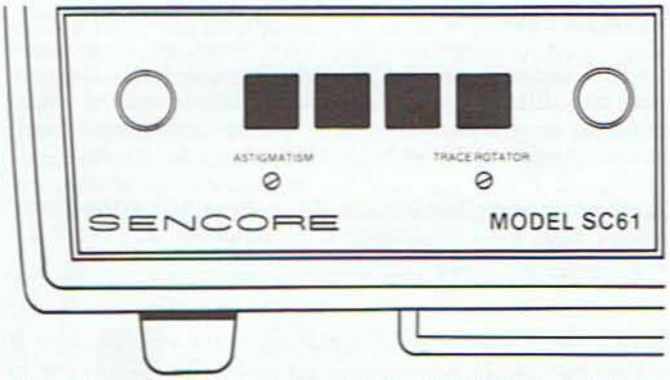


Fig. 41 — Location of the ASTIGMATISM and TRACE ROTATOR controls.

ASTIGMATISM

The ASTIGMATISM control works in conjunction with the FOCUS control to produce the sharpest possible trace. The ASTIGMATISM control compensates for minor changes in the CRT and high voltage power supply. The ASTIGMATISM and FOCUS controls are simply balanced for the sharpest trace. Once the controls are balanced, the FOCUS control should have sufficient range to compensate for variables, such as changes in brightness, different sweep speeds, etc.

To adjust the ASTIGMATISM control:

1. Set both INPUT COUPLING switches to the "ground" position and depress the VECTOR CRT display pushbutton.

2. Adjust the INTENSITY control until a dot appears that is reduced in brightness enough to prevent blooming (a halo around the dot).

3. Alternately adjust the FOCUS and ASTIGMATISM controls until the dot is as small and round as possible. It is normal for the two controls to interact.

TRACE ROTATOR

The TRACE ROTATOR ensures the trace is parallel to the CRT graticule markings. External magnetic fields (including the earth's) affect every oscilloscope. If, for example, you move the SC61 from a north-south to an east-west orientation, the tilt of the CRT beam changes slightly. It is normally not necessary to reset the TRACE ROTATOR control unless the SC61 is moved to a new location or some change occurs in the external magnetic fields.

To set the TRACE ROTATOR:

1. Set the TRIGGER MODE switch to "Auto" to provide a base line with no input signal.

2. Set the channel A INPUT COUPLING switch to the "ground" position and depress the CHAN A CRT display pushbutton.

3. Adjust the channel A VERTICAL POSITION control until the trace is adjacent to one of the CRT graticule lines.

4. Adjust the TRACE ROTATOR until the trace is parallel to the CRT graticule line.

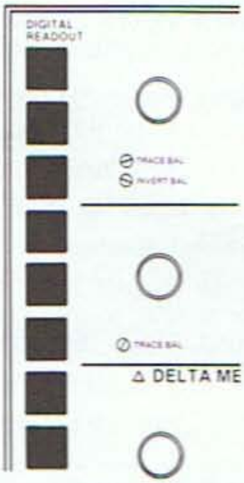


Fig. 42 — Location of the amplifier balance controls.

TRACE BAL

The two TRACE BAL controls balance DC bias of the vertical amplifiers to insure the trace does not move vertically when adjusting the VOLTS/DIVISION switches or the vertical vernier controls. Proper setting of these controls results in accurate measurements when using the CRT display to measure the DC level of a signal.

To set the TRACE BAL controls:

1. Set the TRIGGER MODE switch to "Auto" to provide a baseline with no input signal.

2. Set the channel A INPUT COUPLING switch to the "ground" position and depress the CHAN A CRT display pushbutton.

3. Set the channel A VOLTS/DIVISION switch to the ".5" position.

4. Set the channel A vernier control fully counterclockwise.

5. Adjust the channel A VERTICAL POSITION control until the trace lies on the horizontal center line of the CRT.

6. Turn the channel A vernier control fully clockwise. If there is any movement of the trace away from the center line, adjust the TRACE BAL control until it returns to the original position.

7. Repeat steps 4 through 6 until there is no further improvement.

8. Repeat steps 2 through 7 for channel B.

NOTE: The TRACE BAL controls are 10-turn potentiometers.

INVERT BAL

The INVERT BAL control balances the DC bias on the channel A inverting amplifier to prevent a change in vertical position when the trace is inverted. **This control should not be adjusted until the channel A TRACE BAL control is properly set.**

To set the INVERT BAL control:

1. Perform the TRACE BAL adjustment listed above. Leave all front-panel controls set as indicated in the previous procedure.

2. Press the CHAN A CRT selector pushbutton.

3. Adjust the channel A VERTICAL POSITION control until the trace lies on the horizontal center line of the CRT.

4. Pull the channel A VERTICAL POSITION control to activate the invert function. Be sure you do not change the setting of the control as it is pulled.

5. If the trace moves, adjust the INVERT BAL control to return it to the center line.

6. Carefully push the channel A VERTICAL POSITION control back to the non-inverted position. If there is a change in trace movement, repeat steps 3 through 6 until there is no further improvement.

NOTE: The INVERT BAL control is a 10-turn potentiometer.

Rear panel fuses and connectors

Fuse replacement

WARNING

Always replace the protective fuses with the correct type and rating. Any other fuse type or rating may cause internal damage to the SC61 or create a fire or safety hazard. Using an improper fuse type or rating voids all warranties.

The SC61 has two protection fuses located on the rear panel. The left-hand fuse is the AC power line fuse. The right-hand fuse protects the low voltage supply from possible damage if the high voltage power supply fails.

A blown fuse often indicates some problem inside the SC61. Try replacing the fuse first, as a fuse occasionally blows for no apparent reason. If the fuse continues to blow, the SC61 should be serviced.

Fuse	Size	Symptom for Blown Fuse
AC Line	1A, Slo-Blo, 3AG	Completely dead, including LCDs.
HV Supply	¼A, Slo-Blo, 3AG	LCD's work, but no trace, even when BEAM FINDER pressed

Fig. 43 — Location of the fuses and jacks on the back panel.

Z AXIS INPUT

A signal applied to the Z AXIS INPUT connector on the rear panel intensifies or blanks the trace. A positive signal of 5 volts causes the trace to blank. The direct-coupled input allows modulation with any signal from DC to 5 MHz.

Do not apply more than 35 volts (DC + Peak AC) to the direct-coupled input. Possible damage to the amplifier may result if a larger amplitude is applied.

NOTE: The Z AXIS INPUT signal leads the channel A or B vertical input by 70 nanoseconds due to the signal delay line in the vertical amplifiers. Consider this delay when using Z AXIS modulation for critical timing tests.

Accessory (output) jack

The small pin-jack on the rear of the SC61 provides an unregulated DC power supply output to power accessories, such as the PR47 600 MHz Prescaler. The output voltage is between 12 and 15 volts DC, with a maximum output current of 100 mA. An accessory connected to the BNC input connectors uses the ground of the connector as the negative return path. Ground isolated accessories through the GROUND jack on the front panel.

The digital readout

Introduction

The internal microcomputer monitors the signals applied to the channel A or B inputs. Pressing the correct DIGITAL READOUT pushbutton displays one of the seven parameters monitored by the microcomputer. The same probe feeds the signal to the microcomputer and the CRT display. Sencore calls this "Auto-Tracking™" because the microcomputer constantly, and automatically, tracks the CRT input at all times.

The CRT and digital display are often used together to completely analyze the signal at a test point. It is usually best to lock the waveform onto the CRT before making digital measurements. Most digital tests, however, operate properly without the CRT trace locked in. This allows the digital tests to be made by themselves, or made before locking in the CRT. The digital peak-to-peak or frequency reading, for example, often helps set the CRT vertical and horizontal controls for an unknown signal.

Digital readout not affected by CRT controls
The unique design of the SC61 provides a complete interface between the CRT display section and the digital readout. The signals feed directly from the vertical amplifiers and horizontal trigger circuits to the microcomputer. Each signal connection is made ahead of circuits strictly associated with the CRT display, such as the position controls or the verniers, allowing the CRT display to be any convenient size without affecting the digital tests.

Measuring DC volts

The 39G183 low-capacity probe supplies signals from the test point to the CRT input and DC input for most tests. The use of the (supplied) 39G157 DC voltage probe allows using the DC test independently from the CRT input.

The DCV function measures the average DC voltage at a test point to agree with the DC values shown on schematics. Applications requiring the absolute DC value of part of a waveform (such as the amplitude of the highs and lows of a digital signal) require conventional analog technique, as explained on page 21.

The DCV function is fully autoranged, allowing it to operate independently of the CRT display. The CRT display may be adjusted to any convenient size, and the INPUT COUPLING switch may be in any position without affecting the DC readings.

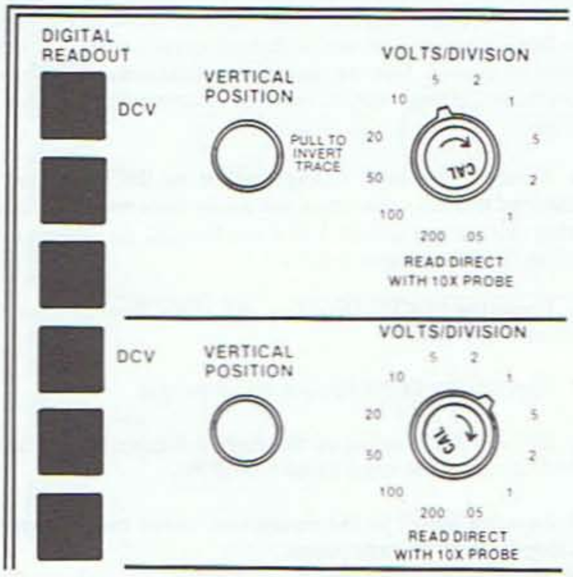


Fig. 44 — Press the channel A or B "DCV" button to measure the average DC voltage applied to the probe. The VERTICAL POSITION controls and VOLTS/DIVISION switches have no effect on the reading.

WARNING

The SC61 DCV function is referenced to the chassis. There is no safe way to float the SC61 to make measurements in circuits that have a common voltage above or below earth ground. These measurements should only be made with a separate meter with sufficient common mode protection (sometimes called "DC Offset") to match the required offset.

To measure DC volts:

1. Supply the DC signal to the DCV IN jack of channel A or B using the 39G157 DC probe or the DCV lead of the 39G183 low-capacity probe.

2. Press the channel A or B "DCV" DIGITAL READOUT pushbutton.

3. Read the digital display. The readings are direct when the supplied probes are used.

Accuracy between channels

The channel A and channel B DC inputs each read within .5% of the actual signal level. The two channels are also matched to read within .5% of each other. Each channel may show a slightly different reading if both probes are connected to the same test point.

For example, applying a precise 1 volt signal to either channel could result in a reading between .995 and 1.005 volts and still be within the .5% tolerance. Adding the two tolerances together results in a possible 1% difference between the channel A and B reading. However, the two channels are matched to keep each channel within .5% of each other.

DC loading

The input impedance of the SC61 is 1.5 megohms at the DCV IN jack. The 39G183 or 39G157 probe has a 13.5 megohm resistor in series with the input to isolate the capacity of the DCV lead from the circuit. The total input impedance is then 13.5 + 1.5 megohms or 15 megohms.

The 15 megohm input impedance, however, is in parallel with the 10 megohm input of the CRT display at the tip of the 39G183 probe, resulting in a parallel impedance of 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. This may be done in one of two ways.

The BNC connector of the 39G183 probe may be disconnected while the DCV IN connector is still connected to the SC61. The 10 megohm input to the CRT is then removed from the parallel path, resulting in the full 15 megohm input impedance. Or, the separate 39G157 DCV probe may be used without the 39G183. In either case, the front panel GROUND lead should be connected to the circuit ground to provide a signal return path.

Peaking or nulling signals

Some applications require the DC level at a test point to be set to the highest or lowest possible value. Any digital DC meter will be slower than using an analog readout because the digital readout updates in steps, rather than on a continuous basis. The CRT display may be used to provide an analog indication of the peaking or nulling action while the DCV function is used to accurately determine the DC level after the ciruict has been set to the peak or null.

To peak or null a circuit:

1. Set the TRIGGER MODE switch to the "Auto" position to provide a CRT trace.

2. Set the INPUT COUPLING switch to the "DC position.

NOTE: It is not necessary to establish a zero reference point because the CRT display will be used for relative peaking and nulling action, and not to determine the actual DC voltage level.

3. Press the "DCV" DIGITAL READOUT button for the channel being used.

4. Note the DC level on the DIGITAL READOUT, and set the VOLTS/DIVISION switch to a position between one-half and one-eighth the measured value. For example, if the DC level is 12 volts, set the switch to the "2" or "5" position.

NOTE: It is not necessary to set the vernier control to the calibrated position, as the CRT is only used as a relative indicator.

5. Observe the CRT display while adjusting the circuit. The CRT trace will move up or down, as the DC level increases or decreases. A peak has been reached when the CRT trace reaches its highest point and begins to decrease, or a null has been reached when the CRT trace reaches its lowest point and begins to increase.

Measuring over 2000 volts DC

Two optional high voltage probes allow DC measurements over 2000 volts. These probes divide the DC signal by 10 or 100. The probes are used with the supplied 39G157 DCV Probe. The 39G157 slips into a special connector in the rear of the multiplier probe which, in turn, is connected to the circuit test point.

The optional TP212 Transient Protector Probe allows voltage measurements to 10 KV with 1% accuracy. The TP212 divides the input signal by 10, requiring the decimal place of the displayed value to be moved one place to the right for the actual circuit voltage. For example, a reading of 395 volts represents a circuit voltage of 3950 volts.

The optional HP200 High Voltage Probe allows voltage measurement to 50 KV with 2% accuracy. The HP200 divides the input signal by 100, requiring the decimal place of the displayed value to be moved two places to the right for the actual circuit voltage. For example, a reading of 395 volts represents a circuit voltage of 39,500 volts.

NOTE: The high voltage probes increase the input impedance by a factor of 10 or 100, allowing measurements in high impedance circuits with minimum DC loading. The TP212 results in a 150 megohm input impedance, or the HP200 results in a 1500 megohm (1.5 gigohm) input impedance.

WARNING

Do not attempt to perform any high voltage testing until you have completely read and understood the following warnings and instructions!

1. Never attempt to measure more than 2000 volts without the use of a high voltage probe. To do so may damage the SC61, the equipment under test, and/or cause a severe shock hazard to the operator.

2. If the common lead should become detached during a high voltage measurement, immediately remove power to the circuit under test. Do not touch the lead, the SC61, or the high voltage probe until the power has been removed as there is a possibility of a severe shock hazard. Be sure the SC61 functions properly before continuing to use it after power to the circuit has been removed. **Damage to the SC61 because of a detached ground lead is not covered by any warranty.**

3. If the SC61 probe should become detached from the high voltage probe during a measurement, immediately remove the power to the circuit under test. Do not touch the high voltage probe until the power has been removed and the high voltage is discharged as there is the possibility of a severe shock hazard.

4. If the high voltage probe must be held during a measurement, do so with extreme caution. Be sure the connection to the probe and the ground lead are firmly attached. Hold the probe behind the molded safely rings to prevent the possibility of contacting the high voltage test point or to prevent arcing across the probe to your body.

5. Remove the power to the circuit under test before making connection to the test point or before disconnecting the high voltage probe from the circuit.

To measure over 2000 volts DC:

1. **Remove power from the equipment in which the high voltage is to be measured.**

2. Connect the 39G157 probe to either of the DCV IN jacks. **Be sure the connector is firmly seated.**

3. Slide the tip of the 39G157 into the opening at the rear of the high voltage probe. **Be sure the tip is firmly seated in the connector inside the probe in such a way that it cannot become detached during the measurement.**

4. **Securely** attach the black ground lead supplied with the SC61 to the common point of the circuit to be tested. **Be sure this lead cannot become detached during the high voltage measurement.** Connect the other end to the GROUND jack on the SC61.

NOTE: The common point must be referenced to earth ground. The SC61 chassis must not be floated above earth ground during a measurement. Use an isolation transformer on the circuit being tested if necessary to isolate the common point from earth ground.

5. Connect the high voltage probe to the test point to be measured **in such a way that the probe does not have to be held during the measurement.** If it must be held, do so with extreme caution (see warning #4 at left).

6. Press the "DCV" DIGITAL READOUT pushbutton for the SC61 channel used.

7. Apply power to the equipment under test.

8. Multiply the reading on the digital display by 10 when using the TP212 or by 100 when using the HP200.

9. **Remove power to the equipment under test before disconnecting the high voltage probe.**

Fig. 45 — Use extreme caution when measuring high voltage with the optional HP200 (shown) or TP212 high voltage probe.

Measuring peak-to-peak volts

The SC61 uses a special (patent pending) circuit that measures the true peak-to-peak amplitude of any signal applied to the channel A or B input. Simply press the channel A or B VPP DIGITAL READOUT pushbutton for a direct readout of the signal amplitude. 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.

You may find at times that the digital readout shows a higher value than is displayed on the CRT. If there is a difference, the digital display will be the more accurate for two reasons. First, the digital peak-to-peak readout is much more accurate. As is typical of most scopes, the CRT amplitude accuracy is 4% with a frequency response of 3dB. The peak-to-peak meter, however, has an accuracy of 2% and frequency response of 0.5dB.

Secondly, the digital meter measures fast transitions on the signal which may not be readily noticeable on the CRT. Two waveform imperfections or interference cause higher peak-to-peak readings. The interference may be overshoot or other fast spikes too dim to normally see. In addition, random noise spikes may occur in either case, something not readily visible on the CRT is causing the meter to read higher.

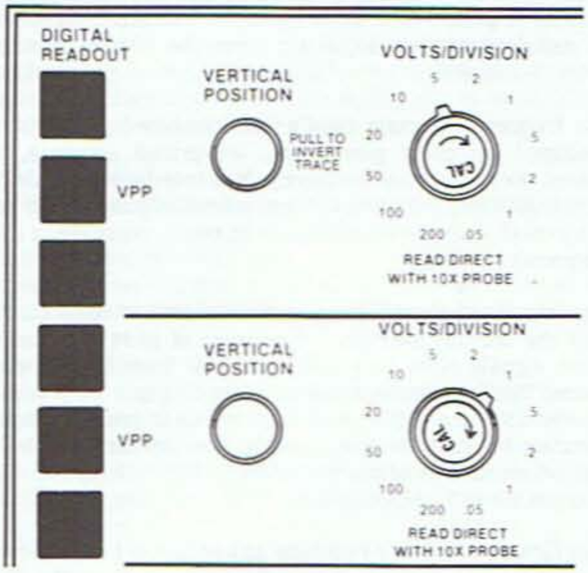


Fig. 46 — The channel A or B "VPP" buttons measure the amplitude of the entire waveform. The VERTICAL POSITION control and vertical vernier have no affect on the accuracy.

Using VPP without the CRT

The digital VPP function speeds signal tracing when the waveshape of the signal is not important. Simply press the VPP button for the channel you are using and move from one test point to another without setting the controls needed for a fully locked CRT display. The VPP test will show the overall amplitude at each point.

The resolution of the digital display is controlled by the VOLTS/DIVISION switch. Move the VOLTS/DIVISION switch to a lower range setting if less than three full digits of resolution are shown on a measurement. Move the switch to a higher range if the displays shows an "overrange" indication of flashing eights.

Using the VPP function to set the CRT display

The VPP function confirms that the setting of the VOLTS/DIVISION switch agrees with the amplitude of the measured signal. If, for example, the trace appears as a straight line, the test point may have no signal, or the VOLTS/DIVISION switch may be set for too large an amplitude. Press the VPP button for the channel you are viewing to determine if there is a signal present. If only one or two digits of the display show a number, reduce the range of the VOLTS/DIVISION switch.

If, on the other hand, the display shows an overrange indication (flashing 888), the input signal is larger than the CRT can display. Increase the setting of the VOLTS/DIVISION switch until the overrange stops.

Frequency measurements

Pressing the channel A or B "FREQ" digital readout button displays the frequency of the signal applied to the vertical input. The frequency function is fully autoranged, so there is no need to select resolution, read rates, or frequency ranges. The microcomputer automatically selects one of two signal conditioning circuits for stable frequency readings.

The SC61 measures signals from 1 Hz to 100 MHz. The SC61 microcomputer automatically selects one of seven internal frequency counter ranges. Signals up to 100 Hz have two full digits after the decimal point for extremely accurate readings on low frequency signals. Signals from 100 Hz to 100 KHz have .1 Hz resolution for accurate audio measurements. Higher frequency signals are autoranged to provide six full digits of resolution. See Fig. 47 for details.

Range Number	Frequencies Covered	Resolution	Update Time
1	1-10 Hz	.01 Hz	2 sec.
2	10-99.9 Hz	.01 Hz	.2 sec.
3	100-999.9 Hz	.1 Hz	.2 sec.
4	1-99.9 KHz	.1 Hz	.2 sec.
5	100-999.9 KHz	1 Hz	.2 sec.
6	1-9.99 MHz	10 Hz	.2 sec.
7	10-99.9 MHz	100 Hz	.2 sec.

Fig. 47 — The microcomputer automatically selects the correct range and read-rate for any applied frequency.

Frequency accuracy versus resolution

The accuracy of the SC61 frequency readings is .001% from 15 - 35°C. This accuracy is the same as most stand-alone frequency counters. The six digit display matches this accuracy for reliable results. Frequency counters with higher accuracy (and more digits) are generally only needed for transmitter service that requires maintaining a frequency to FCC specifications.

The .001% accuracy of any service-grade frequency counter means that a frequency of 1 MHz will be measured accurately to ±10 Hz. The 3.58 MHz color oscillator frequency of a video recorder, for example, is accurate to ±36 Hz (.001% times 3.58 MHz). As you can see, the last digit of a 7-digit, .001% frequency counter is totally meaningless.

The SC61 provides resolution that agrees with the measuring accuracy. The last digit of a 3.58 MHz reading, therefore, is within ±4 counts.

But, the question still remains, "Is this accurate enough to use as a frequency reference?" The answer is yes any time you calibrate an uncompensated crystal oscillator. The SC61 accuracy exceeds the accuracy of the circuit, except in the case of a TCXO (temperature compensated crystal oscillator) module or an oven-controlled crystal. These high accuracy circuits, however, are rarely found in applications outside broadcast or communications transmitters.

Signal levels needed for a stable reading

The SC61 frequency function allows the frequencies of two signals to be measured, even though they may be totally unrelated. The SC61 requires two internal frequency channels to accomplish this. Each channel has a slightly different design to give optimum results. The microcomputer automatically selects which of the two channels is used to display a frequency reading depending on which channel "FREQ" button is selected, and which input is used to trigger the CRT display.

The "main" frequency channel receives its signal from the output of the CRT trigger amplifier. Taking the signal from the trigger output results in a stable frequency reading any time the CRT display is locked to the incoming signal. This, in turn, allows frequency measurement of complex waveforms, which cannot be measured with a conventional counter. The microcomputer automatically selects the main counter channel 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 most important thing to remember about the main counter channel is that the frequency counter reads correctly whenever the CRT display is locked to the incoming signal. Conversely, the counter will read all zeros if the trigger circuits are not locked.

The second counter ("auxiliary") channel allows counting a second signal, unrelated to the signal used to trigger the CRT display. The auxiliary channel provides more stable signals than most stand-alone frequency counters because it has an auto-baseline circuit that seeks the average DC level of the incoming signal. Most counters accurately measure either a positive or negative polarity pulse, but not one of the opposite polarity. Some brands of counters measure positive pulses, and others measure negative pulses. The SC61 measures both.

The auxiliary channel requires at least 1.5 major divisions of signal on the CRT for accurate measurements. Check the amplitude of the auxiliary channel on the CRT to confirm the signal is large enough to measure. Change the setting of the VOLTS/DIVISION switch if the CRT amplitude is less than 1.5 major divisions.

The chart in Fig. 48 shows when the main and auxiliary channels are used for the different TRIGGER SOURCE switch positions. For example, if the CRT is triggered from channel A, pressing the channel A "FREQ" button routes the signal through the main channel. Pressing the channel B "FREQ" button routes the signal through the auxiliary channel.

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

Fig. 48 — The microcomputer automatically routes the signal through the correct counter channel depending on the source used for triggering the CRT.

Frequencies below 10 Hz require longer counting time

The microcomputer automatically selects the amount of time needed for each frequency reading. All frequencies above 10 Hz use an update rate of .2 seconds. A special microcomputer program provides extra resolution in the 10 Hz to 100 KHz range to provide .1 Hz resolution with a .2 second read rate. A conventional frequency counter requires a 10 second read rate to provide this same resolution.

Signals below 10 Hz require 2 seconds to produce the needed resolution and accuracy. The microcomputer automatically switches to the longer read time when these signals are measured.

Some video frequencies read low

A special circuit in the video sync separators compensates for the equalization pulses which follow the vertical sync of an interlaced video signal. A standard frequency counter shows a higher frequency than the SC61 because the equalization pulses (which occur at a rate twice the horizontal frequency) add to the standard sync pulses. The SC61 reads an interlaced signal at the correct frequency of 15,734 Hz when the trigger circuits are properly adjusted.

The frequency circuits read a non-interlaced signal (such as produced by color generators, low-priced cameras, video games, etc) at a lower frequency. Non-interlaced signals do not have equalizing pulses or vertical serration pulses. This results in a period of time with no signals to count, resulting in a lower frequency reading.

Non-interlaced signals have a vertical rate of 60.05 Hz rather than the normal interlaced frequency of 59.94 Hz. Non-interlaced signals have only 524 horizontal lines in one vertical frame. The extra line used in interlaced signals (to produce the standard 525 line raster) is divided in half to produce interlaced scanning in which the horizontal lines of one field fall between the horizontal lines of the second field. The missing line slightly changes the vertical frequency.

The first frequency reading takes from 1 to 3 seconds

The frequency function is usually selected after the CRT is adjusted to display the signal. The microcomputer locks to the incoming signal during the CRT setup procedure, or while some other DIGITAL READOUT button is pressed. The first reading takes about 1.2 seconds to appear when the "FREQ" button is pressed because the autoranging circuits first measure the signal for 1 full second (in case the incoming signal is less than 10 Hz) and then go through the normal .2 second reading to come up with the final range. The frequency function then updates at either the .2 second or 2 second rate, depending on the frequency of the incoming signal.

If the "FREQ" button is already depressed when the signal is first applied to the vertical input, however, there is about a 3 second pause before the first reading appears. The extra time is needed for the microcomputer to detect the signal, switch to the correct read rate, and process the data. The longer delay is normal, and should be expected when you first connect the probe to the circuit or first adjust the trigger circuits for a locked trace.

Removing signal causes last reading to freeze

The digital display continues showing the last reading for about four seconds if the input signal is suddenly removed. This feature may prove helpful when monitoring an intermittent oscillator, amplifier, etc, as the last frequency reading is left on the digital display long enough to note the frequency. When performing this test, observe the signal on the CRT to tell when the circuit signal quits. Read the digital display as soon as the CRT shows the signal has disappeared.

NOTE: The microcomputer must be in the frequency mode at the time the signal quits. You cannot switch to the frequency mode during the four second period and obtain the last frequency reading.

Delta Digital Tests

Delta Bar:

Measurement Bar: Intensified area set to any portion of waveform with Delta Begin and Delta End controls; functions of controls automatically reverse if overlapped.

Range: 1 second to 50 nanoseconds.
Setability: ±20 nS typical.

Peak-to-Peak Volts:

Function: Amplitude of intensified area measured.
Range and Specifications: Same as Peak-to-Peak volts above.
Source: Selected with channel A or B pushbutton.

Delta Time:

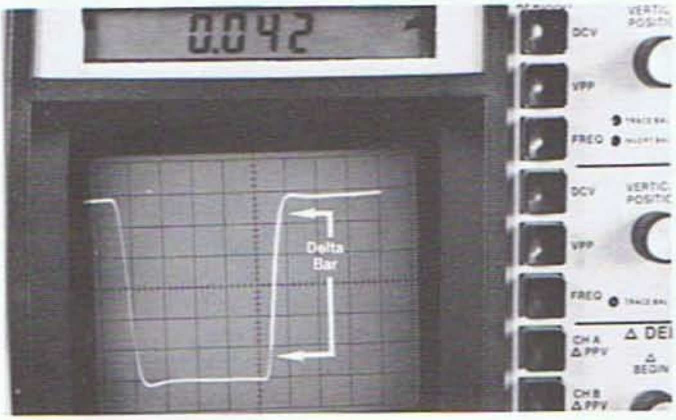
Function: Actual time of intensified area measured.
Accuracy: Same as frequency function above. Accuracy unaffected by setting of horizontal or vertical controls.
Ranging: Microcomputer automatically places decimal and annunciator reading of mS or uS.

1/Delta Time:

Function: Calculates equivalent frequency of Delta Time reading.
Accuracy: Same as Delta Time.
Ranging: Microcomputer automatically places decimal and annunciator reading of Hz, KHz, or MHz.

Digital Display:

Type: Liquid crystal with high temperature fluid for fast response time and high contrast.
Number of Digits: Six (resolution controlled by microcomputer).
Annunciators: 12 (controlled by microcomputer) Δ, A, B, MHz, KHz, Hz, uS, mS, VDC, VPP, A/B, and B/A.



The Delta measurements

The three Auto-Tracking™ tests of DC volts, peak-to-peak volts, and frequency measure the entire waveform. Many applications require measuring only a part of a waveform for amplitude, time relationships, or frequency. The SC61 Delta Measurements make these measurements with the same speed and accuracy of the Auto-Tracking™ tests.

Pressing any of the four Delta measurement buttons activates the Δ BEGIN and Δ END controls. These controls position an intensified bar anywhere on the waveform. The intensified bar is the only part of the waveform measured by the digital circuits.

The Δ BEGIN and Δ END controls are multi-turn potentiometers to allow the Delta Bar to be set with the highest degree of accuracy possible. The microcomputer automatically exchanges the funtion of the two controls if the end of the Delta Bar is positioned before the beginning. This feature eliminates the chance of losing the intensified bar when the beginning and end are overlapped. It also is 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.

A given combination of settings of the Δ BEGIN and Δ END controls results in the bar covering approximately the same percentage of the CRT screen horizontally for any setting of the TIMEBASE-FREQ switch or the horizontal frequency vernier. The beginning and ending positions will, therefore, need to be readjusted if the sweep rate is changed. However, the Delta Bar stays in the same position on the trace when changing the HORIZ POSITION control or activating the 10X expand function.

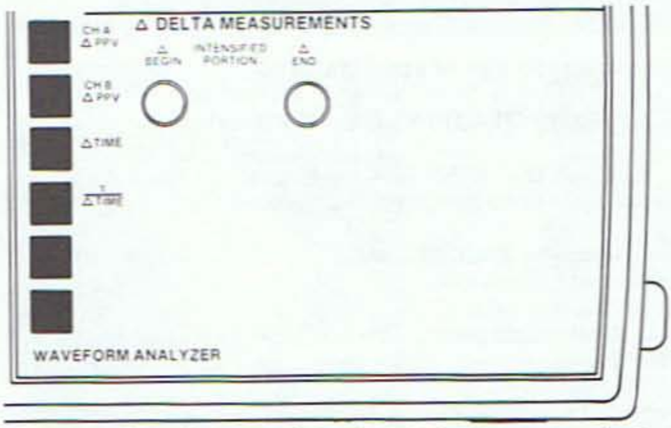


Fig. 50 — Pressing any of the four Delta buttons activates the Delta Begin and Delta End controls to set the position of the intensified bar on the waveform.

The beginning and end of the Delta Bar are always timed identically in channel A and B. This allows the Delta Bar to be used to measure the time delay between two signals, or to mark the position of a transition in one channel to compare the time relationship of a transition in the second channel.

The amount of intensity difference between the Delta Bar and the background is a fixed ratio. Use the INTENSITY control to adjust the contrast between the Delta Bar and background trace. It may be desirable, for example, to reduce the setting of the INTENSITY control until the Delta Bar is the only part of the trace shown. Increasing the setting of the INTENSITY control slightly causes the non-intensified areas of the waveform to also show on the CRT screen. Setting the INTENSITY control too high may result in little contrast between the Delta Bar and background, leading to difficulty in seeing the beginning and ending points.

It is much easier to determine the position of the Delta Bar when the trace is not expanded with the 10X expand feature because the intensified area may be in the 90% of the trace that is not shown in the expanded mode. The intensified area may be placed at the vertical center line, and the 10X expand feature activated after determining its position on the unexpanded waveform.

NOTE: The SC61 must be properly triggered for reliable Delta measurement because each measurement is made on the actual part of the signal intensified by the Delta Bar. Unstable triggering conditions cause unstable Delta readings. A total lack of a CRT trace (caused by setting the TRIGGER MODE switch to "Norm" and having the TRIGGER LEVEL control set outside the range of the input signal) causes the delta functions to read zero.

Delta peak-to-peak

The ΔPPV function measures the amplitude of the portion of the waveform intensified by the Delta Bar. The amplitude of channel A or B may be measured by depressing the appropriate button. The digital circuits measure all parts of the intensified signal.

Some applications may require the Delta Peak-to-Peak function to isolate extraneous signals from an amplitude reading. A waveform with an overshoot or other interference, for example, will include the interference in the total peak-to-peak value, even though the interference has no affect on the circuit. Simply use the Delta Bar to intensify all parts of the waveform except the interference to measure the effective amplitude of the rest of the signal.

To measure the PPV of a part of a signal:

1. Press the CH A ΔPPV or CH B ΔPPV button.

2. Adjust the INTENSITY control for the desired contrast between the Delta Bar and the background.

3. Adjust the ΔBEGIN and ΔEND controls until the area to be measured is intensified.

4. Read the amplitude of the intensified area on the digital display.

NOTE: The special display annunciators will show the "Δ" and "A" or "B" to show which channel is being measured and "VPP". The readings are direct when the supplied 10X low-capacity probe is used. The decimal should be moved one place to the left if a direct probe is used.

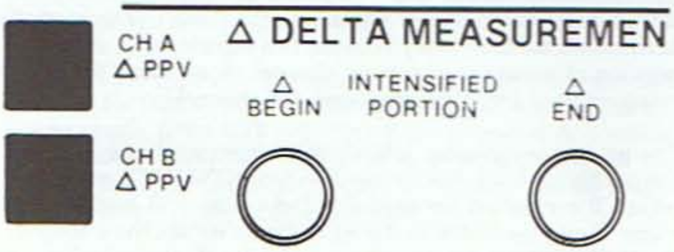


Fig. 51 — The amplitude of any part of the channel A or B waveform is measured by pressing the correct button and adjusting the BEGIN and END controls until the Delta Bar covers the area to be measured.

Slow sweep speeds require longer ΔPP time

The peak-to-peak function makes between 2 and 26 calculations for each digital update, depending on the signal amplitude. This method provides the highest accuracy possible over the wide frequency range of the SC61. The standard VPP function makes the tests continuously, providing a readout in less than one second for any input signal. The Delta function, however, may make only one calculation for each sweep (depending on the applied signal) because the peak-to-peak circuits are only activated during the time the waveform is intensified with the Delta Bar. Delta peak-to-peak measurements on the three slowest sweep speeds (20, 50, and 100 m sec/division) require longer measuring times.

Delta peak-to-peak and video signals

Delta peak-to-peak readings of video signals require the use of the special video sync separators. The sync separators eliminate vertical sync interference in addition to their main function of producing a stable trace. The Delta peak-to-peak test may show an error when attempting to measure part of a horizontal line with vertical interference. Consider the following example to understand why this is true.

The waveform in Fig. 52 shows the vertical sync interference common to all other triggered oscilloscopes. Notice the faint vertical sync pulse extending between the horizontal sync pulses. Now, look at Fig. 52 to see what happens when the Delta peak-to-peak function is applied to this signal. The color burst is intensified with the Delta Bar. But, the circuits measure the amplitude from the bottom of the sync pulse to the top of the burst (as shown) rather than the burst by itself. Now, compare this to the results obtained when the sync separators are properly used.

The sync separators detect the vertical sync and blanking signals and prevent the CRT from sweeping during that time. The result is clean horizontal signals without the vertical interference. The amplitude of the color burst (or any other portion of the waveform) will now be accurately measured with the Delta peak-to-peak test as shown in Fig. 53.

NOTE: Always check for the presence of the faint vertical sync pulse before attempting to make a Delta peak-to-peak measurement on a horizontal video waveform. Adjust the TRIGGER LEVEL control until the vertical interference is eliminated.

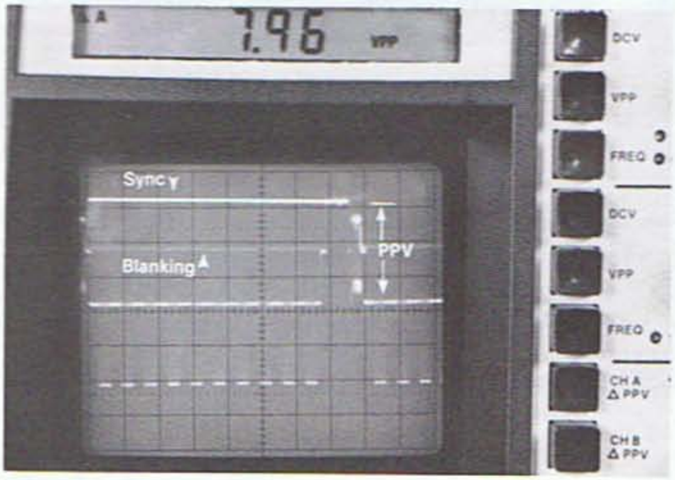


Fig. 52 — The Delta P-P function will measure the amplitude from the vertical sync pulse to the top of the waveform if the video sync separators are improperly adjusted.

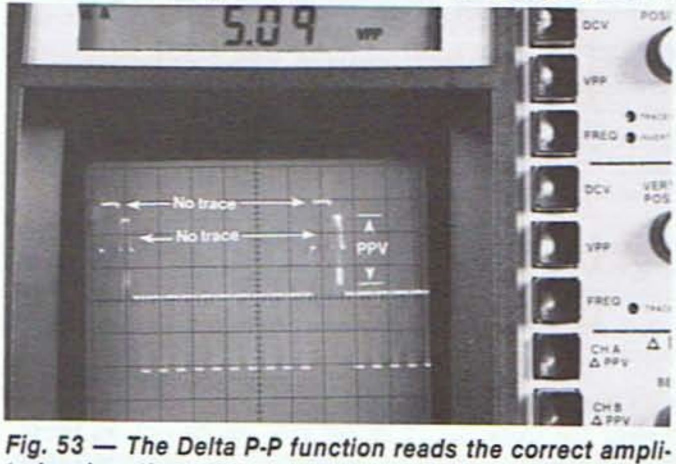


Fig. 53 — The Delta P-P function reads the correct amplitude when the sync separators are adjusted to eliminate the vertical sync information.

Delta Time measurements

The Delta Time function measures the actual time duration of the intensified Delta Bar. The time is measured with the same high accuracy circuits used to measure frequency. The Delta Bar minimized interpretation errors because the intensified area is part of the waveform, eliminating parallax errors and errors in interpreting a part of a CRT division.

To measure any time relationship:

Press the **Δ**TIME button.

2. Adjust the INTENSITY control for the desired contrast between the Delta Bar and the background.

3. Adjust the **Δ**BEGIN and **Δ**END controls until the area to be measured is intensified.

4. Read the time relationship on the digital display.

NOTE: The microcomputer automatically places the decimal and selects the "mS" or "uS" annunciator. The channel A or B annunciators are not displayed for time measurements because the Delta Bar measures the same time interval in both channels.

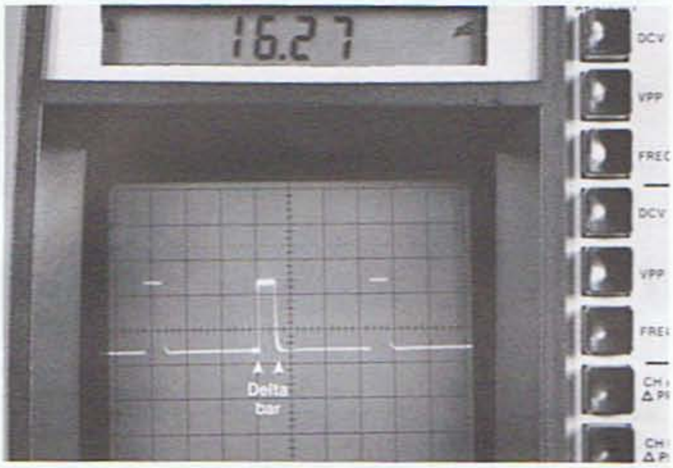


Fig. 54 — The Delta Time function measures the actual time of the intensified area. The vertical or horizontal verniers have no effect on the accuracy.

Measuring duty cycle

The **Δ**TIME feature may be used to make the two measurements needed to calculate duty cycle by changing only one of the Delta Bar position controls. Follow the waveforms in Fig. 55 as you read the following instructions.

To determine duty cycle:

1. Press the **Δ**TIME button.

2. Adjust the **Δ**BEGIN and **Δ**END controls until the on-time of the waveform is intensified.

3. Read the digital display and record the displayed time.

4. Adjust the **Δ**BEGIN and **Δ**END control until one full cycle of the waveform is intensified.

5. Read the digital display and record the displayed time.

6. Divide the on-time by the total time to determine the duty cycle. For example, an on-time of 50 uS, and a total time of 100 uS, represents a duty cycle of 50%.

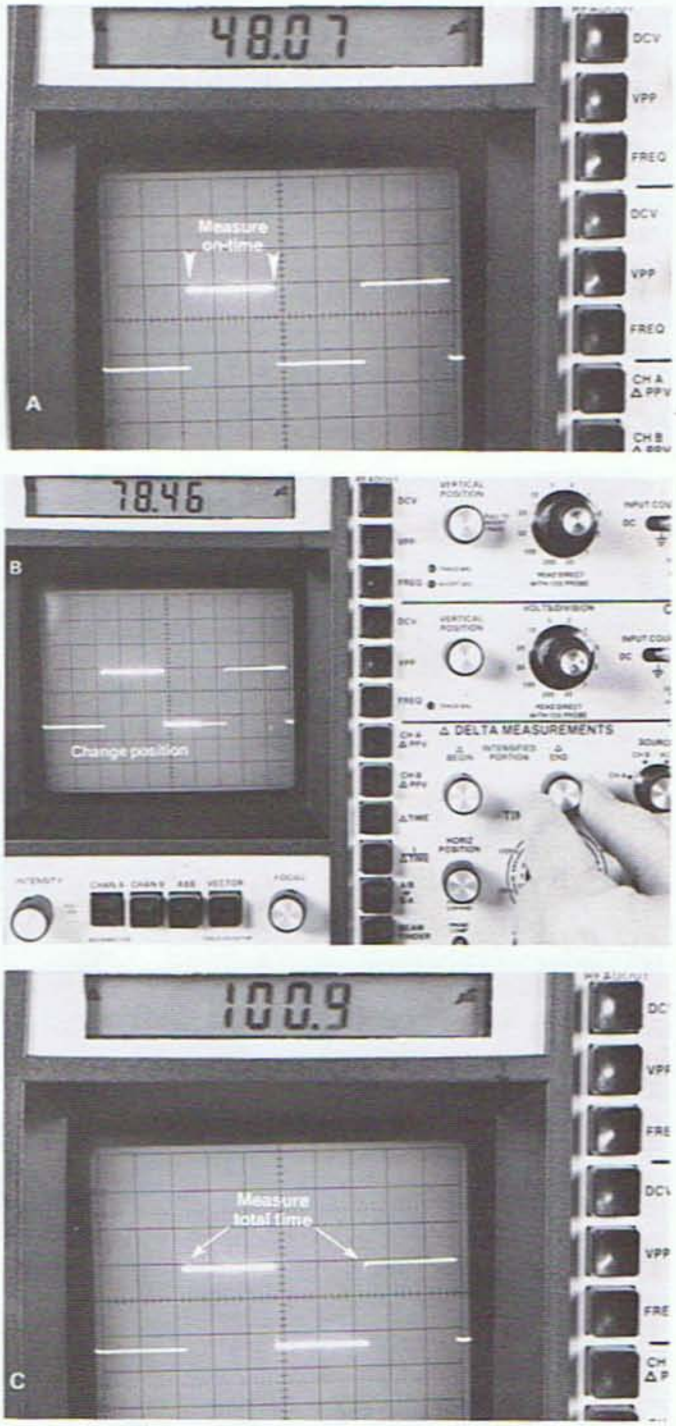


Fig. 55 — Duty cycle is measured by comparing the on-time to the total time of a waveform. Note that only one Delta position needs to be changed to expand the Delta Bar.

Measuring the delay between two signals

The Delta Bar simplifies measuring time relationships between two signals because the beginning and ending point are at the same place in both traces. The intensified area is adjusted to intensify the difference between a transition of the waveform in channel A compared to the same transition of the waveform in channel B. The digital display then shows the time difference of the two points.

To determine the time delay between two signals:

1. Press the ΔTIME button.

2. Position the two waveforms on the CRT so an identifiable transition is visible in both traces.

3. While looking only at the **top** waveform, adjust the ΔBEGIN control until the end of the intensified bar that is moved by this control is positioned exactly at the selected transition in the waveform.

NOTE: Ignore the second channel and the second end of the intensified bar.

4. While looking only at the **bottom** waveform, adjust the ΔEND control until the end of the intensified bar that is moved by this control is positioned at the selected transition in the waveform.

NOTE: Do not readjust the ΔBEGIN control. Ignore the position of the end of the Delta Bar in the top channel.

5. Read the digital display to determine the amount of time delay between the two channels.

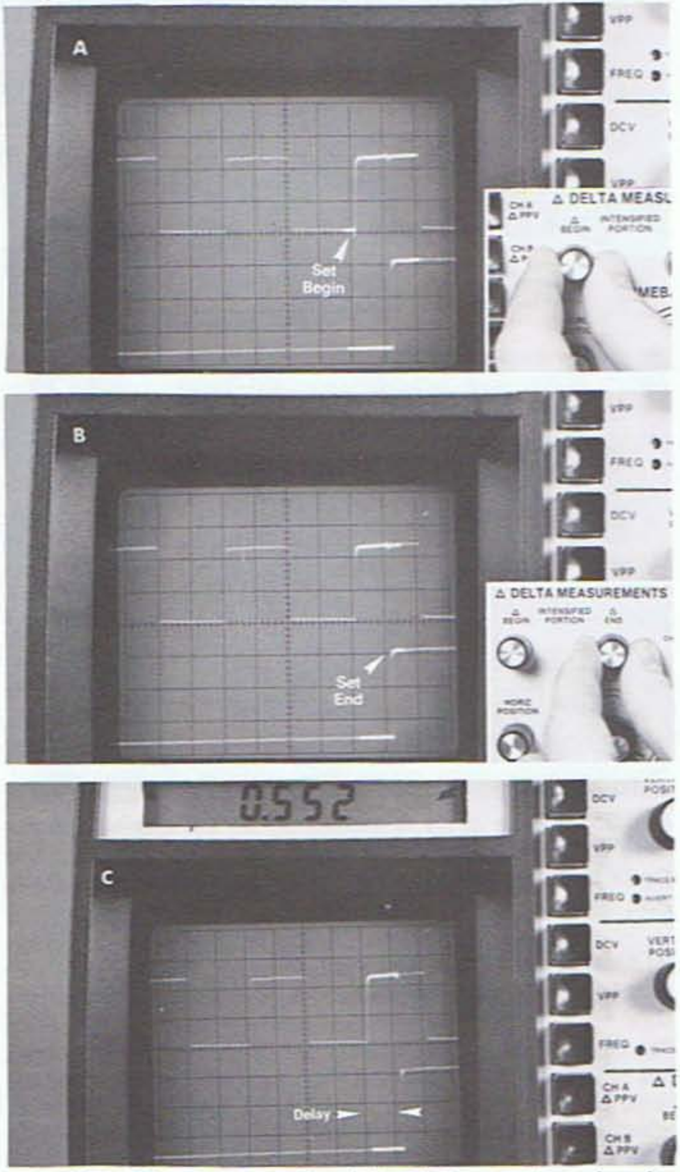


Fig. 56 — To measure the delay between two signals: (A) Adjust the Delta Begin control until the bar is on the top waveform transition, (B) Adjust the Delta End control until the bar is on the bottom waveform transition, (C) Read the delay on the digital display.

Adjusting a circuit for a desired time

The Delta Time function allows adjusting a circuit to a predetermined time. The Delta Bar is adjusted until the desired time is displayed in the digital readout. The circuit is then, in turn, adjusted until the waveform falls into the intensified area.

To adjust a circuit to a predetermined time:

1. Press the ΔTIME button.

2. Adjust the ΔBEGIN control until the Delta Bar begins at the start of the waveform interval to be adjusted.

3. Adjust the ΔEND control until the digital display reads the desired time.

NOTE: There is a slight delay between the time the control is set and the digital readout produces a reading.

4. Adjust the circuit until the waveform just fills the area intensified by the Delta Bar.

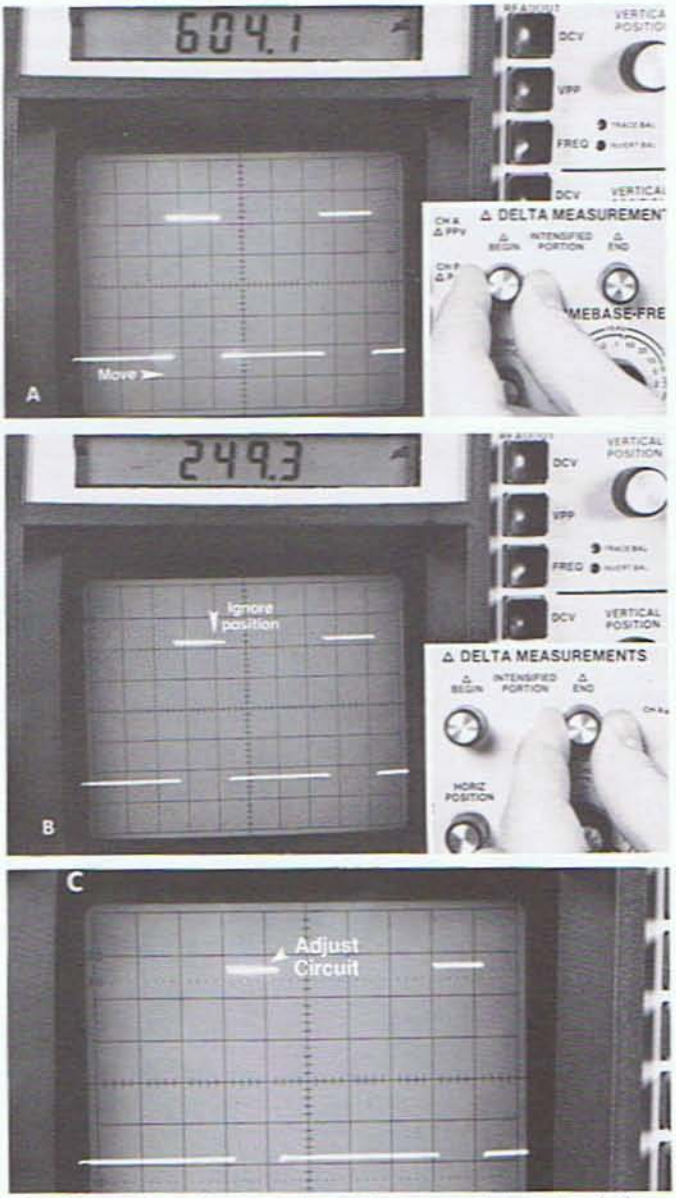


Fig. 57 — To adjust a circuit for a predetermined time: (A) Adjust the Delta Begin control until the Delta Bar starts at the reference point on the waveform, (B) Adjust the Delta End control for the correct time, (C) Adjust the circuit until the waveform falls into the intensified area.

Slower sweep speeds produce slower readings

The Delta Time function measures the actual time covered by the intensified area of the CRT beam. The display updates every third sweep. At higher sweep speeds, the display updates at a constant rate determined by the microcomputer processing time. At lower sweep speeds, however, you may notice a slightly slower update time as the microcomputer must wait for the end of three sweeps to produce accurate readings.

Measuring rise time or fall time

Rise or fall time is the amount of time it takes a waveform to change from 10% to 90% amplitude. The Delta Time function is used with the special markings on the left side of the CRT to measure rise or fall time. The waveform is adjusted until it just fills the CRT from the 0% to the 100% marks, and the Delta Bar is then adjusted to cover the area from 10% to 90%.

To measure rise time:

1. Adjust the VOLTS/DIVISION switch VERTICAL POSITION control and vertical vernier control until the waveform extends between the 0% and 100% CRT markings.

2. Press the ΔTIME button.

3. Adjust the ΔBEGIN and ΔEND controls until the Delta Bar covers the portion of the waveform between the 10% and 90% marks (the dotted lines on the CRT screen).

4. Read the rise time from the digital display.

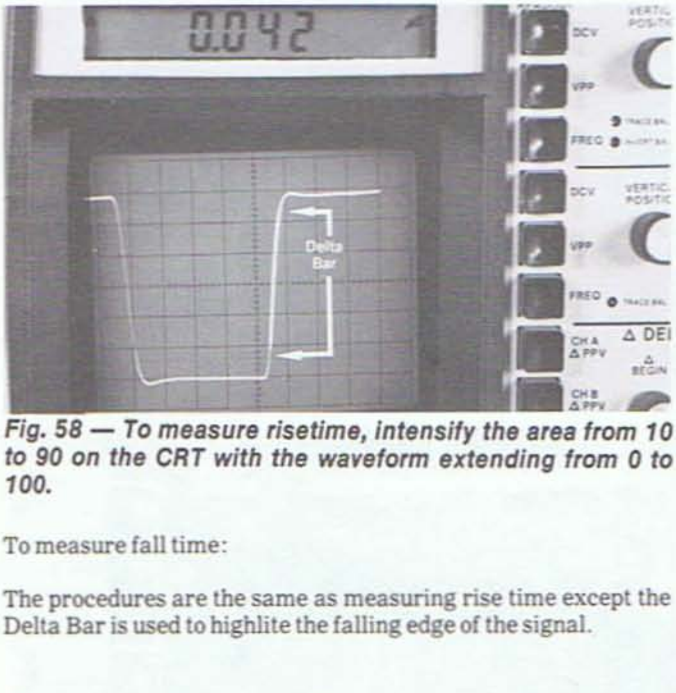


Fig. 58 — To measure risetime, intensify the area from 10 to 90 on the CRT with the waveform extending from 0 to 100.

To measure fall time:

The procedures are the same as measuring rise time except the Delta Bar is used to highlite the falling edge of the signal.

Using the Delta functions to measure frequency

The 1/ ΔTIME function calculates the equivalent frequency of any signal based on the period of one of its cycles. The applications of this function are different than the frequency functions covered earlier because the resulting frequency reading is only an approximation based on the period of one cycle. It is, therefore, less accurate than using the frequency function on a periodic signal, such as a sinewave or square wave.

The main application of the 1/ ΔTIME function is to determine the approximate frequency of a signal that is part of some other signal, such as interference. The results are faster and more accurate than making a frequency measurement using analog oscilloscope procedures because there are fewer chances of introducing interpretation error into the calculations. The test is, however, based on the same concept of measuring a time period to calculate frequency. The microcomputer simply divides the ΔTime results into "one" to produce the 1/ ΔTIME reading.

The accuracy of the results depends on how closely the Delta Time Bar can be set to cover exactly one cycle of the signal. This requires estimating the beginning and end of the waveform to be measured. When measuring a sinewave, for example, it is generally easier to adjust the Delta Measurement Bar from one peak of the signal to the following peak than it is to approximate the midpoint. Both methods are shown in Fig. 59 for comparison.

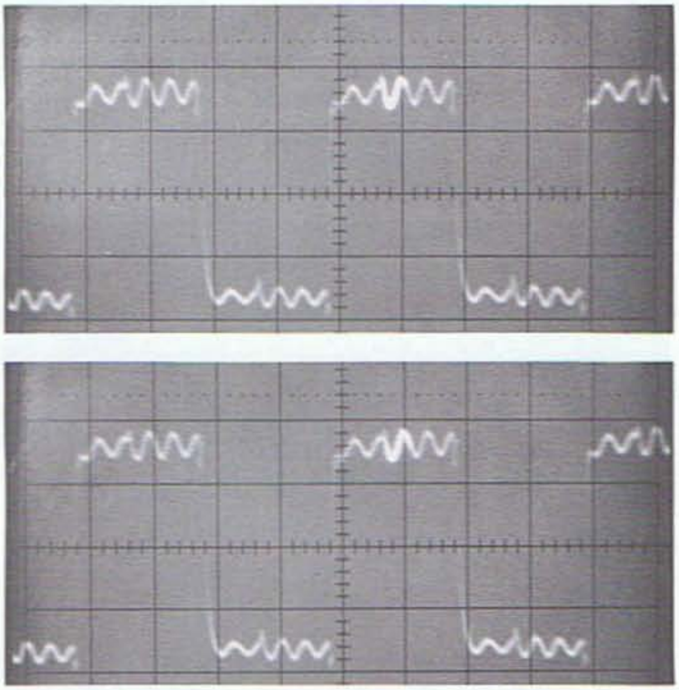


Fig. 59 — It is usually easier to mark the waveform from one peak to the next (B) than to try to accurately estimate the midpoints when measuring equivalent frequency.

It is often easier to measure the period of two cycles, and then multiply the resulting frequency by two, on fast signals. This is especially true if the signal being measured has a frequency over 20 MHz, or if the period of the signal is very small compared to the time of one cycle of the main waveform. Remember that you multiply the resulting frequency by two because having the period twice as long results in a calculated frequency that is one-half the correct frequency.

To measure the frequency of a signal with the Delta function:

1. Expand the locked waveform until the detail of the signal to be measured can be seen on the CRT.

2. Press the 1/ ΔTIME button.

3. Adjust the ΔBEGIN and ΔEND controls until the intensified Delta Bar exactly covers one cycle of the signal.

4. Read the equivalent frequency from the digital display.

NOTE: The display annunciators indicate whether the results are in Hz, KHz, or MHz. The decimal is always correctly placed by the microcomputer for the displayed range.

Measuring phase shift

The 1/ΔTIME function may be used to determine the phase shift between two signals much faster than using conventional analog scope methods. The Delta function is used to measure the time delay between the two signals. The time delay is converted to an equivalent frequency by pressing the 1/ ΔTIME button. The equivalent frequency is then compared to the actual frequency of the waveform measured with the FREQ function. The ratio of these two frequency readings is the fractional part of 360° represented by the phase shift between channels.

For example, the waveform in Fig. 60A shows two 1 MHz signals with 180° phase shift between channels. When the Delta Time function is set between the peak of the signal in channel A and the peak of the signal in channel B (Fig. 60B), the measured time .5 microseconds, or one-half the period of the entire signal. The equivalent frequency of .5 microseconds (displayed when the 1/ Δ TIME button is pressed) is 2 MHz. Dividing 2 into 1 gives .5, and multiplying this times 360° gives an answer of 180° phase shift between channels.

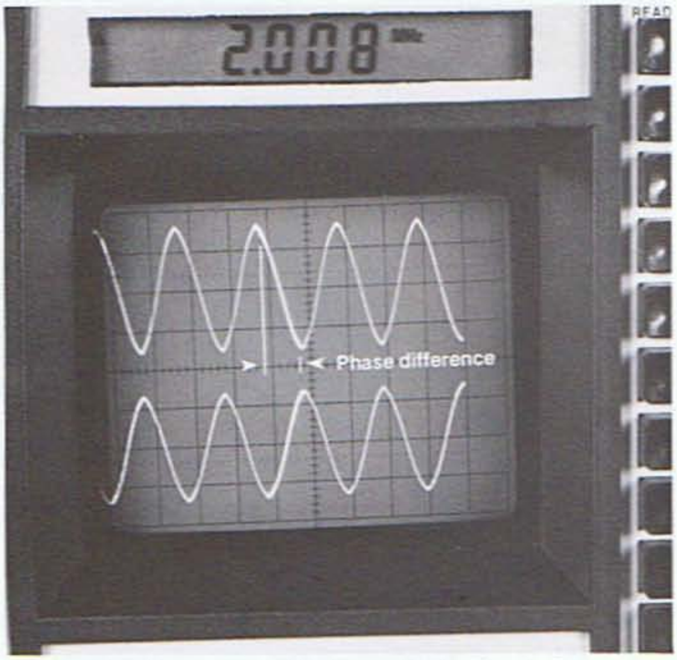


Fig. 60 — The phase shift between the signals is measured by intensifying the difference of the two signals and reading the 1/Delta Time frequency. Here, the 2 MHz reading compared to the 1 MHz signal indicates 180° phase shift.

The zero reference signal should always be connected to the channel A input in order to tell whether the phase of the second signal is leading or lagging the reference signal. Procedures are given for calculating either leading or lagging phase angles. Most phase measurements are made as a lagging angle.

Initial setup for measuring phase:

1. Connect the channel A probe to the reference signal and the channel B probe to the second signal.

2. Adjust the size of both signals with the VOLTS/DIVISION switches and vertical verniers until the signals are between 2 and 4 vertical divisions on the CRT. The exact size is not important.

3. Adjust the channel A VERTICAL POSITION control until the channel A trace is in the top half of the CRT, and the channel B VERTICAL POSITION control until the channel B trace is in the bottom half of the CRT.

To calculate lagging phase:

1. Press the 1/ ΔTIME button.

2. Observe the top waveform as you adjust the ΔBEGIN control until the beginning of the Delta Measurement Bar is at the very top of the trace.

3. Adjust the ΔEND control until the end of the Delta Measurement Bar is at the very top of the first cycle of the **bottom** waveform to the **right** of the Bar's beginning point.

4. Read the equivalent frequency from the digital display.

5. Press the FREQ button for either channel A or B (the frequency will be the same for both channels).

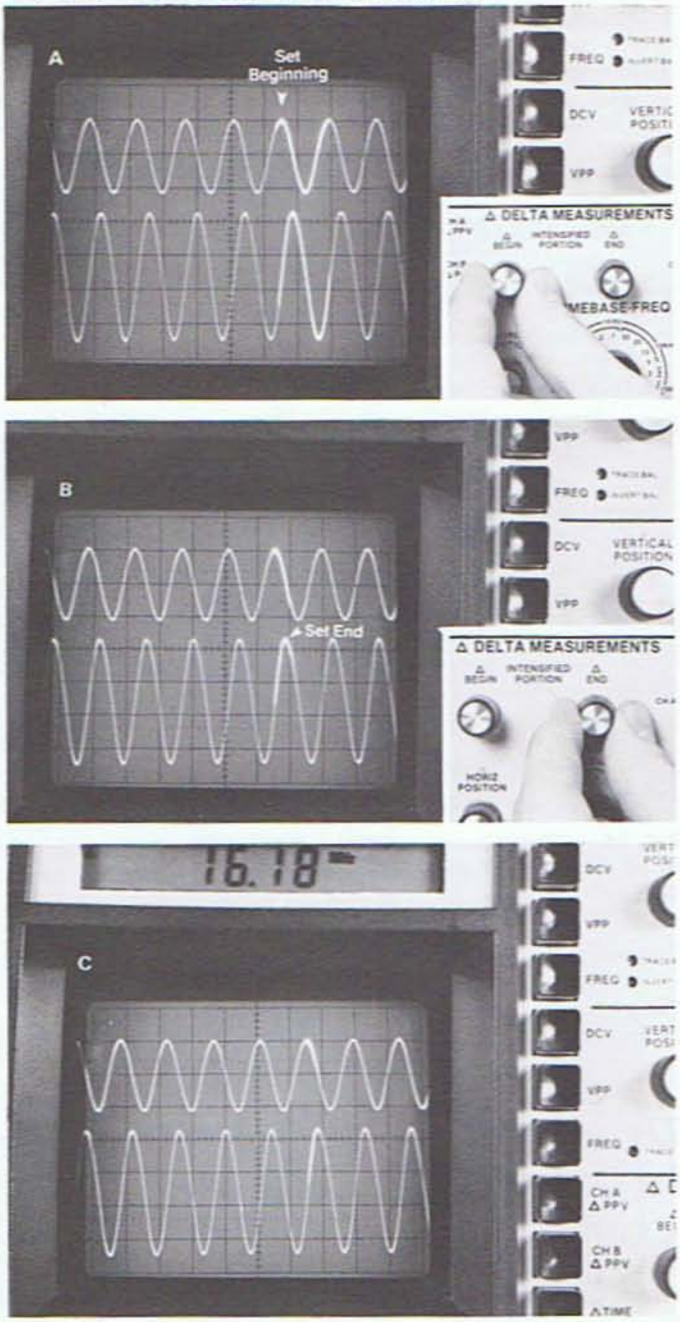


Fig. 61 — To measure phase shift: (A) Set the beginning of the Delta Bar to the top of the waveform in the top trace, (B) Set the end of the Delta Bar to the same point in the bottom trace, (C) Read the 1/Delta Time frequency. Here, the 16 MHz reading compared to the actual frequency of 3.58 MHz represents an 80.5° phase shift.

6. Divide the actual frequency step (step 5) by the equivalent frequency (step 4) and multiply the results times 360°.

$$\text{Phase Shift} = \frac{\text{FREQ}}{1/\Delta\text{TIME}} \times 360^\circ$$

NOTE: If the channel B signal is leading the channel A signal phase (the results are greater than 180°), you may calculate the leading phase by subtracting 180 from the above calculations, or use the following procedure.

To calculate **leading** phase:

1. Press the 1/ Δ TIME button.

2. Observe the top waveform as you adjust the Δ BEGIN control until the beginning of the Delta Measurement Bar is at the very top of the signal.

3. Adjust the ΔEND control until the end of the Delta Measurement Bar is at the very top of the first cycle of the **bottom** waveform to the **left** of the beginning point.

4. Read the equivalent frequency from the digital display.

5. Press the FREQ button for either channel A or B (the frequency will be the same for both channels).

6. Divide the actual frequency (step 5) by the equivalent frequency (step 4) and multiply the results times 360°.

Frequency ratio tests

The SC61 automatically calculates the ratio of the frequencies applied to channel A and B by pressing the "A/B or B/A" button. The ratio test is used to confirm that a fixed or programmable digital divider is dividing the input signal properly, or that a frequency multiplier stage is multiplying correctly.

The microcomputer not only calculates the ratio, it also indicates whether the frequency in channel A or B is larger. If, for example, the channel A signal is higher in frequency than channel B, the display annunciator will show "A/B". If, on the other hand, the channel B signal has a higher frequency, the annunciator will show "B/A". The ratios will always be shown as a number 1 to 999,999.

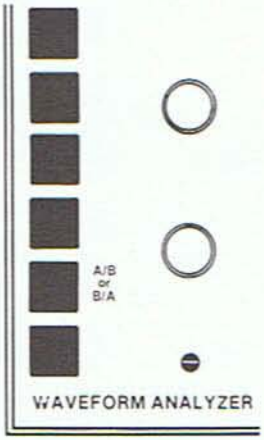


Fig. 62 — Press the "A/B or B/A" button to calculate the ratio of the frequencies applied to the two input channels.

To measure the ratio of two frequencies:

1. Apply the signals to the channel A and B inputs.

NOTE: Both channels must have sufficient amplitude to operate the FREQ functions. See page 33 for details.

2. Press the "A/B or B/A" button.

3. Read the ratio of the frequencies.

NOTES: 1. The microcomputer requires about 2 to 4 seconds between updates because it must first complete a measuring cycle for each channel and then calculate the ratio of the two frequencies.

2. Some ratios may show 2 counts low (for example 5 may show as 4.9998) because each of the frequency readings is ±1 count. Simply round these readings to the next whole number.

3. When both signals are exactly the same frequency, the display will show 1. The A/B and B/A annunciators normally alternate when both frequencies are the same.

4. The display reads 0.000 if either channel does not have enough signal to produce a frequency reading. Use the A/B and B/A annunciators to determine which channel is not reading a frequency. If the "A/B" annunciator is on, channel A does not have enough signal to produce a frequency reading. If the "B/A" annunciator is on, channel B does not have enough signal to produce a frequency reading.

5. Ratios over one million will cause the display to overrange with four dashes (— — — —).

6. When measuring ratios involving frequencies over 100 MHz using the PR47 UHF Prescaler on one channel, multiply the resulting ratio by 10.

MAINTENANCE

Introduction

As with any precision piece of test equipment, the calibration of the SC61 should be checked periodically to insure that the instrument remains within specifications. A one-year recalibration interval is recommended to insure the SC61 remains within published specifications.

Service and Calibration

The SC61 should be returned to the Sencore Factory Service center for a complete check-out and recalibration. Normal turn around time is 3 working days. User calibration procedures dealing with the front panel adjustments, such as DC balance, are found in the operating instruction section of this manual.

The schematic and parts list for the SC61 are included on separate sheets with this manual. Any parts required may be ordered directly from the Sencore Factory Service Department, 3200 Sencore Drive, Sioux Falls, SD 57107, or you may call at (605) 339-0100.

Circuit Description and Calibration Instructions

Complete circuit descriptions and calibration instructions are available from the Factory Service Department, 3200 Sencore Drive, Sioux Falls, SD 57107. The cost of each is $10.00 to cover copying and handling. Ask for the "SC61 Circuit Description" or the "SC61 Calibration Instructions".

Converting the SC61 from 120 VAC to 220 VAC operation

The power transformer used in the SC61 has two primary windings that allow you to connect them in parallel for 120 VAC operation or in series for 220 VAC operation for either a 50 or 60 Hertz AC line. The terminal strip near the AC line fuse has an extra terminal for this conversion.

To convert the SC61 to 220 VAC, 50/60 Hertz:

1. Disconnect the power cord from the AC outlet and remove the case.

2. Remove the solid blue wire from the terminal strip where it is attached to the solid black wire. Remove the black/white wire from the terminal strip where it was attached to the blue/white wire.

3. Connect the solid blue wire and black/white wire to the center unused terminal on the AC terminal strip.

4. Solder all connections and replace the SC61 case.

NOTE: Mark the rear label with another self-sticking label indicating that the scope has been converted to 220 VAC operation. Damage will not result from 120 Volt AC operation, but may cause someone to believe that the scope has a defect.

SERVICE & WARRANTY

Warranty

Your SC61 Waveform Analyzer has been built to the highest quality standards in the industry. Each unit has been tested, aged under power for at least 24 hours, and then retested on every function and range to insure it met all published specifications after aging. Your instrument is fully protected with a 90-day warranty and Sencore's exclusive 100% Made Right Lifetime Guarantee in the unlikely event a manufacturing defect is missed by these tests. Details are covered in the separate booklet. Read this booklet thoroughly, and keep it in a safe place so you can review it if questions arise later.

Service

The Sencore Factory Service Department provides all in- or out-of-warranty service and complete recalibration services for Sencore instruments. NO LOCAL SERVICE CENTERS ARE AUTHORIZED TO REPAIR SENCORE INSTRUMENTS. Factory service assures you of the highest quality work, the latest circuit improvements, and the fastest turnaround time possible because every technician specializes in Sencore instruments. Sencore's Service Department can usually repair your instrument and return it to you faster than a local facility servicing many brands of instruments, even when shipping time is included.

YOU DO NOT NEED AUTHORIZATION TO RETURN AN INSTRUMENT TO SENCORE FOR SERVICE. Be sure you include your name and address along with a description of the symptoms if it should ever be necessary to return your instrument. Ship your instrument by United Parcel Service or air freight if possible. Use parcel post only when absolutely necessary.

BE SURE THE INSTRUMENT IS PROPERLY PACKED. Use the original shipping carton and all packing inserts whenever possible. If the original packing material is not available, make certain the unit is properly packed in a sturdy box with shock-absorbing material on all sides. Sencore suggests insuring the instrument for its full value in case it is lost or damaged in shipment.

A separate schematic and parts list is included if you wish to repair your own instrument. Parts may be ordered directly from the Factory Service Department. Any parts not shown in the parts list may be ordered by description.

We reserve the right to examine defective components before an in-warranty replacement is used.

SENCORE FACTORY SERVICE
3200 Sencore Drive
Sioux Falls, SD 57107
1-800-SENCORE
FAX: 605/335-6379

Fill in for your records:

Date Purchased: ____________________________

Serial Number ______________________________

Run Number ______________________________

(NOTE: Please refer to the run number if it is necessary to call the Service Department. The run number may be updated when the unit has been returned for service.)

SENCORE
3200 Sencore Drive, Sioux Falls, South Dakota 57107
Phone Toll-Free 1-800-SENCORE

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