Part No. 070-6963-99
Product Group 45

THE SCD1000 &SCD5000

TRANSIENT WAVEFORM RECORDER

Service Manual

WARNING

The following servicing instructions are for use by qualified service personnel only. To avoid personal injury, do not perform any servicing unless you are qualified to do so. Refer to the Safety Summary prior to performing any service.

Please check for CHANGE INFORMATION at the rear of this manual.

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COMMITTED TO EXCELLENCE

Instrument Serial Numbers

Each instrument manufactured by Tektronix has a serial number on a panel insert or tag, or stamped on the chassis. The first letter in the serial number designates the country of manufacture. The last five digits of the serial number are assigned sequentially and are unique to each instrument. Those manufactured in the United States have six unique digits. The country of manufacture is identified as follows:

B010000	Tektronix, Inc., Beaverton, Oregon, USA
E200000	Tektronix United Kingdom, Ltd., London
J300000	Sony/Tektronix, Japan
H700000	Tektronix Holland, NV, Heerenveen, The Netherlands

Instruments manufactured for Tektronix by external vendors outside the United States are assigned a two digit alpha code to identify the country of manufacture (e.g., JP for Japan, HK for Hong Kong, IL for Israel, etc.).

Tektronix, Inc., P.O. Box 500, Beaverton, OR 97077

Printed in U.S.A.

Contents

Specifications

Operating Information

Theory of Operation

Performance Verification

Adjustment

Maintenance

Options

List of Figures

List of Tables

Safety

Please take a moment to review these safety precautions. They are provided for your protection and to prevent damage to the SCD1000 and SCD5000. This safety information applies to all operators and service personnel.

Symbols and Terms

These two terms appear in manuals:

- CAUTION statements identify conditions or practices that could result in damage to the equipment or other property.
- WARNING statements identify conditions or practices that could result in personal injury or loss of life.

These two terms appear on equipment:

- *CAUTION* indicates a personal injury hazard not immediately accessible as one reads the marking, or a hazard to property including the equipment itself.
- *DANGER* indicates a personal injury hazard immediately accessible as one reads the marking.

This symbol appears in manuals:

Static-Sensitive Devices

These symbols appear on equipment:

DANGER
High Voltage

Protective
ground (earth)
terminal

ATTENTION
Refer to
manual

Specific Precautions

Observe all of these precautions to ensure your personal safety and to prevent damage to either the SCD1000 and SCD5000 or equipment connected to it.

Power Source

The SCD1000 and SCD5000 is intended to operate from a power source that will not apply more than 250 V rms between the supply conductors or between either supply conductor and ground. A protective ground connection, through the grounding conductor in the power cord, is essential for safe system operation.

Grounding the SCD1000 and SCD5000

The SCD1000 and SCD5000 is grounded through the power cord. To avoid electric shock, plug the power cord into a properly wired receptacle where earth ground has been verified by a qualified service person. Do this before making connections to the input or output terminals of the SCD1000 and SCD5000.

Without the protective ground connection, all parts of the SCD1000 and SCD5000 are potential shock hazards. This includes knobs and controls that may appear to be insulators.

Use the Proper Power Cord

Use only the power cord and connector specified for your product. Use only a power cord that is in good condition.

Use the Proper Fuse

To avoid fire hazard, use only the fuse specified in the parts list for your product, matched by type, voltage rating, and current rating.

Do Not Remove Covers or Panels

To avoid personal injury, do not operate the SCD1000 and SCD5000 without the panels or covers.

Do Not Operate in Explosive Atmospheres

The SCD1000 and SCD5000 provides no explosion protection from static discharges or arcing components. Do not operate the SCD1000 and SCD5000 in an atmosphere of explosive gases.

Electric Overload

Never apply to a connector on the SCD1000 and SCD5000 a voltage that is outside the range specified for that connector.

Specifications

Performance Conditions

This specification applies when the following conditions are true:

- the instrument is verified at an ambient temperature between +20°C and +30°C
- the instrument has been running for at least 20 minutes (minimum warm-up period)

Specifications

Specifications are verifiable qualitative or quantitative limits that define the measurement capabilities of the instrument.

For environmental specifications, the test result is highly dependent on the procedure used. For verification of environment performance, refer to the listed government/industry documents for test methods. Tektronix internal verification procedures and in some cases more stringent requirement for performance, are contained in the listed standards. Tektronix standards may be provided upon request.

Under MIL-T-28800D, the instrument is classified as Type III, Class 7. Only those requirements from MIL-T-28800D listed in these specifications apply. Non-operating specification means the principal power switch on the rear panel is off, or the power cord is disconnected.

Characteristics

Characteristics qualitatively or quantitatively describe the typical behavior or operation of the instrument.

Recommended Calibration Interval

To ensure accurate measurements, check the performance of this instrument every 2000 hours of operation or every 12 months, whichever comes first. In addition, replacement of components may necessitate readjustment of the affected circuits.

It is recommended that the internal calibration be performed if the temperature varies more than 5°C since the last internal calibration.

Electrical Specifications

The electrical specifications for the SCD1000 and SCD5000 are listed in Table 1-1. The specifications apply to both instruments unless stated otherwise.

Table 1-1: Electrical Specifications

Feature	Specification
Vertical System (SCD1000)	
Δ Volts Accuracy (1 kHz or lower)	
10% to 90% full-scale signal	
within ±5°C of calibration temperature	±(1% + 0.003 × range)
0°C to 40°C; calibrated at 20°C to 30°C	±(2.5% + 0.005 × range)
Offset Accuracy	±(2.0% + 0.02 × input range)
Low-frequency Linearity	1% full-scale or less of compression or expansion for a 25% of full-scale, center-of-range signal when offset is anywhere within 10% to 90% of full-scale range
Frequency Response (HF −3 dB)	At least 71% of 10 MHz gain at 1 GHz
Common Mode Rejection Ratio	
Full-scale sine wave signal on each channel for same range and coupling	At least 20:1 DC to 50 MHz
Ch A and CH B Rms Noise (referred to input) ADD (with INVERT off)	0.003 × range 0.006 × range
Vertical System (SCD5000)	
Δ Volts Accuracy (1 kHz or lower)	
10% to 90% full-scale signal	±2% of range
Low-frequency Linearity	2% full-scale or less of compression or expansion for a 25% of full-scale, center-of-range signal when offset is anywhere within the full-scale range.
Offset Accuracy	±(2.0% + 0.02 × input range)
Frequency Response (HF −3 dB)	
SCD5000	At least 71% of 10 MHz gain at 4.5 GHz
SCD5000 Opt. 01	At least 71% of 250 MHz gain at 3.0 GHz

Table 1-1: Electrical Specifications (Cont.)

Feature	Specification
Horizontal System	
Accuracy	
10% to 90% of time window	
within 5°C of calibration temperature	±3%
0°C to 40°C; calibrated at 20°C and 30°C	±5%
Trigger System	
Sensitivity (sine wave)	
Channel A or B Inputs (SCD1000)	0.05 × range, DC to 250 MHz 0.15 × range, 250 MHz to 1 GHz
Internal Trigger (SCD5000 Opt. 01)	0.5 × range, 20 kHz to 50 MHz 0.15 × range, 50 MHz to 500 MHz 0.35 × range, 500 MHz to 1 GHz
External Input	500 mV, DC to 50 MHz 1.5 V, 50 MHz to 500 MHz 3.5 V, 500 MHz to 1 GHz
Sensitivity (Pulse)	
0.5 ns half amplitude duration pulse	
External input (SCD5000)	150 mV p-p
Calibrator	
Amplitude Accuracy	
Absolute	±(0.1% + 1 mV)
Δ (Delta), for each pair of amplitudes with equal absolute values	±0.2%
Timing Accuracy	±0.1%

Table 1-1: Electrical Specifications (Cont.)

Feature	Specification
CRT Operating Parameters	
Writing Speed	
SCD1000 conditions: Writes a sine wave of at least 1 GHz in a single sweep after 1 hour of operation with proper adjustment of intensity, focus and CRT background. Performance is derated by 50% below 10°C .	90% full-scale
With CRT background = 0%	80% full-scale
SCD5000 conditions: Writes a sine wave of at least 4.5 GHz in a single sweep after 1 hour of operation with proper adjustment of intensity, focus and CRT background. Performance is derated by 50% below 10°C.	50% full-scale
With CRT background = 0%	25% full-scale
Geometry	
Correction off (10% to 90% of range; 10% to 90% of window)	
SCD1000	±4% of range
SCD5000	±5% of range
Correction on (correction run at current instrument settings)	±1%

Electrical Characteristics

The electrical characteristics for the SCD1000 and SCD5000 are listed in Table 1-2. The characteristics apply to both instruments unless stated otherwise.

Table 1-2: Electrical Characteristics

Feature	Characteristic
Vertical System (SCD1000)	
Input Range	100 mV to 10 V full-scale in a 1, 2, 5 sequence
Offset Range	±2.5× input range
Offset Resolution	0.05 × input range (101 steps)
Low Frequency Limit (–3 dB)	
AC Coupled	1 kHz or less from 50 Ω source
Step Response	
(0.5 × range with centered signal, $t_r \leq$120 ps)	
Rise time	≤0.35 ns calculated from BW (0.35/BW)
Channel Isolation	
test on 100 mV range with other channel driven 0.8 × full-scale on 1 V range. Ratio = Ampl.(driven channel)/Ampl.(undriven channel)	At least 40:1 DC to 1 GHz
Input Characteristics	
Maximum Input Voltage (AC or DC Coupled)	5 V rms (0.5 W) or 0.25 W-sec pulses not exceeding 25 V peak
Maximum Input Voltage (AC Coupled)	±100 V (DC + peak AC) (Signals of more than 25 V peak must be connected with coupling off so the coupling capacitor precharges.)
Input Protection Disconnect Threshold	5 V rms DC to 100 MHz, typical
Input Resistance	
Power-off & Disconnect	500 kΩ ±10%
DC Coupling within ±5°C of calibration temperature	50 Ω ±0.25 Ω
AC Coupling	50 Ω ±1Ω in series with nominally 2.2 μF
VSWR	
100 mV range	<1.45:1 10 MHz to 1 GHz
200 mV to 10 V range	<1.25:1 10 MHz to 1 GHz

Table 1-2: Electrical Characteristics (Cont.)

Feature	Characteristic
Vertical System (SCD1000)	
Input Characteristics (cont.)	
Input Bias Current	
0 V offset, 100 mV range	≤10 μA
0°C to 50°C, calibrated at 20° to 30°C	≤50 μA
Delay match between channels same range and coupling	100 ps
Vertical System (SCD5000)	
Input Range	
SCD5000	5 V full-scale
SCD5000 Opt. 01	10 V full-scale
Offset Range	
SCD5000	±4 V
SCD5000 Opt. 01	±8 V
Offset Resolution	0.05 × input range (33 steps)
Input Characteristics	
Maximum input voltage	5 V rms (0.5 W) or 0.25 W-sec pulses not to exceed 70 V peak
Input Resistance	50 Ω ±0.5 Ω
VSWR	≤1.5:1 for frequencies ≤3.5 GHz
Horizontal System	
Window Range	5 ns to 100 μs in a 1, 2, 5 sequence
Gate Output (BNC connector)	
Output Voltage	2.4 to 5 V high level, 0 to 0.5 V low level
Polarity	Low during sweep
Output Drive	Source 400 μA into 2 V, sink 100 mA
Double Sweep	
Range	10 ns to 200 ns in the 1, 2, 5 sequence
Delay Time between Sweeps	≤700 ns
Sweep start delay (SCD5000)	≤50 ns
Preview Time	
5 ns time window (SCD1000 and SCD5000 Opt. 01)	≥2 ns

Table 1-2: Electrical Characteristics (Cont.)

Feature	Characteristic
	Trigger System
Jitter	
500 mV p-p square wave, rise time ≤1 ns	≤30 ps rms
Trigger Level	
Accuracy	
CHA, CHB, or ADD	±(2% + 0.05 × vertical range)
External Input	±(10% + 50 mV)
Range (SCD1000)	
CHA, CHB or ADD (AC)	±vertical range
CHA, CHB or ADD (DC)	±(vertical range/2) + offset
External Input	±1.0 V
Range (SCD5000)	
External Input	±0.5 V
Internal Input (Opt. 01)	±5 V
Resolution (201 steps) SCD1000	
CHA, CHB, or ADD (AC)	0.01 vertical range
CHA, CHB, or ADD (DC)	0.005 vertical range
External Input	10 mV
Resolution (201 steps) SCD5000	
External Input	5 mV
Internal Input (Opt. 01)	50 mV
Slope	Positive or negative
Coupling	
Channel A or B (SCD1000)	DC or AC (Triggering sensitivity is reduced below 2 kHz when AC coupled.)
External Input	AC
Internal Input (SCD5000 Opt. 01)	DC

Table 1-2: Electrical Characteristics (Cont.)

Feature	Characteristic
	Trigger System
External Trigger Input	
Maximum Safe Input	DC component: 100 V DC
SCD1000	AC component: 0.2 watt average, 25 V peak (3 V rms)
SCD5000	AC component: 0.5 watt average, 25 V peak (5 V rms)
Input Impedance	Nominally 0.1 μf in series with 50 Ω ±5%
Delay (when operated within 5°C of temperature where internal calibration was last performed)	
Accuracy	±(3% of time window + 1 ns)
Range	0% to 500% of the acquire time window
	Digitizer System
Vertical Resolution	9 bits of amplitude data with 6 bits of intensity data from linear array query (GPIB command); 11 to 14 bits of centroided data
Horizontal Resolution	256, 512, or 1024 points
Maximum Acquisition Recycle Rate Display off, Repeat Mode on	4 acquisitions/second for 256 point waveforms 2 acquisitions/second for 512 point waveforms 1 acquisition/second for 1024 point waveforms
Opt. 1P (≤20% of target pixel area written. Data transfer must be DL mode)	10 acquisitions/second for 512 point waveforms
	Calibrator
Amplitude Range	
SCD1000	±2.5, ±2.0, ±0.8, ±0.4, ±0.2, ±0.08, ±0.04, 0 VDC
SCD5000	±4.0, ±3.0, ±2.0, ±1.0, ±0.8, ±0.4, ±0.2, ±0.1, 0 VDC
Timing	
Amplitude	
SCD1000	≥100 mV p-p into 50 Ω, reduced to 50 mV p-p at 4 ns period
SCD5000	≥2 V p-p into 50 Ω; reduced to 1 V p-p at 4 ns period
Period	4 ns to 80 μs in 4, 8, 16, 40 sequence
Offset	
SCD1000	600 mV ±100 mV
SCD5000	1 V ±500 mV

Table 1-2: Electrical Characteristics (Cont.)

Feature	Characteristic
	Video Output
Type	640 × 400 pixel resolution, compatible with TTL input of Multi-sync video monitors
	Auxiliary Inputs and Outputs
Rear Panel	
IEEE-488 Connector type	24-pin female connector located on rear panel. Meets specification IEEE-488-1978
	Power
AC Line Power	
Voltage	Selected by rear panel switch 90 to 132 V rms 180 to 250 V rms
Line Frequency	48 to 440 Hz
Power Consumption	250 W typical
Line Current	4.6 amps maximum at 90 V, 50 Hz line
Fuse Rating	115 V operation: 6 A, 250 VAC, normal blow 230 V operation: 6 A, 250 VAC, normal blow

Physical Characteristics

The physical characteristics for the SCD1000 and SCD5000 are listed in Table 1-3.

Table 1-3: Physical Characteristics

Feature	Characteristic	
Dimensions		
Height	178 mm (7 inches)	
Width	483 mm (19 inches)	
Depth Recommended rack depth	762 mm (30 inches) ≥30 inches	
Weight		
Net	SCD1000 SCD5000 SCD5000 with Opt. 01	58 lbs 50 lbs 56 lbs
Shipping	31.75 Kg (70 lbs.)	
Cooling Type	forced air circulation	
Airflow	Internal airflow is approximately 100 CFM at fan voltage (8 V). Airflow direction is intake from sides, exhaust at rear, and is not reversible. Air flow is regulated, based on internal temperature of the power supply.	
Clearance		
Sides	51 mm (2 inches)	
Rear	25 mm (1 inch)	
Top	3 mm (0.125 inch)	
Rear	25 mm (1 inch)	

Environmental Characteristics

The environmental characteristics for the SCD1000 and SCD5000 are listed in Table 1-4. The characteristics apply to both instruments unless stated otherwise.

Table 1-4: Environmental Characteristics

Feature	Characteristic
Temperature without Display	
Operating & Nonoperating	Meets MIL-T-28800D, Type III, class 7
Operating	0°C to +40°C
Nonoperating	–40°C to +70°C
Temperature with Display	
Operating & Nonoperating	Meets MIL-T-28800D, class 7
Operating	+5°C to +40°C
Nonoperating	–20°C to +60°C
Humidity without Display	
Operating & Nonoperating	Meets MIL-T-28800D type III, class 5
Operating	Up to 85% relative humidity, non-condensing, up to 40°C
Non-operating	20% to 90% relative humidity, non-condensing
Humidity with Display	
Operating & Nonoperating	Meets MIL-T-28800D, class 7
Operating	30% to 85% relative humidity, non-condensing
Nonoperating	20% to 90% relative humidity, non-condensing
Altitude	
Operating & Nonoperating	Exceeds MIL-T-28800D type III, class 5
Operating	4.5 km (15,000 ft.) maximum
Nonoperating	15 km (50,000 ft.) maximum
Vibration	
Operating	Meets MIL-T-28800D type III, class 5; tested per paragraph 4.5.5.3.1 0.015 in. p-p, 10 to 55 Hz sine wave; total test time is 75 minutes

Table 1-4: Environmental Characteristics (Cont.)

Feature	Characteristic
Shock	
Nonoperating	Meets MIL-T-28800D type III, class 5; tested per paragraph 4.5.5.4.1 30 g (1/2 sine), 11 ms duration, 3 shocks in each direction along 3 major axes, 18 total shocks
Bench Handling	
Operating	Meets MIL-T-28800D type III, class 5; tested per paragraph 4.5.5.4.3 Withstands 12 drops from 10 cm (4″)
Packaged Product	
Vibration	Meets ASTM D999-75, method A, paragraph 3.1g (NSTA Proj. 1A-B-1)
Shock	Meets ASTM D775-61, method 1, paragraph 5 (NSTA Proj. 1A-B-2)
Electrostatic Immunity	
No disruption or degradation of performance	15 kV, 500 pF capacitor discharged in series with 100 Ω resistor
Electromagnetic Compatibility	
U.S.	Within limits of FCC Regulation, Part 15, Subpart J, class A. In compliance with MIL-STD-461B, CE01 Part 2, narrowband CE03 Part 4; CE07 Part 2; CS01 Part2 CS02 Part 2; CS06 Part 5; limited to 300 V RE01 Parts 5 and 6; RE02 Part 2; RS02 Part 2 RS03 Part 2, limited to 1 GHz when tested per MIL-STD-462 test procedures
Germany	Complies with acceptance criteria of VDE 0871/6.78 class B

General Information

Supplying Operating Power

Refer to the safety summary at the front of this manual for power source, grounding, and other safety considerations pertaining to the use of the instrument. Before connecting the instrument to a power source, read both this section and the safety summary.

Line Voltage

The SCD1000 and SCD5000 operate from either a 115 V or 230 V nominal AC power source with a line frequency ranging from 48 Hz to 440 Hz. The line voltage selector on the rear panel indicates the voltage source required by the waveform recorder (Figure 2-1). Before connecting the power cord to a power source, check that the voltage at the power source falls within the selected voltage range listed on the label near the line voltage selector. If the line voltage of the instrument needs to be changed, use a small-blade screwdriver to switch the line voltage selector on the rear panel.

CAUTION

This instrument may be damaged if operated from a power source line voltage outside the range shown on the label near the line voltage selector on the rear panel. Damage may also occur if the wrong size power input line fuse is installed in the rear panel of the instrument. If the instrument is set for 115 operation and is connected to a 230 power source, an internal line fuse will blow. It should be replaced only by a qualified service person.

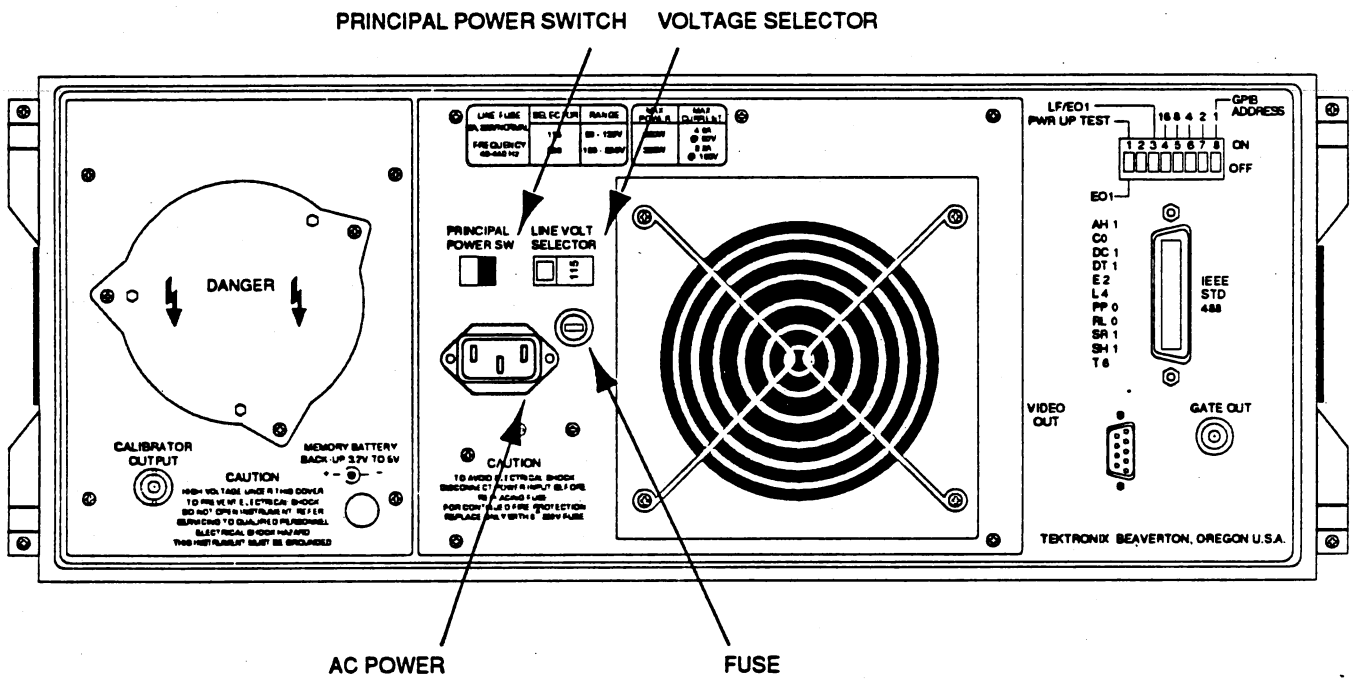


Figure 2-1: Line Voltage Selector, Line Fuse, Power Cord Receptor

Line Fuse

To verify the proper value of the instrument's power input line fuse, perform the following:

1. Unplug the instrument from line voltage.
2. Press in the fuse-holder cap and release it with a counterclockwise rotation.
3. Pull the cap (with the attached fuse inside) out of the fuse holder.
4. Verify the proper fuse value (Table 2-1).
5. Install the proper fuse, if required, and reinstall the fuse-holder cap by carefully pushing it in while rotating it clockwise.
6. Plug the instrument into line voltage receptacle.

Table 2-1: Line Voltage Ranges & Fuses

Line Voltage Indicator	Voltage Range	Line Fuse
115 V, nominal	90–132 VAC	6A, 250 V, normal blow
230 V, nominal	180–250 VAC	6A, 250 V, normal blow

Power Cord

This instrument has a detachable three-wire power cord with a three-contact plug for connection to both the power source and protective ground (Figure 2-1). The protective ground contact on the plug connects (through the power cord protective grounding conductor) to the accessible metal parts of the instrument. For electrical shock protection, insert this plug into a power source outlet that has a properly grounded protective-ground contact.

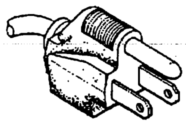
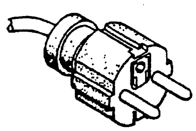
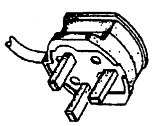
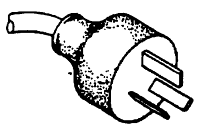
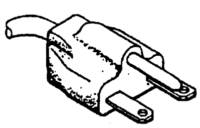
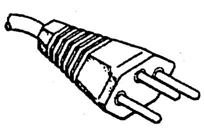
WARNING

This instrument operates from a single-phase power source, and has a detachable three-wire power cord with a two-pole, three-terminal grounding-type plug. The voltage to ground (earth) from either pole of the power source must not exceed the maximum rated operating voltage of 250 volts.

Before making connection to the power source, be sure that the voltage selector is set to match the voltage of the power source and that the power source receptacle has a suitable plug (two pole, three-terminal, grounding type). Do not defeat the grounding connection. Any interruption of the grounding connection can create an electric shock hazard.

Instruments are shipped with the required power cord as ordered by the customer. Information on the available power cords is presented in Table 2-2. Part numbers are listed in Options, *page 7-1.*

Table 2-2: Power-Cord and Plug Identification

Plug Configuration	Usage (Max Rating)	Reference Standards & Certification	Option #
	North America 125 V/6 A	ANSI C73.11[1] NEMA 5-15-P[2] IEC 83[3] UL[10] CSA[11]	Standard
	Europe 220 V/16 A	ICE 83[3] CEE (7), II, IV, VII[4] VDE[8] SEMKO[9]	A1
	United Kingdom 240 V/13 A	IEC 83[3] BSI 1363[5]	A2
	Australia 240 V/10 A	AS C112[6] ETSA1[2]	A3
	North America 240 V/15 A	ANSI C73.20[1] NEMA 6-15-P[2] IEC 83[3] UL[10] CSA[11]	A4
	Switzerland 220 V/10 A	SEV[7]	A5

[1]**ANSI — American National Standards Institute**
[2]**NEMA — National Electrical Manufacturers' Association**
[3]**IEC — International Electrotechnical Commission**
[4]**CEE — International Commission on Rules for the Approval of Electrical Equipment**
[5]**BSI — British Standards Institute**
[6]**AS — Standards Association of Australia**
[7]**SEV — Schweizerischer Elektrotechnischer Verein**
[8]**VDE — Verband Deutscher Elektrotechniker**
[9]**SEMKO — Swedish Institute for Testing and Approval of Electrical Equipment**
[10]**UL — Underwriters Laboratories**
[11]**CSA — Canadian Standards Association**
[12]**ETSA — Electricity Trust of South Australia**

Environmental Considerations

Instrument Cooling

To prevent instrument damage from overheating, adequate internal airflow must be maintained. A clearance of 2 inches on the side and 1 inch on the rear must be maintained for proper cooling to take place.

Before turning on the instrument, be sure that the air intake and exhaust holes on the instrument are free from any obstructions to airflow. The SCD Waveform Recorders typically generate 700 Btu/hour (based on 250 Watts typical power). An internal fan moves 100 cfm of air for cooling. Cooling is automatically regulated according to the power supply temperature.

Temperature

The SCD Waveform Recorders can be operated in an environment where the ambient temperature is between +5°C (0°C without display) and +40°C. For storage lengths over an hour, the temperature should be between -20°C and +60°C. After storage at temperatures outside the operating limits, allow the chassis to reach a normal operating temperature before applying power.

CAUTION

Storage in temperatures below -20°C will damage the Liquid Crystal Display (LCD).

Humidity

If condensation occurs on the instrument or any circuitry following storage at low temperatures, allow all condensation to evaporate before applying power to the instrument.

Switch Settings

A set of eight switches on the waveform recorder's rear panel set the SCD's GPIB operation and Power-Up Self-Test execution. See the *SCD1000/SCD5000 Instrument Interfacing Guide* for setting these switches before operation.

External Interfacing

Signal Cabling

The SCD Waveform Recorders allow connection of the following input and output cables. Some channel input parameters vary depending on the model of the waveform recorder. These differences are described below.

SCD1000

- two signal inputs (front panel connectors)
- external trigger input (front panel connector)
- IEEE-488.1 bus using a standard GPIB connector (rear panel connector)
- calibrator signal output (rear panel connector)
- VGA video output (rear panel connector)
- gate signal output (rear panel connector)

SCD5000

- one signal input (front panel connector)
- external trigger input (front panel connector)
- calibrator signal output (front panel connector)
- IEEE-488.1 bus using a standard GPIB connector (rear panel connector)
- VGA video output (rear panel connector)
- gate signal output (rear panel connector)

Signal Inputs

The SCD1000 includes two input channels. (Either of the two signal inputs can be selected or they can be added.) The SCD5000 includes one input channel. Input cables are connected to front panel connectors. The signal inputs have a 50 Ω impedance on both waveform recorder models.

On the SCD1000, input signals can be AC or DC coupled. On the SCD5000, only DC coupling is provided.

Observe the maximum input voltage and power described in *Electrical Characteristics*, Table 1-2.

CAUTION

When AC coupling signals greater than 25 VDC, set the input coupling to OFF (SCD1000 only) to allow the input capacitor to precharge.

External Trigger Input Signal

An external trigger signal can be connected to the front panel TRIG IN connector. The DC component of the trigger signal must not exceed 100 V. The AC component should be limited to 0.2 watts average or 25 V peak. The input impedance is nominally 50 Ω.

IEEE 488 Cabling

The IEEE-488.1 (GPIB) connector on the rear panel allows waveform recorder control over the GPIB. Connect the IEEE-488 cable (available as an optional accessory) between the rear panel connector and the bus controller or the nearest instrument on the bus. More information on the GPIB is provided in the *SCD1000/SCD5000 Instrument Interfacing Guide*. GPIB cabling and interconnection conventions must be observed for proper operation.

Video Output

The SCD's are configured at the factory for providing video signals compatible with VGA video monitors (640 × 400 lines resolution). See Figure 2-2. Internal jumpers on the MPU circuit board can be set to alter the signal pinout and polarity for monochrome displays and video copy processors.

PIN	SIGNAL
1	Ground
2	N/C
3	Video RGB
4	Video RGB
5	Video RGB
6	N/C
7	Video Mono
8	Horizontal Sync
9	Vertical Sync

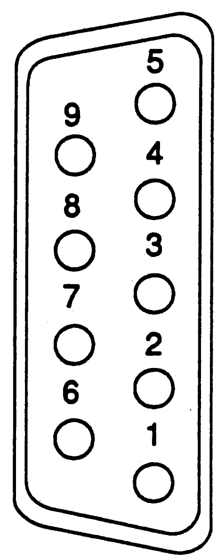


Figure 2-2: Video Connector Pinout (Factory Configuration)

Rackmounting Instructions

The SCD Series digitizer includes hardware for mounting the instrument in a standard 19-inch rack. The rack should have the following dimensions:

- a rack rail hole spacing of 0.5 inches
- a rack depth of at least 27.5 inches
- a width between rack rails of at least 17.65 inches

In addition, there must be at least two inches of clearance between the rear of the instrument and any cabinet panel or wall to provide adequate ventilation.

WARNING

The rack mounting hardware must be installed on the side (right or left) for which it is intended. If hardware is installed on the wrong side, the extension stop (safety latch) will not engage. This could allow equipment to come out of the slides unexpectedly while being removed and fall from the rack, possibly causing injury and damaging the equipment.

When mounting the stationary tracks, find the LH (left hand) and RH (right hand) markings on the stationary track to determine the correct placement. Facing the front of the rack, install the LH track on the left side and the RH track on the right side.

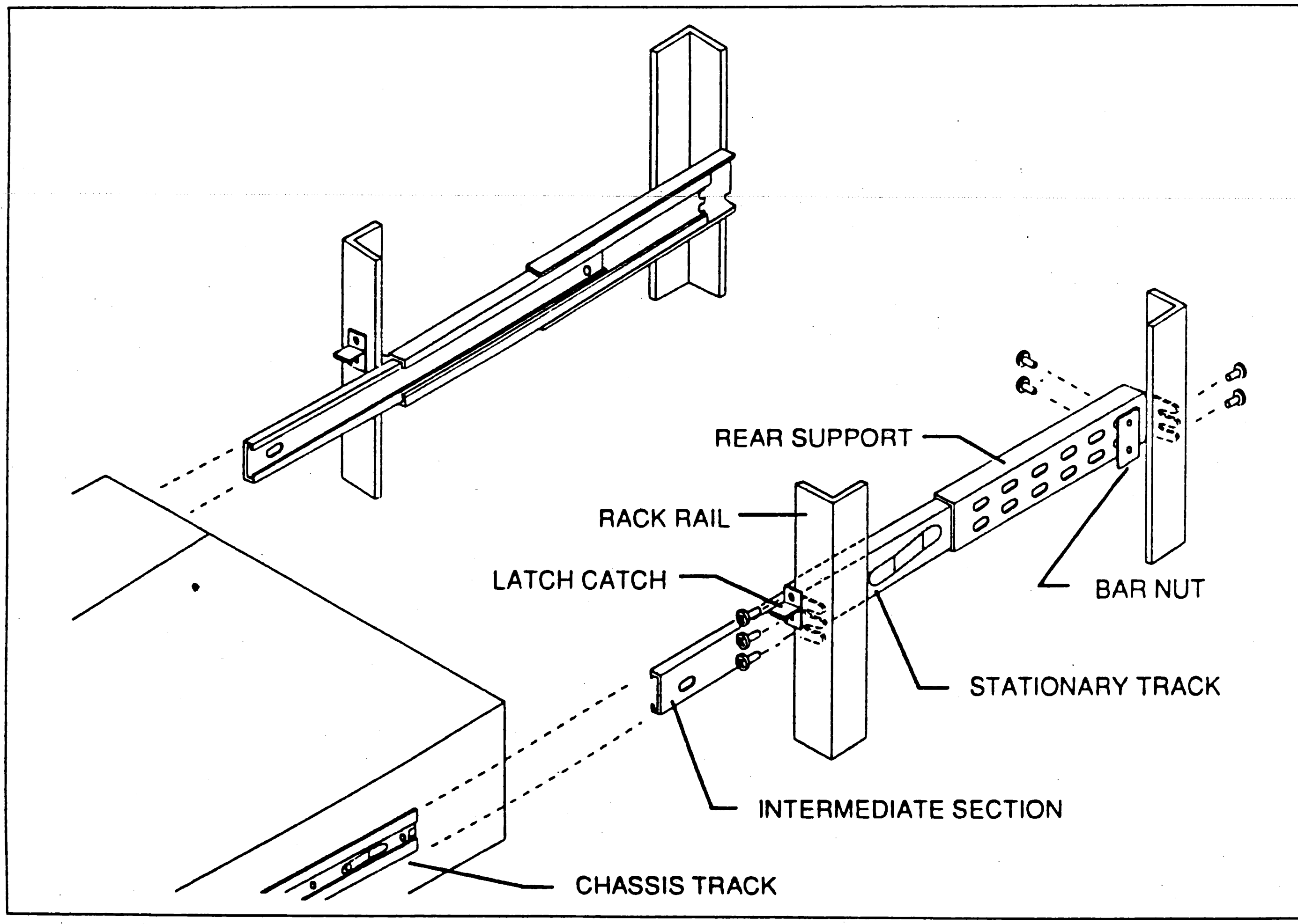


Figure 2-3: Rack Mounting Hardware

The SCD Series digitizer is supplied with the chassis slide tracks already in place. Install the digitizer as follows (refer to Figure 2-3):

1. Slide a stationary track into a rear support and hold the track and support up to the rack to fit them to the depth of the rack. Bolt the track and support together with bolts and bar nuts, but do not fully tighten the bolts. (For shallow racks, reverse the rear supports as shown in Figure 2-4. In this position, there must be room for the instrument to extend beyond the rear of the rack.) Assemble both sets of stationary tracks and rear supports in this way.

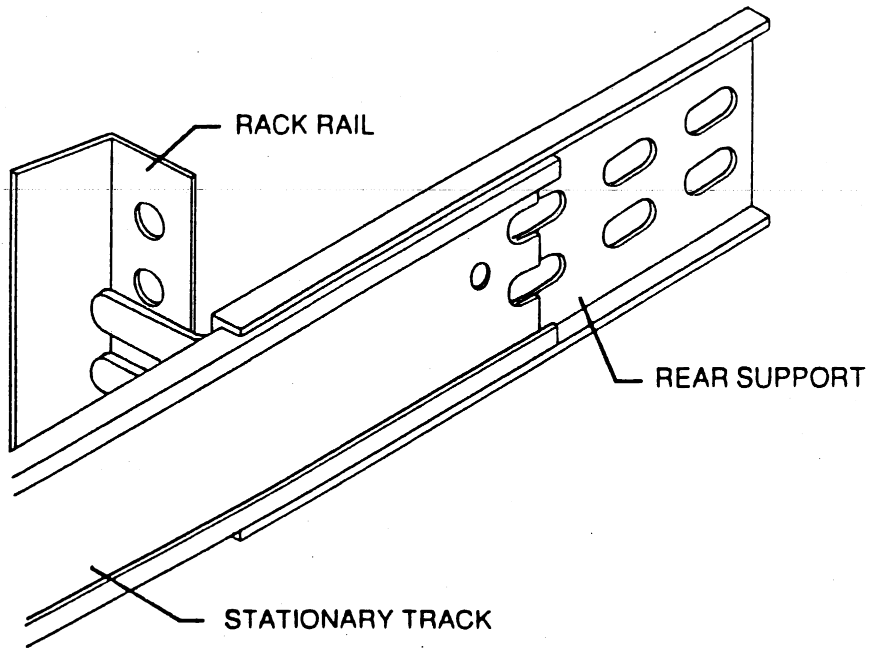


Figure 2-4: Rear Support Position for Shallow Racks

2. Install the latch catches on the front rack rails one screw hole above the screw holes for the stationary track. (Note that the right and left catches are different.) Install the catches so that the screw holes face outward and the lip of the catch faces down.
3. Bolt the stationary track/rear support assemblies to the rack rails. Note that the right and left tracks are not the same. Check the RH and LH markings and compare them with the chassis tracks on the sides of the SCD Series digitizers. Use nuts or bar nuts if the rack rail holes are not threaded. Tighten the bolts enough to secure the stationary track/rear support assemblies but still allow movement. Fully tighten the bolts that attach the rear supports to the stationary tracks.
4. Slide the intermediate sections into the stationary tracks so they lock in their extended positions.
5. With help from another person, carefully lift the digitizer so that the chassis tracks are aligned with the intermediate sections, and slide the instrument into place.
6. The sliding sections of the track should align themselves as the instrument is pushed into the rack. Tighten all bolts with the tracks aligned.
7. Push the digitizer into place and check that the latches catch properly. The tracks are prelubricated and should slide freely.
8. Check that the fan exhaust at the rear of the instrument is not blocked. There should be at least two inches of clearance at the rear of the instrument. Install the cables for the instrument as described in the *SCD1000/SCD5000 Operator Manual.*

Packaging for Shipment

It is recommended that the original carton and packing material be saved for shipping the waveform recorder. If the original materials are unfit or not available, package the instrument as follows:

1. Use a corrugated cardboard shipping carton having a test strength of at least 275 pounds and with an inside dimension of at least six inches greater than the instrument dimensions.
2. If the instrument is being shipped to a Tektronix Service Center, enclose the following information:
   - the owner's address
   - name and phone number of a contact person
   - type and serial number of the instrument
   - reason for return
   - a complete description of the service required
3. Completely wrap the instrument with polyethylene sheeting, or an equivalent, to protect the instrument case and to prevent entry of harmful substances into the instrument.
4. Cushion the instrument on all sides using three inches of padding material or urethane foam, tightly packed between the carton and the instrument.
5. Seal the shipping carton with an industrial stapler or strapping tape.
6. If the instrument is being shipped to a Tektronix service center, mark the address of the Tektronix Service Center and also your own return address on the shipping carton in two clearly visible locations.

General Operating Instructions

Power On

Before turning on the power for the first time, be sure to read the safety summary at the front of this manual and *General Information*, starting on page 2-1.

CAUTION

If the waveform recorder has been stored in an environment outside its specified operating temperature, do not turn on the power until the instrument has stabilized to an ambient temperature within its specified operating temperature range. If moisture has collected on the instrument, allow the moisture to evaporate before powering up.

The two power switches on the waveform recorder are the PRINCIPAL POWER switch (on the rear panel) and the ON/STANDBY switch (on the front panel). To power up the instrument, first make sure the rear panel PRINCIPAL POWER switch is ON and turn on the front-panel ON/STANDBY switch.

Power Off

To turn the waveform recorder completely off, first set the front-panel ON/STANDBY switch to STANDBY, then turn off the rear-panel PRINCIPAL POWER switch.

Before powering off during a normal power-off sequence, the waveform recorder stores, in nonvolatile memory, the current instrument settings, and the waveforms in records 1 through 4. Settings are reestablished when the waveform recorder is later powered up. If power is turned off or interrupted during a self-test or while performing a normal operation, the instrument may not properly save these settings. The settings are then set to factory default.

In addition to saving the current settings, up to 10 different instrument settings can be saved in nonvolatile memory for quick recall. Saving settings can be done over the GPIB (SAVE command) or from the Display Unit.

Self-Test and Diagnostics

The SCD Waveform Recorders perform internal self-test routines each time the instrument is powered up. The power-up self-test can be bypassed by setting the rear-panel PWR UP TEST switch OFF. Power-up self-test routines require no user interaction.

NOTE

Instrument warm-up can take 20 minutes.

If any test fails, the following occur:

- the instrument attempts to run while reporting an Internal Error event code over the GPIB
- the front-panel FAULT indicator (beneath the Display Unit) lights to indicate a fault
- A descriptive message is displayed in the Message/Measurements Zone of the Display Unit

The power-up self-test consists of the Kernel Tests and the Essential Diagnostics Tests. Kernel tests include the microprocessor, processor RAM and ROM, and the GPIB communication system tests. These tests verify that all the resources needed by the operating system are working. Once the kernel tests have passed, the operating system is activated.

The first task of the operating system is to execute the Essential Diagnostics tests, which assure that all basic subsystems properly function. No kernel or essential diagnostics are performed with Power-up test off.

Self-test can also be initiated over the GPIB (using the TEST command) or from the Display Unit. See Section 6 of the *SCD1000/SCD5000 Operator Manual* more information on the TEST command.

The SCD Waveform Recorders also provide calibration routines for the following subsystems. These routines are only initiated from the Display Unit or over the GPIB, and are not part of the power-on sequence.

- CALIBRATE HORIZONTAL: Performs self-calibration of the horizontal sweep circuits.
- CALIBRATE TRIGGER: Performs self-calibration of trigger circuits.
- CALIBRATE VERT: Performs self-calibration of Gain and Offset vertical circuits.
- CALIBRATE CRT: Performs self-calibration of the CRT circuits.
- CALIBRATE ALL: Executes all calibration routines.

Refer to Section 6 of the *SCD1000/SCD5000 Operator Manual* for more information on the CALIBRATE command.

Initialization

Once the power-up self-test has successfully completed, the SCD Waveform Recorders automatically returned to the settings that existed prior to the power being turned off. If initialization to factory default settings is desired, initialization can be invoked from the Display Unit or over the GPIB. Over the GPIB, the instrument settings (Panel), the GPIB (GPIB), or both can be initialized. From the Display Unit menus, any mode, function, or the entire instrument (Panel) can be initialized.

The factory default settings for the SCD Waveform Recorders is found in Section 6 of the *SCD1000/SCD5000 Operator Manuals*.

Display Unit Overview

The SCD waveform recorders can be controlled over the GPIB or from the Display Unit (shown in Figure 2-5 attached to a waveform recorder). The instrument's GPIB command set is described in the *SCD1000/SCD5000 Instrument Interfacing Guide*.

The Display Unit provides instrument control and display of digitized waveform data and instrument status on a high-resolution Liquid Crystal Display (LCD). Instrument control is through several "soft keys" around the perimeter of the LCD. Key functions change depending on the operating mode of the instrument and the soft keys previously pressed. A label displayed on the LCD next to a key defines the current function of that key.

The Display Unit plugs into the waveform recorder. It is easily removed as described in *Removing/Replacing Display Unit* on page 2-16.

The LCD is a backlit, high-resolution display (640 × 400 pixels). Up to 64 characters by 16 rows of text can be displayed on the screen. A CONTRAST adjustment knob allows changes in contrast for comfortable viewing over a wide range of ambient lighting.

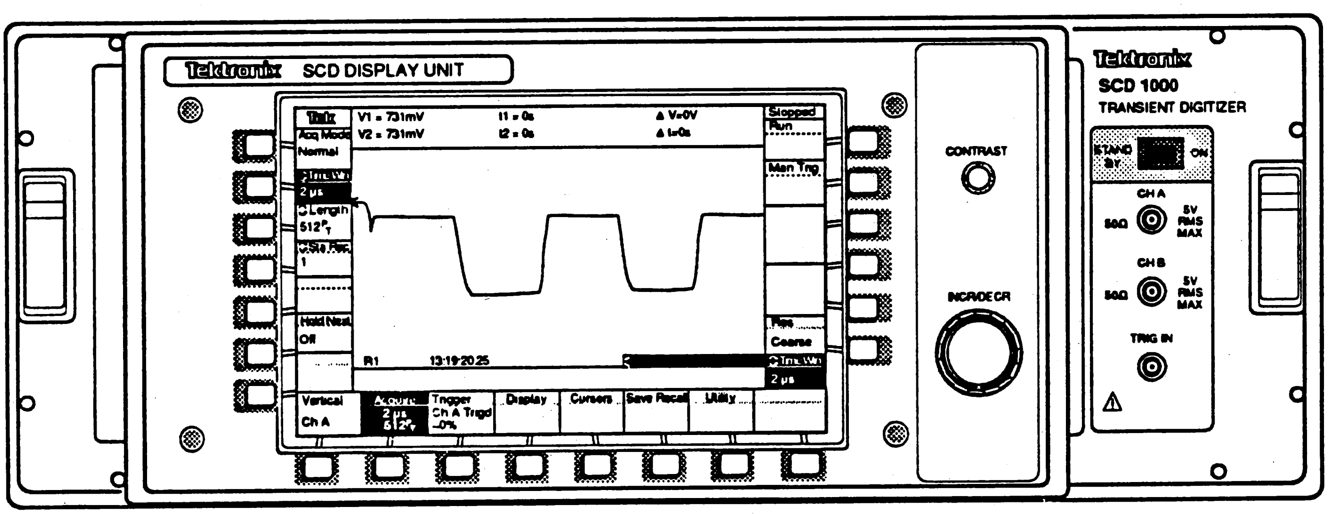


Figure 2-5: SCD1000 Waveform Recorder With Display Unit Attached

Removing/Replacing Display Unit

The Display Unit is a removeable device. It is attached to the waveform recorder front panel by four "clasps" that engage posts on the instrument's front chassis. The clasps are engaged and disengaged by the handle on the left side of the Display Unit. By firmly pulling the handle to the left, the clasps are disengaged. The Display Unit can then be removed by pulling the unit forward, away from the waveform recorder.

When re-installing the Display Unit, make sure the handle is completely pulled out. Place the Display Unit onto the waveform recorder, making sure the display connector properly mates. Slide the handle to the right to engage the clasps and secure the Display Unit to the waveform recorder.

CAUTION

Make sure the handle is pressed all the way in. If the handle is not pressed in all the way, the Display Unit is not secured to the instrument, and it may fall off. The yellow "Latch Open" warning label will be totally hidden when the latch is fully engaged.

Display Unit Operation

Display Zones

The Display Unit includes six display zones, as illustrated in Figure 2-6. These zones contain soft key menus and settings, waveform data, messages, and waveform recorder status information.

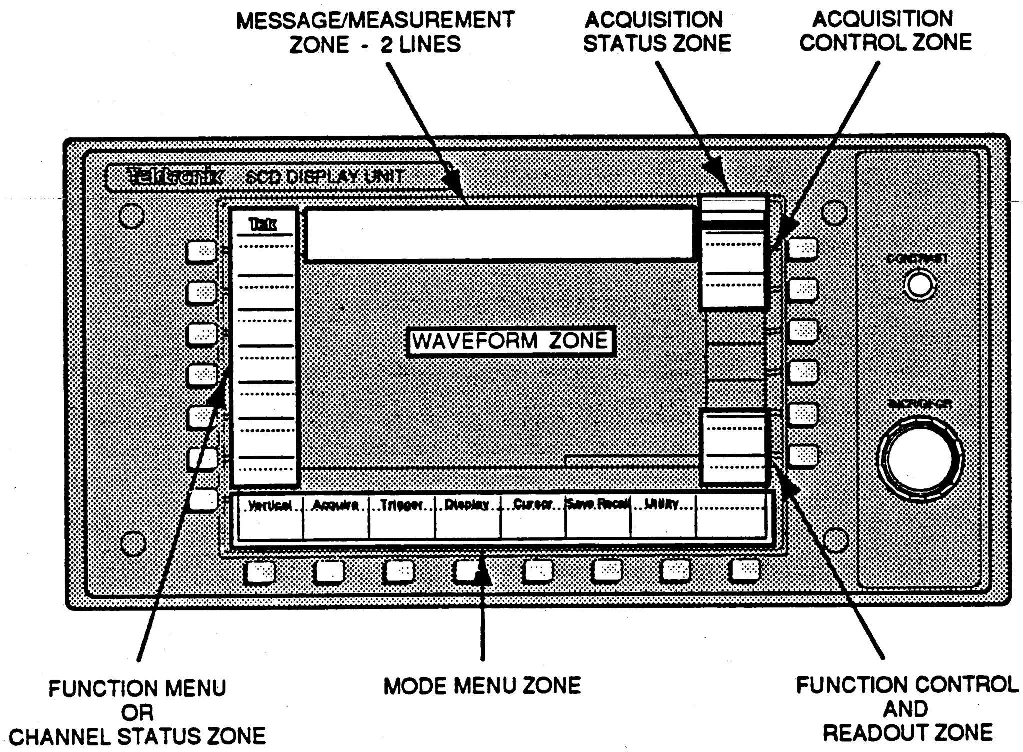


Figure 2-6: Display Unit Display Zones

Mode Menu Zone – The mode menu zone is always displayed when the Display Unit is on.

Function Menu/Channel Status Zone – This zone displays the function key labels when a mode is active or vertical channel status information when no mode is active. Each channel's status includes the vertical mode (Ch A, Ch B, or Add), vertical range and coupling, offset value, and the vertical expansion factor.

Acquisition Status Zone – This zone displays the current state of the waveform recorder:

- Stopped indicates the system has stopped acquiring data.
- Running indicates the system is acquiring data.
- HoldNext indicates the system is waiting for an acquisition to complete and the HoldNext acquisition mode is on.

Knob Readout Zone – This zone displays the last parameter that was set by the knob and its current value. Turning the knob affects the value in this zone.

Message/Measurements Zone – This zone displays error messages, warning messages, or measurement results from the two cursors or expansion point. When any error or warning occurs from the front panel or the GPIB, an appropriate error/warning message is written in the message zone. This message remains until a new message replaces the current one, or until a cursor position is changed or the Cursors mode key is activated. The last 20 messages are saved in nonvolatile memory and can be recalled using the Recall Status function.

Cursors must be turned on for measurement information to be displayed.

Cursors – Cursor measurements include absolute time and voltage for each cursor and the Δt (or 1/t) and Δ amplitude between the cursors. The cursors can be assigned to the same display window or different display windows.

This zone is shared amongst all functions that use it, so the information displayed here is a result of the last function that used it. None of the functions has priority over any other function; this means if an error message is displayed in the area and the cursor function is requested, the cursor will display its readout in the area, overwriting the error message.

Waveform Zone – This zone displays waveform data in 1, 2, or 4 windows. Each window can display one waveform and several indicators. A typical single waveform display is shown in Figure 2-7. Waveform zone indicators are shown in Figure 2-8.

The horizontal axis for each window covers 512 pixels. The vertical axis for each window covers 256 pixels (1 window), 128 pixels (2 windows), or 64 pixels (4 windows).

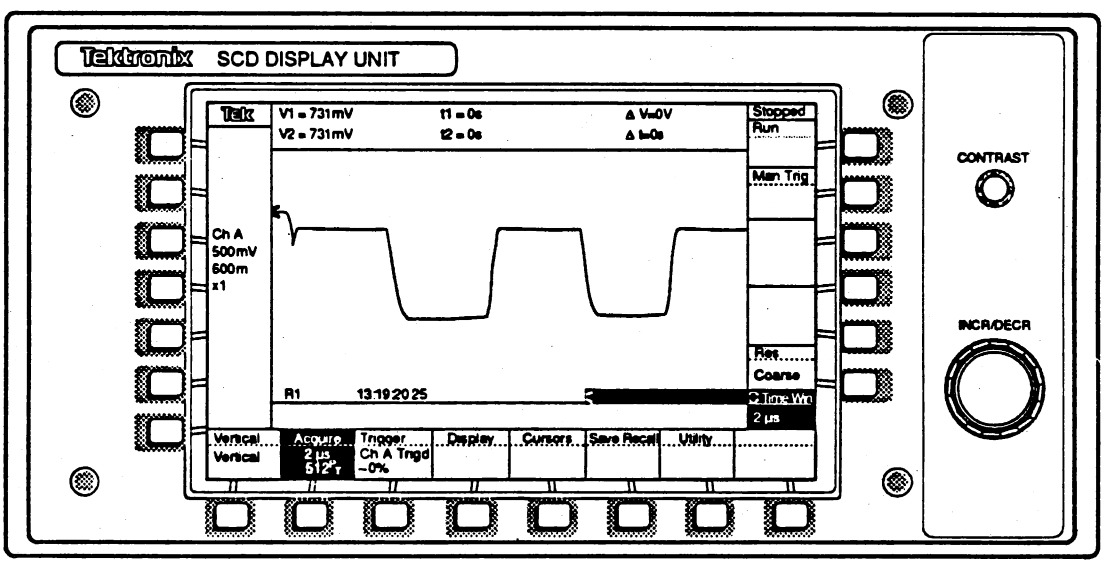


Figure 2-7: Single Waveform Display

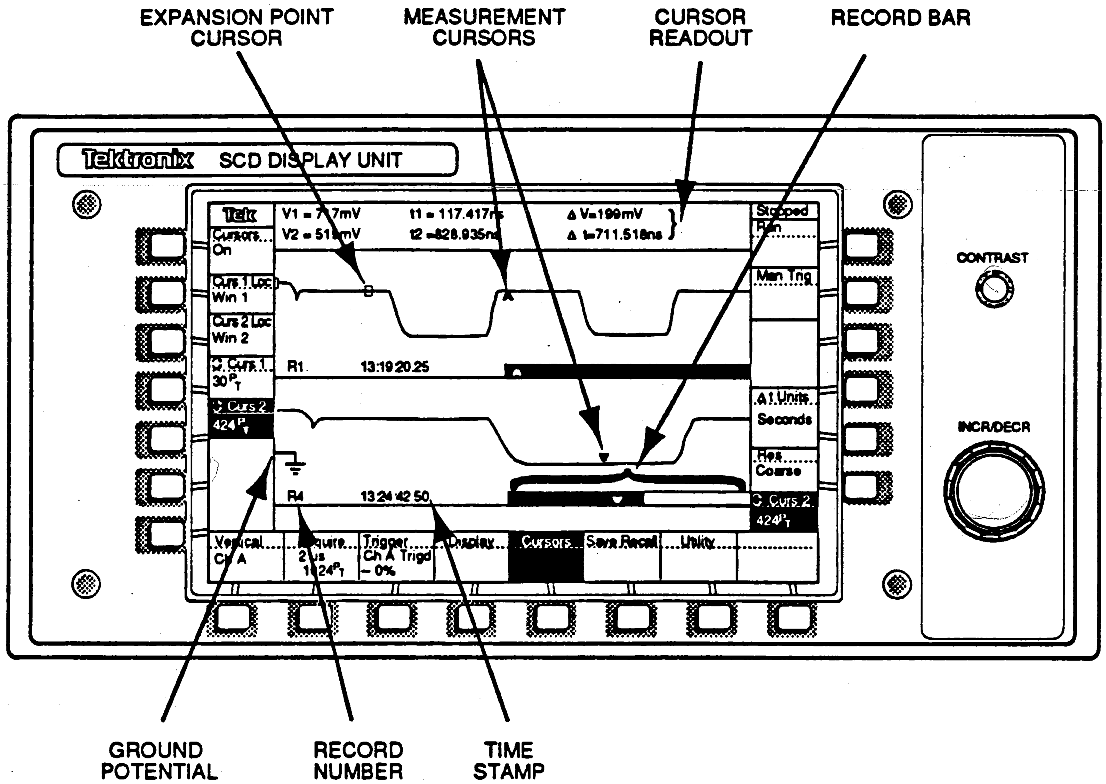


Figure 2-8: Waveform Zone Indicators

Theory of Operation

This section explains how the SCD Series digitizers work. Read this part to gain an understanding of general concepts and terminology helpful in trouble-shooting the instrument.

Block diagrams are included at the end of this section. Figures 3-1 and 3-2 refer to the SCD1000, and Figures 3-3 and 3-4 refer to theSCD5000.

System Overview

The SCD1000 and SCD5000 waveform recorders are designed to capture low nanosecond and picosecond single-shot events. The SCD captures transient waveforms with scan conversion digitizing technology. Scan conversion uses a fast in/slow out concept: the SCD records a fast analog signal, then slowly reads out and digitizes the signal. This process is similar to taking a photograph of an oscilloscope screen the instant a transient waveform is displayed. The difference is that the SCD writes the waveform on one side of a silicon diode target with an electron gun and reads it off the other side with another electron gun, all within a single scan conversion CRT. Refer to the *SCD1000/SCD5000 Operator Manual* for information on how the target image is processed to produce a digitized waveform.

The SCD contains four subsystems:

- The write system amplifies the input signal, triggers the acquisition, controls the write gun electron beam, and generates calibration signals.
- The read system controls the read gun electron beam and amplifies the read signal.
- The control system digitizes and processes the read signal, displays the waveform, and controls the instrument.
- The power supply system creates and distributes the various voltages used by the circuit boards and the CRT.

Scan Converter Operation

The scan converter CRT used in the SCD consists of two facing electron guns with a silicon diode target positioned between them. This is conceptually the same as two CRTs joined at a common faceplate.

In the write gun, the heater, cathode, and anode generate the write gun electron beam, and the grid controls its intensity. The focus lens and astigmatic lens collimate and focus the electron beam. (The SCD1000 has one astigmatism lens, and the SCD5000 has two). Traveling-wave vertical deflectors move the beam in response to the input signal.

These deflectors handle high frequencies by moving the input signal through helical deflectors with the same velocity that the write beam electrons travel through the tube. Electrostatic horizontal deflectors move the beam across the target. Shielding protects the deflectors from electromagnetic interference, and a drift tube shields the electron beam in the last part of its journey to the target.

The read gun also has a heater, cathode, grid, anode, and shielding. The read gun uses a cylindrical electrostatic deflectron for horizontal and vertical deflection. The deflectron is formed by an etched metal foil pattern twisted about the CRT axis and immersed in an axial magnetic field by the focussing coil. The read gun has a mesh in front of the target that collects excess electrons from the target after the target is charged. The read beam is blanked when the beam retraces to the top of the next scan line and when the write gun is writing.

The target is an N-type silicon substrate with P-type islands, forming hexagonally close-packed diodes at a density of about 1,000,000 diodes per square centimeter. The read and write beams scan regions on opposite sides of the target.

The acquisition cycle proceeds as follows:

1. At the beginning of an acquisition cycle, the read beam erases the target by using a rectangular raster to scan 2048 vertical lines across the target at least twice. The read beam charges the target negatively with respect to the cathode, effectively reversing the bias on the diodes and storing charge in them as in a capacitor. If the SCD isn't triggered, the read beam continuously erases the target.
2. When the instrument is triggered, the write beam writes on the other side of the target. During writing, 10 kV electrons bombard the target, creating electron-hole pairs near the surface. The holes diffuse through the target across the depletion region formed by the reverse biased diodes, discharging the target surface in the written area.
3. The read beam then scans the target again. When the beam scans over the written area, current flows from the target and recharges the diodes. This signal from the target lead is amplified and processed to create an image of the input signal.
4. The read beam then continues to erase the target in preparation for the next acquisition.

The target can be burned by the write beam, so the SCD has protection circuitry to control the intensity of the beam and the amount of time it spends on the target. If the target is in danger of being burned, the SCD immediately blanks the write beam.

System Descriptions

The SCD waveform recorders accomplish the digitization of high speed transient events using a number of different systems, described below. Following the system descriptions, a general description of the circuitry on each of the circuit boards is given.

Main Processor System

The main processor provides the high level control for signal acquisition, GPIB interface control and front panel interfacing and the rear panel video output. The main processor is located on the MPU board. A small board on the rear panel, the GPIB Address Select Switch board, allows setting of the GPIB and power up operation. The switch settings are read by the main processor.

Display System

The display system is a detachable LCD display with push buttons and a knob to control operation of the instrument. When the display is removed, status LEDs are visible to indicate the operational state of the instrument. Control of the LCD and front panel controls is accomplished with circuitry on the Front Panel board. The status LEDs are on the LED board.

Write System

The write system is made up of circuitry required for the creation of the image written on the diode target within the CRT. Six major blocks of circuitry are involved with the writing of the target:

1. The vertical circuitry provides the interface between the input signal and the vertical deflectors of the CRT and offset. Offset allows the signal to be positioned within the input range. Vertical circuitry for the SCD1000 consists of attenuators and amplifiers to allow signal varying from millivolts to tens of volts to be captured with maximum resolution.

   The SCD1000's attenuator, preamplifier and offset circuits are located on the Analog circuit board. A vertical amplifier on the Output board further amplifies the input signal to deflect the CRT's write electron beam. A delay line is inserted between the Analog and Output boards to delay the arrival of the input signal at the CRT's vertical deflector to allow time for the sweep generator in the horizontal system to start and become linear. A resistive network terminates the output of the CRT's vertical deflector.

The SCD5000 provides a direct connection between the input and CRT to provide maximum bandwidth and minimum aberrations to transient signals. A single high quality coaxial cable connects the input to the CRT. Offset is accomplished by magnetically defecting the write beam using a coil attached to the CRT. The Trigger board contains a current source to drive the coil based on the Vertical Offset setting.

Option 01 adds a trigger pickoff and delay line to the input signal path. The trigger pickoff allows the input signal to be used as a trigger source. The delay line delays the arrival of the input signal at the CRT's vertical deflector to allow time for the sweep generator in the horizontal system to start and become linear. Additional circuitry in the trigger pickoff module compensates for high frequency losses in the delay line. A 50 Ω terminator terminates the output of the CRT's vertical deflector.

2. The trigger circuitry produces the signal used to start the sweep generator in the horizontal subsystem. The trigger works in conjunction with the control system to allow triggering only when the CRT is prepared to accept writing of the target. Trigger circuitry is located on the Analog board in the SCD1000 and the Trigger board on the SCD5000.
3. The horizontal circuitry generates a differential high speed ramp to deflect the CRT's writing beam across the target. Sweep generation and deflection amplifiers are located on the Write Gun board.
4. The high voltage/z-axis circuitry provides the operating voltages for the CRT's write gun and controls the unblanking of the electron beam during the acquisition of a signal, when the target is written. This circuitry is located on the High Voltage board.
5. The calibrator circuits provide accurate DC voltages for vertical calibration and precise frequency timing signals for the calibration of the time window duration and trigger delay. Calibrator circuitry is located on the Analog board in the SCD1000 and the Trigger board in the SCD5000. The Calibrator is located on the Analog board of the SCD1000 and the Trigger board in the SCD5000.
6. Option 1E provides the interface for detecting and controlling Tektronix Tekprobes (TM) on the Tekprobe board.

Read System

The read system controls the read gun portion of the CRT. The Read Gun circuit board generates differential ramps for X and Y deflection, controls the unblanking of the read beam and supplies the operating voltages and focusing for the read electron gun. Scanning of the target after an acquisition causes current to flow in the target. The current flow is detected and amplified by the Video Preamp board. The video preamp output is digitized by the control system to produce the digitized input signal.

Acquisition System

The acquisition system provides the low level and realtime control of the write and read systems. The Control board enables the acquisition based on the operators commands and the current state of the instrument and digitizes the target's video signal after the target is written. Digitized target data is sent to the Data Memory board for defect removal, storage and centroid processing by the main processor. If Option 1P, Fast Waveform Capture is present, the digitized target data is centroid processed faster and without using the main processor. After acquisition, the Control board prohibits another trigger and acquisition until the target and can have its previous signal image erased.

Power Supply And Distribution System

Power for the various supplies needed to operate the SCD's circuitry is produced by the Power Supply Assembly module. The front panel Stand by/Off switch controls instrument operation by shutting down the Power Supply Assembly's power converter when the instrument is in standby. Regulated supplies in the module power the logic in the instrument. Semi-regulated voltages, from the assembly, are precision regulated by the Regulator board. Power from the module and Regulator board is distributed on the Backplane board as are signals between the boards in the card cage. Additional supply voltages are generated on the Power Converter board which also serves to distribute power to other portions of the instrument.

Board Descriptions

The following section provide a general description of the circuitry on each of the circuit boards in the SCD instruments.

Analog Board (SCD1000 only)

The Analog board contains circuitry for the vertical amplifier and calibrator. Control signals for the attenuators, amplifier and calibrator are generated on the Control board.

The amplifier path begins with a pair of attenuator hybrids, one for each channel, followed by a compensator board that compensates for skin effect loss in the attenuator. Two IC's monitor the input voltage to detect overload conditions. Overload results in an interrupt to the main processor and opening of the inputs (unless inhibited). Output from the compensator assembly enters a dual channel amplifier. The dual channel amplifier provides offset, trigger pickoff for internal triggering and channel selection, summation and inversion. One output of the dual channel amplifier is the internal trigger source to the trigger generator, the other drives the delay line driver amplifier hybrid. A trigger hybrid produce trigger to begin the acquisition. The input to the trigger generator is selected by two relays, one for the internal (CHA or CHB) trigger, the other for external trigger. Level and slope selection take place in the trigger hybrid. Output from the trigger is a differential logic signal to the Write Gun board. Control signals from the Control board inhibit trigger during completion of an acquisition and can force a trigger when manually trigger or when auto triggering.

The calibrator has two major functions, one provides timing signals for sweep and trigger delay calibration, the other provides precise voltage for input range calibration. Timing calibration is derived from a 250 MHz oscillator phase locked to a 25 MHz reference from the Control board. The 250 MHz signal is divided to produce the lower frequencies for calibration of the longer time windows. Range calibration is accomplished using a high resolution DAC and amplifier with remote sensing to insure accurate voltages at the attenuator inputs. The two calibration sources are relay switched. When one source is selected for application to one of the input channels, the other is applied to the calibrator output on the rear panel.

Output Board (SCD1000 only)

The Output board receives its input from the delay line and amplifies to a level sufficient to deflect the write gun electron beam. Two hybrids provide the gain. A number of operation amplifiers provide low frequency compensation and control the bias of the hybrid amplifiers.

Trigger Board (SCD5000 only)

The Trigger board contains circuitry for the trigger generator and calibrator.

The input to the trigger generator is selected by two relays, one for the internal trigger , the other for external trigger. The internal trigger is connected to the calibrator in the SCD5000 and to the trigger pickoff in the SCD5000 Option 01. Level and slope selection take place in the trigger hybrid. Output from the trigger is a differential logic signal to the Write Gun board. Control signals from the Control board inhibit trigger during completion of an acquisition and can force a trigger when manually trigger or when auto triggering.

The calibrator has two major functions, one provides timing signals for sweep and trigger delay calibration, the other provides precise voltage for input range calibration. Timing calibration is derived from a 250 MHz oscillator phase locked to a 25 MHz reference from the Control board. The 250 MHz signal is divided to produce the lower frequencies for calibration of the longer time windows. Range calibration is accomplished using a high resolution DAC and amplifier with remote sensing to insure accurate voltages at the attenuator inputs. The two calibration sources are relay switched. When one source is selected for application to the input channel, the other is applied to the calibrator output on the front panel.

Write Gun Board

The Write Gun board contains circuitry for the horizontal deflection of of the write gun and control voltages for the write gun electron beam.

Horizontal deflection is produced by a sweep generator hybrid which feeds a discrete differential amplifier

An eight output DAC provides voltage for control of the sweep, trigger delay, CRT background (writing rate enhancement) and intensity. The intensity control voltage and sweep gate from the sweep hybrid are combined to produce a signal to drive the Z-axis amplifier on the High Voltage board. The Z-axis amplifier output and CRT first anode are monitored to detect excessive write beam current that could damage the diode target. The detector will deflect the beam off the target and interrupt the main processor under fault conditions.

High Voltage Board

The High Voltage board contains circuitry for generating and controlling the write gun electron beam. The write gun is powered by a high voltage power converter. A power oscillator and transformer drive a potted module containing all the high voltage circuitry. The cathode voltage is regulated by feedback from the high voltage module to the oscillator. The Z-axis amplifier amplifies the gated intensity signal from the Write Gun board to a level high enough to control the electron gun grid. Focus control is provided by a control voltage from the Write Gun board which is amplified to vary a voltage in the high voltage module.

Read Gun Board

The Read Gun board controls the scanning of the the read gun during the digitization and erasing of the target. and also distributes control and power to the Write Gun, Tekprobe and Video Preamp boards. Timing and control signals for the generation of the read scanning are produced on the Control board. The vertical scan of the read raster is produced by a sweep generator triggered by the Control board. The horizontal location of the vertical scan is controlled by a DAC whose input is also originates on the Control board.

Video Preamp Board

The Video Preamp board contains a low noise transresistance amplifier to sense the read beam scanning written portions of the target.

Control Board

The Control board provides the control signals to the Analog (SCD1000), Trigger (SCD5000), Write Gun, Read Gun and Data Memory to initiate complete and acquisition. Aside from controlling the other boards, most of the activity on the Control board takes place after the Write Gun sweep has run. After the sweep the target is ready to be digitized. During digitization, the target signal from the video preamp is digitized with a pair of flash converters and sent to the Data Memory board for storage. After digitization of the target is complete, the target is scanned several times to erase the previous image then the trigger may be armed for another acquisition. While waiting for a trigger the target is repeatedly scanned by the read gun to maintain high target sensitivity.

Data Memory Board

Two block of memory provide storage for the Reverence Array and Linear Array data. The Reference Array contains a bitmap indicating which portions of the target should be ignored during target digitization. The bitmap is produced during the Set Ref operation. The Linear Array is filled during target digitization when flash and read scan position data from the Control board is qualified by the Reference Array data and formatted. The Linear Array is read by the main processor during centroiding when Option 1P is absent. The formatted data is placed on the backplane for use by option board.

Mpu Board

The main processor provides the high level control for signal acquisition, GPIB interface control and front panel interfacing and the rear panel video output.

Led Board

Signals to the Front Panel Unit pass through the LED board. If the main processor detects the front panel is absent, the signal line will be used to drive the LEDs that indicate instrument status.

Front Panel Board

The Front Panel board contains circuitry to scan the push buttons and convert the video signal from the MPU board to drive the LCD.

Backplane Board

Power from the Regulator board and Power Supply module are distributed to most of the instrument through the backplane. Digital signals between boards in the card cage and to/from the other boards also pass through the backplane.

Power Supply Assembly

The Power Supply Assembly module contains the main power converter that provides the 5.1 volt logic power and preregulated voltages for the Regulator board and high voltage power converter.

Regulator Board

Series pass regulators provide low noise, stable and accurate voltage for the analog portion of the instrument.

Power Converter Board

+15 volts is used to generate +365 V, +130 V and −130 V for use elsewhere in the instrument. Since several other voltages pass through the Power Converter board, test points are provided for trouble shooting.

Option 2e Tekprobe Board

Control and sensing of the Tekprobe connector occur on this board. Power is supplied via the Power Converter board. Control signals to/from the main processor are passed via the Read Run board. Fuses on the power supplies to the probes protect against shorts exterior to the instrument.

Option 1p Fast Waveform Capture Board

Specialized hardware and a digital signal processor (DSP) are used to speed the centroiding, interpolation and geometry correction normally done by the main processor. Formatted data from the Data Memory board is used to produce the centroided waveform.. When the centroided waveform is available, the main processor is signaled to read it for display, measurements or sending over GPIB.

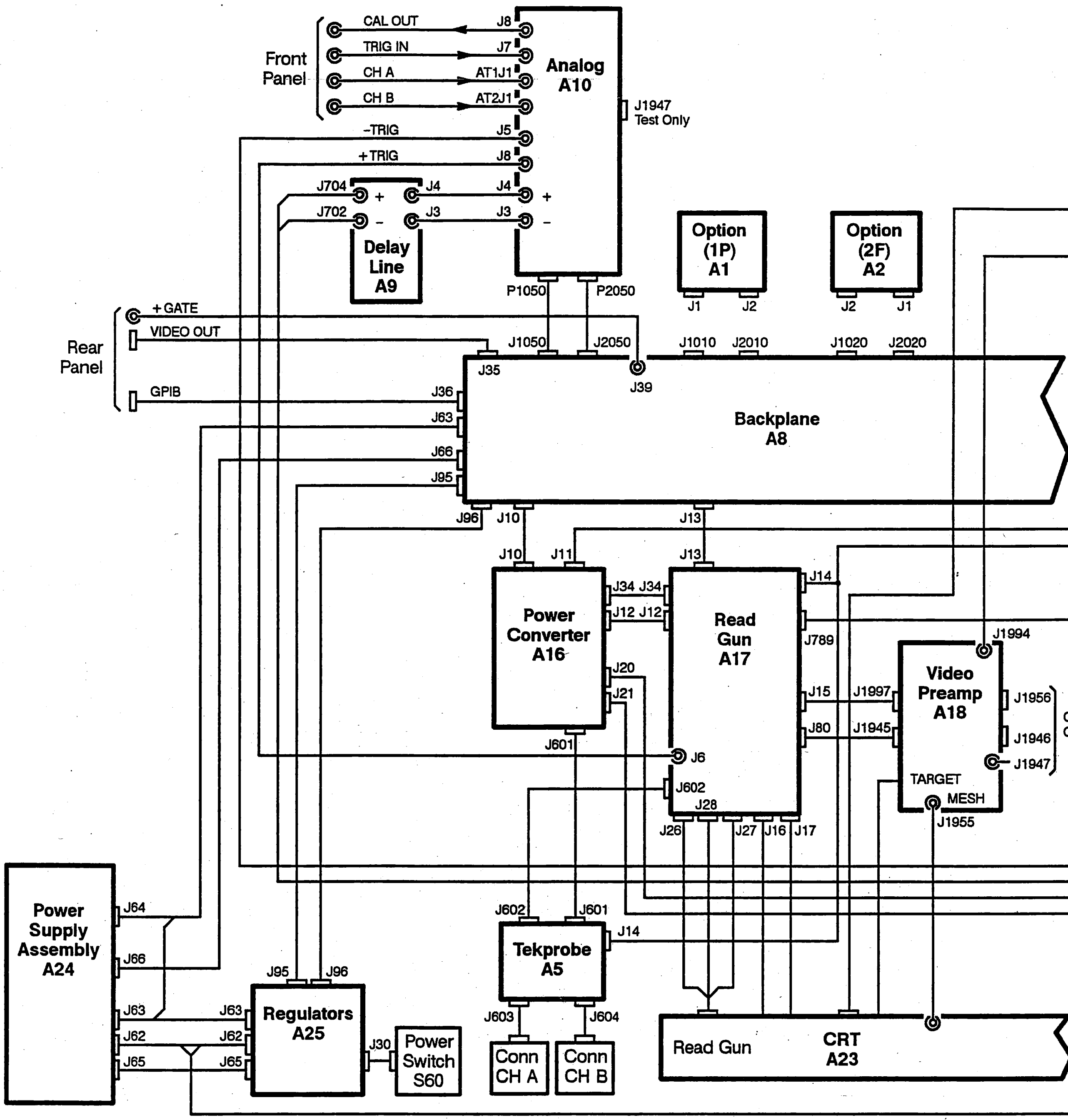


Figure 3-1: Part A — SCD1000 Block Diagram

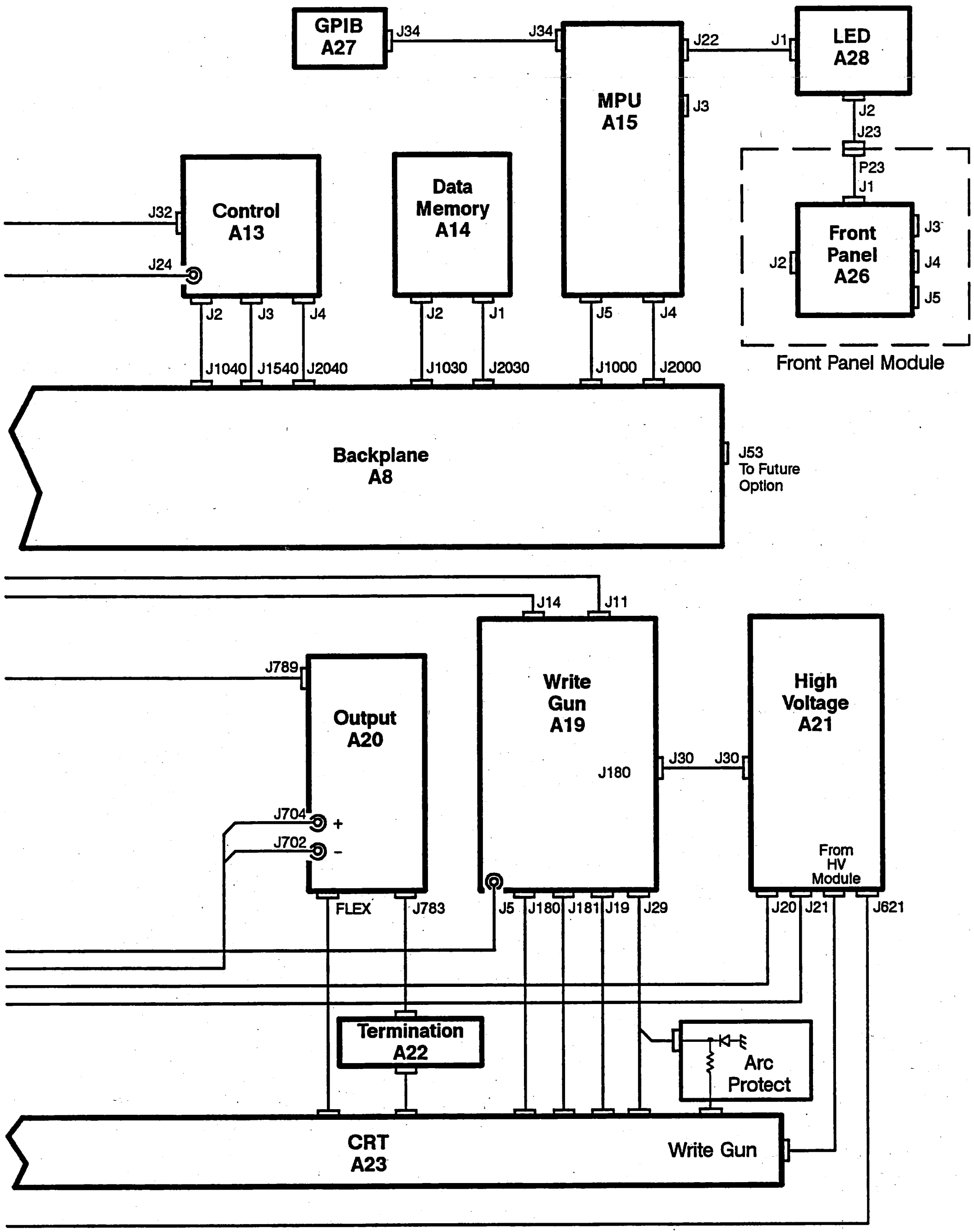


Figure 3-2: Part B — SCD1000 Block Diagram

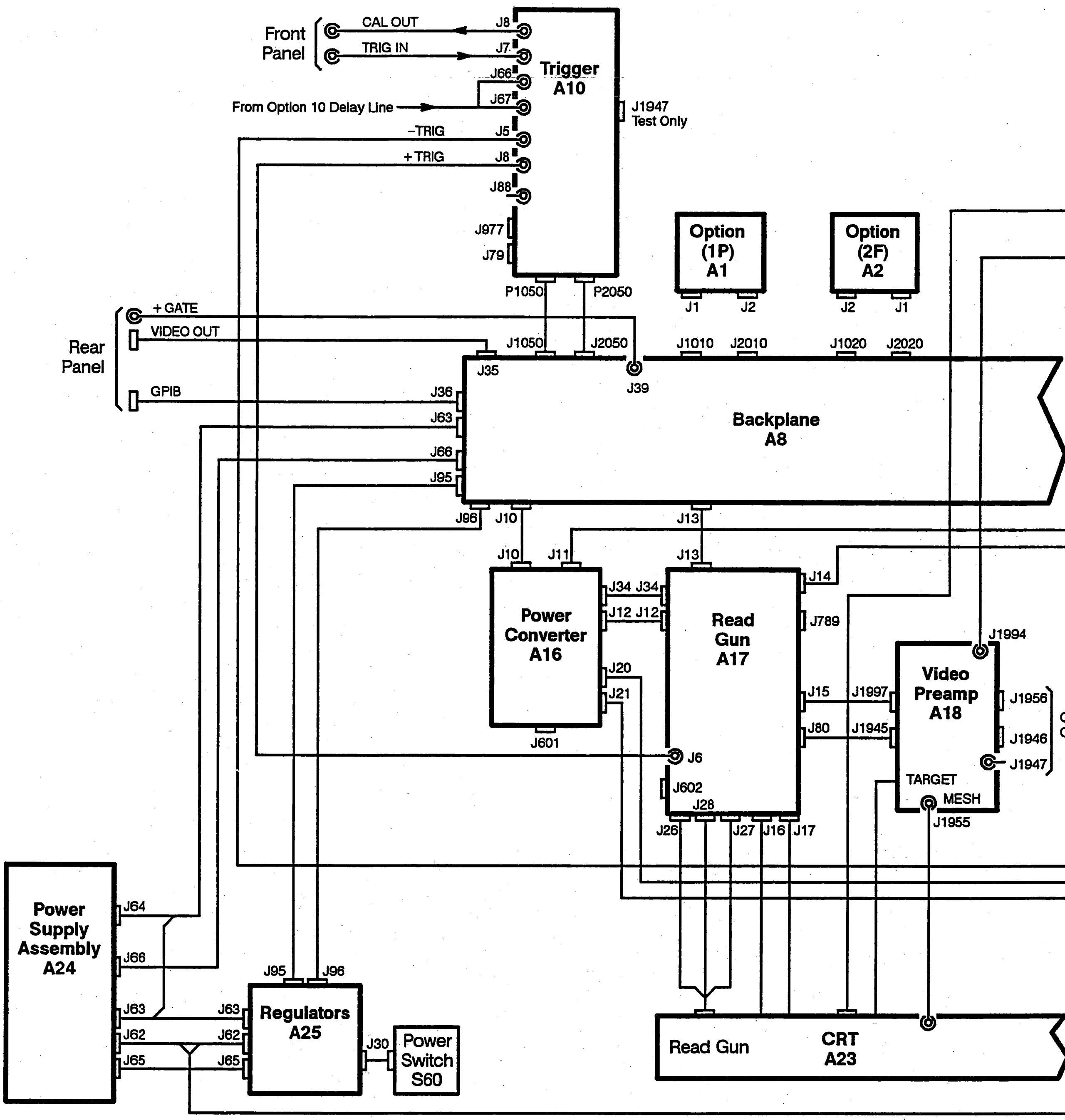


Figure 3-3: Part A – SCD5000 Block Diagram

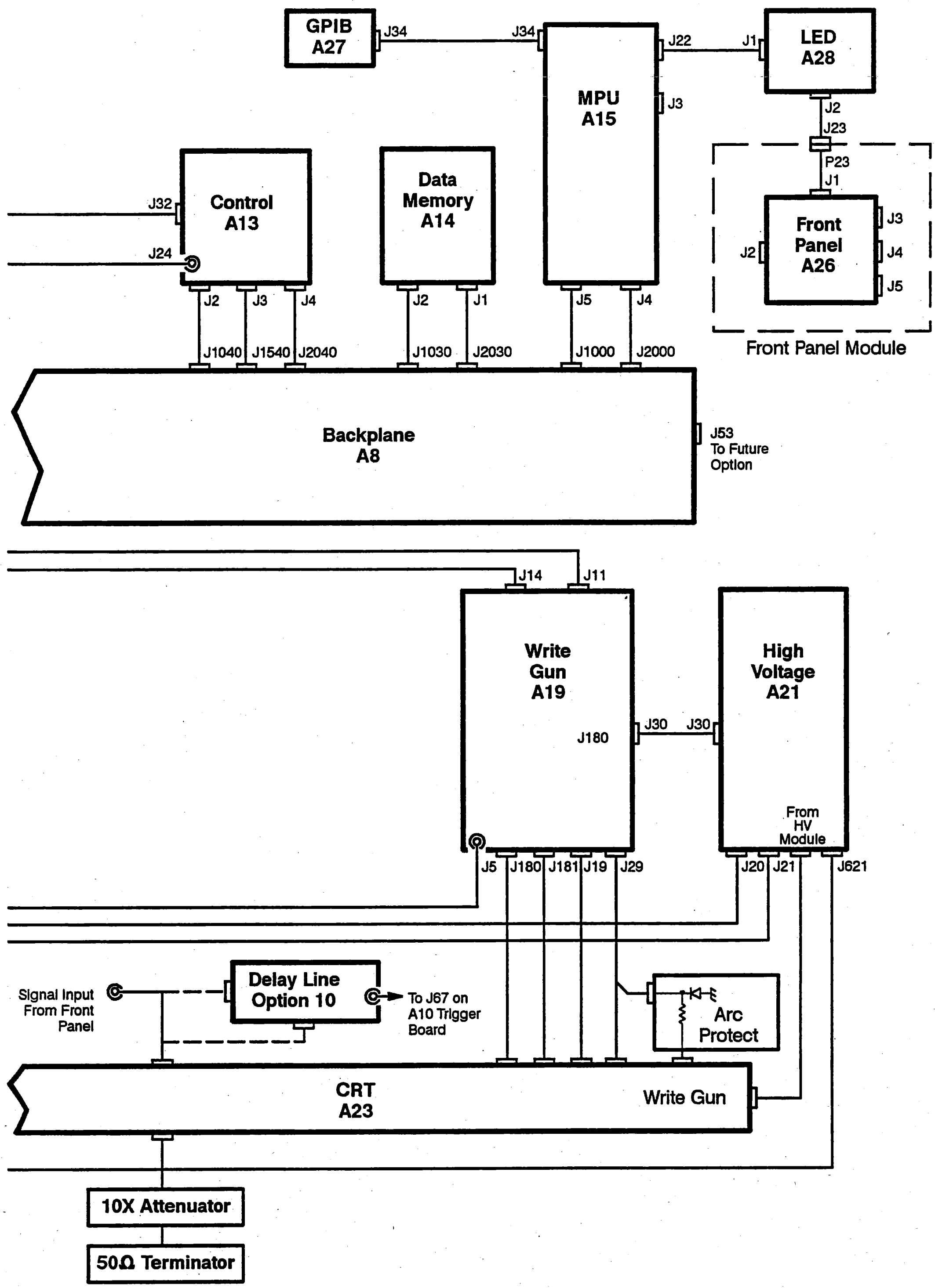


Figure 3-4: Part B – SCD5000 Block Diagram

Incoming Inspection

This section contains procedures for checking that the SCD1000 or SCD5000 is operating within specifications. It includes the following subsections:

Incoming Inspection – This section, which includes the procedure to check the instrument's basic operation when it first arrives and after servicing.

Performance Verification Procedure – Tests that verify that the instrument is operating within specifications. Run these tests every 12 months or after every 2000 hours of operation to ensure that the instrument is operating within specifications.

Inspection Procedure

The tests in this section should be run in the order indicated. After the instrument has been powered on for at least 20 minutes, Test 1 (Diagnostics) should be run to ensure that the instrument is in general working order. If this test fails, the instrument should be returned to an authorized service center for servicing. After diagnostics has passed, Test 2 (Cal Time Frequency) and Test 3 (Cal Reference Voltage) should be run to ensure that the internal standards are within specification. If they are outside the limits, the performance of the instrument cannot be guaranteed, and the instrument should be returned to an authorized service center for servicing. Test 4 (Internal Calibration) should then be run before proceeding with instrument operation.

NOTE

This procedure is only intended to verify the general operation of the instrument. It DOES NOT verify that the instrument meets all specifications. In order to verify that the instrument meets all specifications, use the Performance Verification Procedure *on page 4-15.*

The incoming inspection procedure requires the use of an SCD Display Unit to successfully complete all sections of this procedure. To order a Display Unit, contact your local Tektronix sales office.

If at any time during the tests the instrument fails to meet a test limit, then it should be returned to an authorized service center for servicing, identifying the test failed and limits exceeded.

The test should be run in a stable environment with the temperature between 20°C and 30°C and provisions made for adequate airflow to the instrument (i.e. the ventilation ports on the rear, sides, and front should be unobstructed). The ambient temperature should not change by more than 5°C during the tests.

Line supply should lie within the limits of 90 to 132 V rms or 180 to 250 V rms.

Table 4-1 lists the tests to be run.

Table 4-1: Lists of Tests for Incoming Inspection

Test Number	Test Name	Description
1	Diagnostics	Verifies general operating condition of the instrument
2	Cal Time Frequency	Checks internal calibration reference signals
3	Cal Reference Voltage	Checks internal calibration reference signals
4	Self-Cal	Performs verification of internal timing, vertical gain and offset, and trigger level circuitry of the instrument

Internal Diagnostics and Internal Calibration

Diagnostics and Internal Calibration can be run either from the IEEE-488 interface or the display unit. See the *SCD1000/SCD5000 Instrument Interfacing Guide* for more information on the associated GPIB commands

The internal diagnostics test the following:

- **PROCESSOR SYSTEM**, including system ROM, RAM, NVRAM, GPIB system, and system timer module
- **FRONT PANEL**, including the LCD, front panel circuitry, and MPU front panel interface
- **ACQUISITION SYSTEM**, including functioning of the digital acquisition control and data path
- **OPTIONS**, Option 1P

Internal system calibration performs the following:

- **VERTICAL (SCD1000)** – Sets the gain and offset range, and the Normal and Invert offset zero level for Channels A, B, and Add.

  VERTICAL (SCD5000) – Sets the input range, offset range, and the offset zero level.
- **HORIZONTAL** – Sets Window timing accuracy and Trigger Delay minimum and maximum values.
- **TRIGGER (SCD1000)** – For DC coupling, sets the gain and offset for both slope settings; for AC coupling, sets the offset for both slope settings; for external, sets the trigger level offset for both slope settings.

  TRIGGER (SCD5000) – Sets trigger external level offset for both slope settings.

Required Equipment

Table 4-2 lists the required equipment to complete the incoming inspection procedures

Table 4-2: List of Required Equipment for Incoming Inspection

Instrument Name	Recommended or Equivalent
5½ digit Digital Multimeter (DMM)	Tektronix DM 5120
250 MHz Digital Counter	Tektronix DC 5010
1 MHz Signal Generator	Tektronix SG 503
Instrument Controller with IEEE-488 interface	
SCD Display Unit (required for instruments with Option 20 only)	Tektronix SCDF019
Miscellaneous Parts	
2 N to BNC adapters	Tektronix part number 103-0045-00
Dual-banana-plug to BNC female adapter	Tektronix part number 103-0090-00
50 Ω terminator with BNC feedthrough	Tektronix part number 011-0049-01
50 Ω coaxial cable (3 ft long)	Tektronix part number 012-0482-00
SCD5000 Only	
50 Ω coaxial cable (8 in long) (1 ns electrical length)	Tektronix part number 012-0118-00
50 Ω feedthrough termination	Tektronix part number 011-0049-01

Test 1 Diagnostics

The general operating condition of the instrument is ascertained by running the internal diagnostic routines.

Setup: Apply power to the waveform recorder.

NOTE

Wait at least 20 minutes for the instrument to warm-up and reach a stabile operating temperature.

Procedure:

1. Verify that the instrument passes the power-up self-test by using the GPIB DIAG? command or checking the front-panel status.
2. Invoke the internal diagnostic routines via IEEE-488 by sending the instrument the commands:

   ```
   INIT ALL
   ```

   ```
   TEST SYS:ALL
   ```

   or

   Invoke the internal diagnostic routines via the optional display unit by selecting the Utility Mode menu. In the function menu which appears when the Utility Mode menu is selected, select the Next Menu function. This will cause an alternate function menu to appear. In this menu select the InstTest function. This will invoke a self-test of the entire instrument.

   Verify that the instrument passes the power-up self-test by using the GPIB DIAG? command or checking the front-panel status.
3. If the self-test routines fail, record the error message displayed on the front-panel (or the response from the DIAG? query). Return the instrument to an authorized service center for servicing along with the failure message.

Table 4-3: Test List

Number	Name	Subsystem	Description
1	Real-time Clock	MPU	Checks for proper operation of the clock used to set the waveform time stamps.
2	GPIB	MPU	Confirms operation of the GPIB system excluding the bus drivers.
3	Bus Error	MPU	Forces a MPU bus error to confirm the bus error detection circuitry is operational.
4	Timer	MPU	Tests the timer used by the operating system for operation at the proper interrupt rate.
5	ROM0 part number (U501)	MPU	Checks the MPU board EPROM location and does checksum test.
6	ROM1 part number (U600)	MPU	Same as test 5.
7	ROM2 part number (U601)	MPU	Same as test 5.
8	ROM3 part number (U700)	MPU	Same as test 5.
9	Display Unit ROM part number	MPU	Check for the proper EPROM on the Front Panel circuit board.
10	NVRAM	MPU	Checks the NVRAM on the MPU board.
11	Video	FP	Checks the RAM on the MPU board used for the LCD display.
12	Button and knob exerciser	FP	Checks the push button logic and the digital encoder knob logic on the Front Panel board.
13	Front Panel Communication	FP	Confirms the link between the MPU and the Display's Front Panel circuit board.
14	Digital Acquisition With Memory Test	DIG	Checks the waveform recorder's control system and waveform memory.
15	Digital Acquisition Without Memory Test	DIG	Checks the waveform recorder's control system.
16	Serial Bus	DIG	Confirms the internal serial communications bus is operational.
17	Options	OPT	Check Option 1P memory, Option 2F memory, and acquisition interface if installed.
18	Option 1P Fast Waveform Capture	OPT	Checks Option 1P host port communication if installed.
19	Option 2F Battery Backup Test	OPT	Checks that NVRAM on the Option 2F board will retain waveform data across a power cycle if installed.

Test 2
Cal Timing Signal

The accuracy of the internal calibration timing reference signal is verified using a digital counter.

Setup: Refer to Figure 4-1 for proper connections. Connect the Calibrator Output connector on the rear of the SCD1000 or the front of the SCD5000 through a 50 Ω coax cable to the DC5010 Counter/Timer.

			Setting		
			SCD1000	**SCD5000**	**Option 01**
Digitizer	Cal Out		Time		
	Utility	CalTime	4 ns		
Counter	Mode		Frequency		
	Trigger	Level	Auto (680 mV)	Auto (2.1 V)	
		Slope	+		
	Coupling		DC		
	Attenuation		1×	5×	
	Termination		50 Ω		

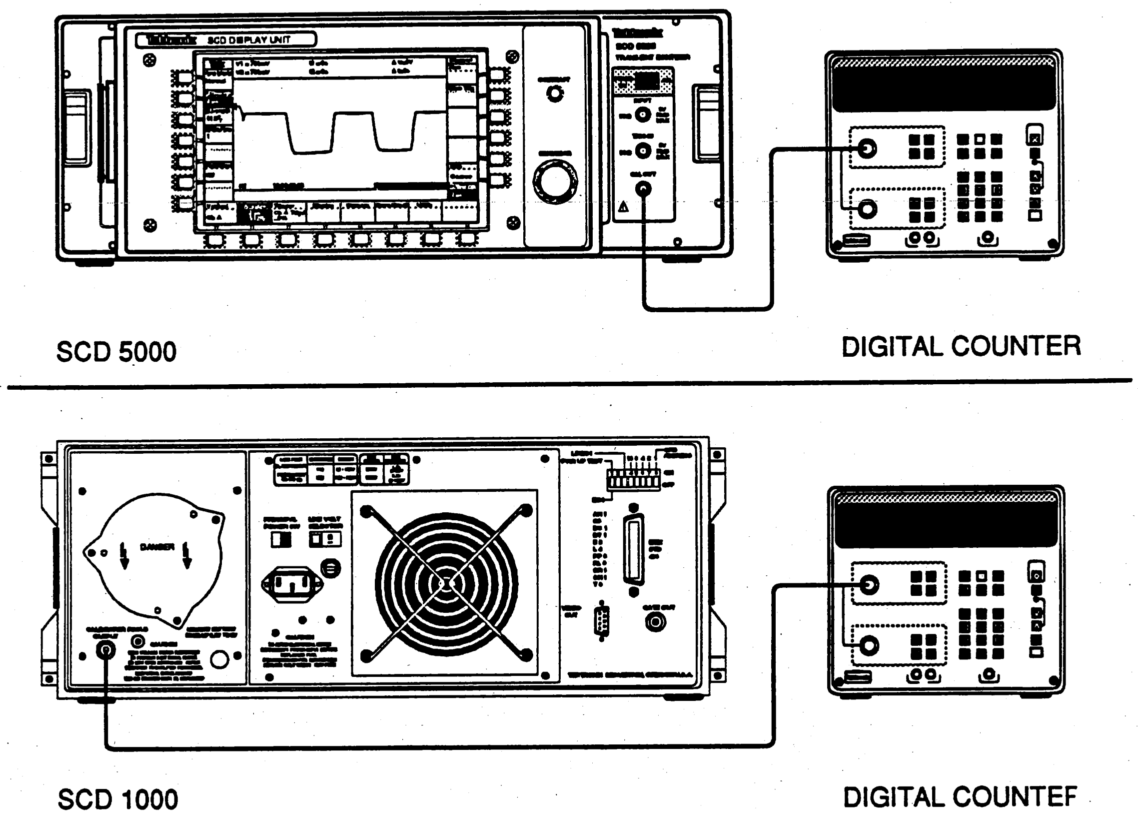


Figure 4-1: Internal Clock Frequency Test Setup

Procedure:

1. Set the counter averaging to AUTO (or highest accuracy setting possible).
2. From the Utility menu (5th level), select EXT CAL (CAL OUT on SCD5000) to Time.
3. Adjusting CAL TIME settings from 4 ns to 80 μs according to the entries in Table 4-4.
4. Verify that the measured period (or frequency) matches the SCD CAL TIME readout value for all settings (4 ns to 80 μs), within 0.1% tolerance:

Table 4-4: Calibrator Timing Measurements

Cal Time	Frequency	Tolerance
4 ns	250 MHz	±250 kHz
8 ns	125 MHz	±125 kHz
16 ns	62.5 MHz	±62.5 kHz
40 ns	25 MHz	±25 kHz
80 ns	12.5 MHz	±12.5 kHz
160 ns	6.25 MHz	±6.25 kHz
400 ns	2.5 MHz	±2.5 kHz
800 ns	1.25 MHz	±1.25 kHz
1.6 μs	625 kHz	±625 Hz
4 μs	250 kHz	±250 Hz
8 μs	125 kHz	±125 Hz
16 μs	62.5 kHz	±62.5 Hz
40 μs	25 kHz	±25 Hz
80 μs	12.5 kHz	±12.5 Hz

Test 3 Cal Reference Voltage

The amplitude of the internal voltage reference is verified using a digital multimeter

Setup: For the SCD1000, connect a Tek DM5120 DMM through a BNC to dual-banana-plug adapter to a 50 Ω coax cable directly to the Calibrator output connector on the rear panel.

For the SCD5000, connect a 50 Ω termination and BNC-to-N adapter directly to the Calibrator output connector on the front panel. Connect the DM5120 through a BNC to dual-banana-plug adapter to a 50 Ω coax cable to the 50 Ω termination.

		Setting		
		SCD1000	SCD5000	Option 01
DMM	Mode	DC Volts		
	Range	Auto		

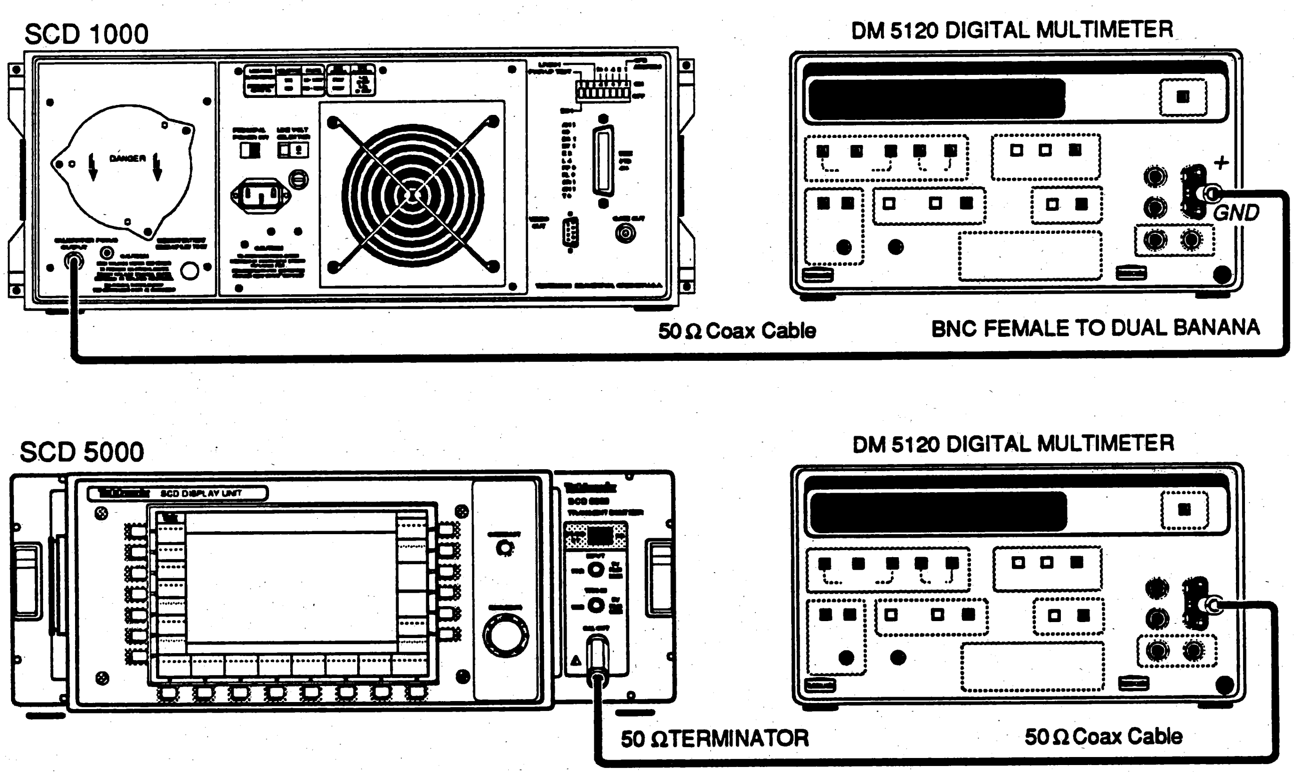


Figure 4-2: Internal Voltage Reference Setup

Procedure (SCD1000):

1. From the Utility menu (5th menu level), select EXT CAL to AMPL.
2. While adjusting CAL AMPL according to Table 4-5, check the calibrator voltage to ± (0.1% + 1 mV) accuracy on all ranges.

Table 4-5: SCD1000 Calibrator Voltage Limits

Calibrator Ampl.	Measurement (min)	Measurement (max)
+2.5 V	2.4965 V	2.5035 V
+2.0 V	1.997 V	2.003 V
+800 mV	0.7982 V	0.8018 V
+400 mV	0.3986 V	0.4014 V
+200 mV	198.8 mV	201.2 mV
+80 mV	78.92 mV	81.08 mV
+40 mV	38.96 mV	41.04 mV
0.0 V	-1.0 mV	+1.0 mV
-40 mV	-41.04 mV	-38.96 mV
-80 mV	-81.08 mV	-78.92 mV
-200 mV	-201.2 mV	-198.8 mV
-400 mV	-0.4014 V	-0.3986 V
-800 mV	-0.8018 V	-0.7982 V
-2.0 V	-2.003 V	-1.997 V
-2.5 V	-2.5035 V	-2.4965 V

3. Adjust CAL AMPL to the first of the two values given in the first column of Table 4-6.
4. Mark down the amplitude measured by the DVM = A1.
5. Adjust the CAL AMPL to the second of the two values given in the first column of the table. Mark down the amplitude measured on the DVM= A2.
6. Add the absolute values of A1 and A2 for the ΔVolts measurement: |A1| + |A2| = ΔVolts.
7. Check the calibrator voltage ΔVolts accuracy to within the specification limits given in Table 4-6.

8. Repeat steps 3 through 7 above for all the rows of Table 4-6.

Table 4-6: SCD1000 Calibrator Δ Voltage Limits

Calibrator Ampl.	ΔV Measurement (min)	ΔV Measurement (max)
+2.5 V, -2.5 V	4.990 V	5.010 V
+2.0 V, -2.0 V	3.992 V	4.008 V
+800 mV, -800 mV	1.597 V	1.603 V
+400 mV, -400 mV	798.4 mV	801.6 mV
+200 mV, -200 mV	399.2 mV	400.8 mV
+80 mV, -80 mV	159.7 mV	160.3 mV
+40 mV, -40 mV	79.84 mV	80.16 mV

Procedure (SCD5000):

1. From the Utility menu (5th menu level), select CAL OUT to AMPL.
2. While adjusting CAL AMPL according to Table 4-7, check the calibrator voltage to ±(0.1% + 1 mV) accuracy on all ranges.

Table 4-7: SCD5000 Calibrator Voltage Limits

Calibrator Ampl.	Measurement (min)	Measurement (max)
+4 V	+3.995 V	+4.005 V
+3 V	+2.996 V	+3.004 V
+2 V	+1.997 V	+2.003 V
+1 V	+0.998 V	+1.002 V
+800 mV	+798.2 mV	+801.8 mV
+400 mV	+398.6 mV	+401.4 mV
+200 mV	+198.8 mV	+201.2 mV
+100 mV	+98.9 mV	+101.1 mV
0.0 V	+1.0 mV	-1.0 mV
-100 mV	-98.9 mV	-101.1 mV
-200 mV	-198.8 mV	-201.2 mV
-400 mV	-398.6 mV	-401.4 mV
-800 mV	-798.2 mV	-801.8 mV
-1 V	-0.998 V	-1.002 V
-2 V	-1.997 V	-2.003 V
-3 V	-2.996 V	-3.004 V
-4 V	-3.995 V	-4.005 V

3. Adjust CAL AMPL to the first of the two values given in the first column of Table 4-8.
4. Mark down the amplitude measured by the DVM = A1.
5. Adjust the CAL AMPL to the second of the two values given in the first column of the table. Mark down the amplitude measured on the DVM= A2.
6. Add the absolute values of A1 and A2 for the Δ Volts measurement: $|A1| + |A2| = \Delta$ Volts
7. Check the calibrator voltage Δ Volts accuracy to within the specification limits given in Table 4-8.

8. Repeat steps 3 through 7 above for all of the rows in the Table 4-8.

Table 4-8: SCD5000 Calibrator Δ Voltage Limits

Calibrator Ampl.	ΔV Measurement (min)	ΔV Measurement (max)
+4 V, -4 V	7.984 V	8.016 V
+3 V, -3 V	5.988 V	6.012 V
+2 V, -2 V	3.992 V	4.008 V
+1 V, -1 V	1.996 V	2.004 V
+800 mV, -800 mV	1.597 V	1.603 V
+400 mV, -400 mV	798.4 mV	801.6 mV
+200 mV, -200 mV	399.2 mV	400.8 mV
+100 mV, -100 mV	199.6 mV	200.4 mV

Test 4 Internal Calibration

Timing, vertical gain, offset gain, and trigger level offset and gain of the instrument are verified by running the internal calibration routines. A calibration in process may be terminated by pressing any front-panel key or sending any GPIB command.

Setup: Apply power to the waveform recorder and wait at least 20 minutes for the instrument to reach a stable operating temperature.

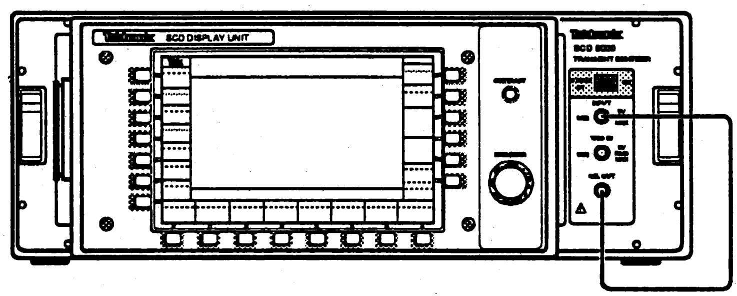


Figure 4-3: Internal Calibration Setup

Procedure:

1. For the SCD1000, remove all signals and cables connected to the CH A and CH B inputs. Run the input calibration routine by selecting INPUT CAL from the Utility menu and pressing the CAL stopped button or by sending the GPIB command:

   ```
   CALIBRATE INPUT
   ```

2. For SCD5000's connect the calibrator output to the signal input using the 8″ cable.

3. Run system calibration routines by selecting SYSTEM CAL from the Utility menu and pressing the CAL stopped button or by sending the GPIB command:

   ```
   CALIBRATE ALL
   ```

   The SCD1000 will immediately begin calibration.

   The SCD5000 will wait approximately 30 seconds for the user to connect the proper signal and press any menu button. If the instrument times out when the 30 seconds has expired, it will report a calibration failure for the system. If this happens, run system calibration again, making sure to connect the proper signal within the time limit. (The user will hear the bell "ticking" while waiting for the user to connect the signal and press a button. The "ticking" speeds up as timeout approaches.)

4. If the calibration routines fail, send the CALIBRATE? query to the instrument and record the response. Return the instrument to an authorized service center for servicing, including the CALIBRATE? query response.

Performance Verification Procedure

The Performance Verification Procedure describes a series of tests that verify that the SCD1000 and SCD5000 meet their performance specifications. These procedures do not require opening the instrument, but do require the test equipment listed in Table 4-10.

NOTE

The tests in this procedure must be performed in the order in which they appear and the steps must be performed in sequence.

Before performing any verification procedure, be sure to perform the *Setup for All Tests*, on page 4-20.

Sections of the instrument can be checked individually. To check a particular section, perform the *Setup for All Tests*, then perform the steps under the test for that particular section (such as *Amplitude Accuracy* or *Trigger Jitter*).

The specifications or measurement limits for each test are given following the test heading. The specifications for the SCD are also listed as a group under *Specifications*, on page 1-1. The setup section of each test describes the cabling and the instrument parameters needed for the first steps of the procedure. The instrument settings are given only where they differ from the instruments' INIT settings.

If at any time during the tests the instrument fails to meet a test limit, calibrate or service the instrument, or return it to an authorized service center along with information about which test failed or which limits were exceeded.

Run the tests in a stable environment with the temperature between 20°C and 30°C (68°F and 86°F) and adequate airflow to the instrument (the ventilation ports on the rear, sides, and front of the instrument must be unobstructed). The ambient temperature must not change by more than 5°C (9°F) during the tests. Line supply must lie within the stated operational limits (90 to 132 V rms or 180 to 250 V rms).

List of Tests

The performance tests are listed below. Tests marked (SCD1000 Only) should not be performed for the SCD5000, and tests marked (SCD5000 Only) should not be performed for the SCD1000.

Table 4-9: Performance Verification Tests

Test	Description
Internal Calibrator Timing Reference	Checks internal clock frequency
Internal Calibrator Reference Voltage	Checks internal calibration reference
Input Resistance (SCD1000 Only)	Checks input resistance of both channels
Input Bias Current (SCD1000 Only)	Checks input bias current of both channels
High Frequency Response (SCD1000 Only)	Checks frequency response of both channels
High Frequency Response (SCD5000 Only)	Checks frequency response of both channels
Amplitude Accuracy	Checks DC amplitude accuracy
Input Offset Accuracy	Checks DC offset accuracy
Step Response (SCD1000 Only)	Checks step response for rise time and aberrations
Low Frequency Linearity	Checks amplifier low-frequency linearity
Common Mode Rejection Ratio (SCD1000 Only)	Measures amplifier CMRR
RMS Noise (SCD1000 Only)	Measures rms noise
Horizontal Timing Accuracy and Linearity	Checks accuracy and linearity of each sweep setting
Trigger Level Range and Accuracy	Checks level accuracy and range of internal triggering (SCD1000 only) and external triggering
Trigger Jitter	Checks internal trigger jitter (SCD1000 Only) and external trigger jitter
Trigger Sensitivity	Checks internal trigger sensitivity (SCD1000 Only) and external trigger sensitivity
Minimum Trigger Delay Accuracy	Checks minimum trigger delay accuracy and range
Maximum Trigger Delay Accuracy	Checks maximum trigger delay accuracy and range
Writing Speed	Checks CRT visible writing speed
CRT Geometry	Checks geometric deviations from a straight line

Equipment Required

The performance tests require the equipment listed in Table 4-10. In the table, a 5000 denotes those instruments used only for SCD5000 performance verification tests.

Table 4-10: Required Test Equipment

Description	Minimum Specification	Recommended Equipment
SCD Display Unit	–	Tektronix SCDF019
Digital Multimeter	200 V Range, 0.01% accuracy, 4 1/2 digits minimum, 4-wire Ω measurements, GPIB controllable	Tektronix DM5120 (requires TM5000 module)
Leveled Sine Wave Generator	250 kHz to 250 MHz, Variable amplitude, 50 kHz reference	Tektronix SG503 Leveled Sine Wave Generator, TM500(0) module
	250 MHz to 1050 MHz, Variable amplitude, 6 MHz reference	Tektronix SG504 Leveled Sine Wave Generator, TM500(0) module
Frequency Synthesizer5000	10 MHz to 21 GHz, Output –30 dBm to +18 dBm	Wiltron Model 6747A Option Frequency Synthesizer (this model is a special configuration for Tektronix)
Power Meter/Sensor5000	10 MHz to 26.5 GHz, Thermocouple type sensor, 300 mW avg., 15 W peak	HP 437B Power Meter, HP 8481A Power Sensor
Precision Power Splitter5000	DC to 26.5 GHz, SMA connectors	HP 11667B Power Splitter
High Amplitude Pulse Gen.5000	10 V pulse, 40 ps rise time	Picosecond Pulse Labs 4050B w/ 4050 RPH pulse head
Calibration Generator	0.25% DC amplitude accuracy, Fast rise output, time markers to 0.5 ns/division.	Tektronix CG5011 Calibration Generator (requires TM5000 module)
		Tektronix PG506 Calibration Generator (requires 067-0681-01 TD Pulser, and TM500(0) module)
Controller	IBM Compatible, GPIB controller with National Instrument PC-GPIB or AT-GPIB package	IBM-Compatible PC with National Instruments PC2A GPIB card
Counter/Timer	250 MHz freq. measurement minimum, 1 ps period resolution	Tektronix DC5010 Counter/Timer
Function Generator	square wave and sine wave outputs, DC to 20 MHz frequency range, 15 V output	Tektronix FG5010 Function Gen., requires TM5000 Power Module
		Tektronix FG504 Function Gen., requires TM500(0) power module
TM5006 power module (1 required, 2 recommended)	6-slot mainframe	Tektronix TM5006(A) power module

Table 4-10: Required Test Equipment (Cont.)

Description	Minimum Specification	Recommended Equipment
Coaxial Cable (3 required)	50 Ω, 42 inches, BNC connectors	Tektronix part number 012-0057-01
DMM Noise Filter		See parts list on page 4-19
Adapter (2 required)	SMA male to Type N male	Tektronix part number 103-1009-00
Adapter (2 required)	Type N male to BNC female	Tektronix part number 103-0045-00
Adapter (2 required)	BNC to Dual Banana Plug	Tektronix part number 103-0090-00
Delay line	47.5 ns, 5 GHz Bandwidth	Tektronix DL-11
Termination (2 required)	50 Ω, feedthrough, BNC connectors	Tektronix part number 011-0049-01
Power divider	SMA (male or female)	Tektronix part number 015-1014-00 or Tektronix part number 015-0565-00
SMA connectors (3 required)	female - female	Tektronix part number 015-1012-00
2× attenuator	50 Ω, BNC connectors	Tektronix part number 011-0059-02
5× attenuator	50 Ω, BNC connectors	Tektronix part number 011-0060-02
10× attenuator	50 Ω, BNC connectors	Tektronix part number 011-0069-02
Dual BNC connector	50 Ω, one female and two male BNC connectors	Tektronix part number 067-0525-02
BNC "T" connector		Tektronix part number 103-0030-00
2× Attenuator (2 required for Option 1E)	6 dB insertion loss, SMA connectors	Tektronix part number 015-1001-00
5× Attenuator (1 required for Option 1E)	14 dB insertion loss, SMA connectors	Tektronix part number 015-1002-00

The *Input Offset Accuracy* and the *Amplitude Accuracy* tests require a special noise filter for the DMM. This DMM noise filter must be constructed of the following parts:

coil, 8.7 μH	108-0057-00
resistor, fixed, 2 kΩ, 0.25 W, 5%	315-0202-00
capacitor, 200 pF, 500 V, 10%	281-0605-00
accessory housing, BNC connectors	011-0081-00

Figure 4-4 shows a schematic for the DMM noise filter.

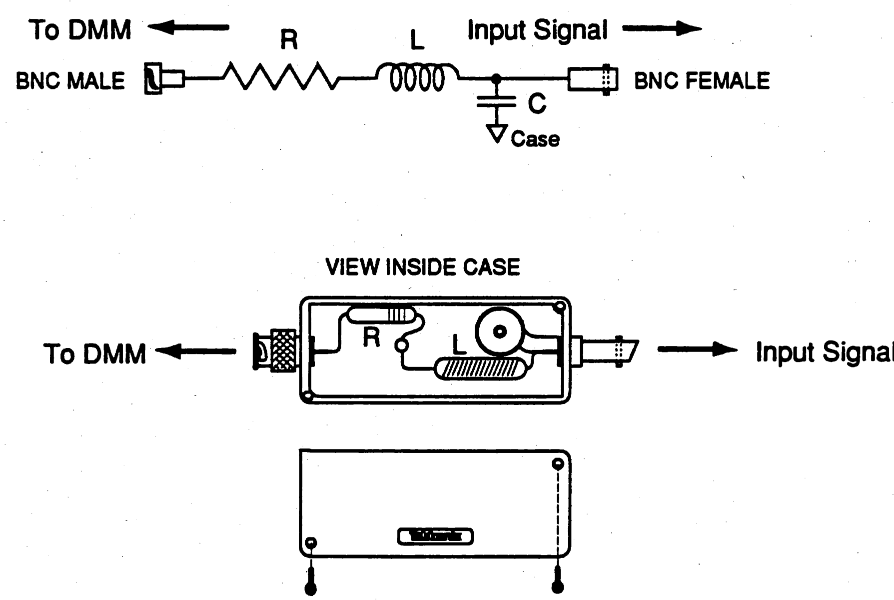


Figure 4-4: DMM Noise Filter Schematic

Setup For All Tests

Perform the following steps before using any of the the performance tests.

1. Connect the SCD to a suitable power source and turn on both the rear-panel main power switch and the front-panel power switch.
2. Allow a minimum of 30 minutes for the instrument to warm up and stabilize before continuing.
3. Perform the instrument diagnostic check from the Display Unit by pressing the **InstTest** key in the third level of the Utility menu. This ensures that the system is functioning properly.
4. Perform the first two tests, *Internal Calibrator Timing Reference* on page 4-21 and *Internal Calibrator Reference Voltage* on page 4-24, to verify that the instrument's internal standards are within specification. If these standards fall outside specification, the instrument's performance cannot be guaranteed and the instrument should be sent to an authorized service center for repair or calibration.
5. Perform a system calibration on the instrument by pressing the **Cal** key in second level of the Utility menu for System calibration mode.
6. Go to the second level of the Acquire menu and turn on geometry correction.

NOTE

All tests are to be performed with internal goemetry correction turned ON unless otherwise specified. The SCD1000 defaults to OFF, and the SCD5000 defaults to ON.

7. Perform the remainder of the performance tests, starting on page 4-29, or the particular test of interest.

NOTE

The settings given in the setup section of the tests assume that the SCD is in the default (INIT) state. The SCD5000 settings are the same as the SCD1000 settings except where specifically stated.

The procedures for the SCD5000 are identical to the procedures for the SCD1000 except where explicitly stated. The procedures for the SCD5000 with Option 01 are identical to the procedures for the SCD5000 except where explicitly stated.

Internal Calibrator Timing Reference

The accuracy of the internal clock is verified using a digital counter.

Specification: Accuracy: 0.1%

Setup: Press **Init** in the Save Recall menu. Connect the Calibrator Output connector on the rear of the SCD1000 or the front of the SCD5000 through a 50 Ω coax cable to the DC5010 Counter/Timer. A prescaler is not necessary with the DC5010, but may be needed for counters with a frequency range less than 250 MHz.

			Setting		
			SCD1000	**SCD5000**	**Option 01**
Digitizer	Utility	Ext Cal or Cal Out	Time		
	Utility	CalTime	4 ns		
Counter/ Timer	Trigger	Slope	+		
		Coupling	DC		
		Level	Auto (680 mV)	Auto (2.1 V)	
	Termination		50 Ω		
	Attenuation		1×	5×	
	Mode		Period		

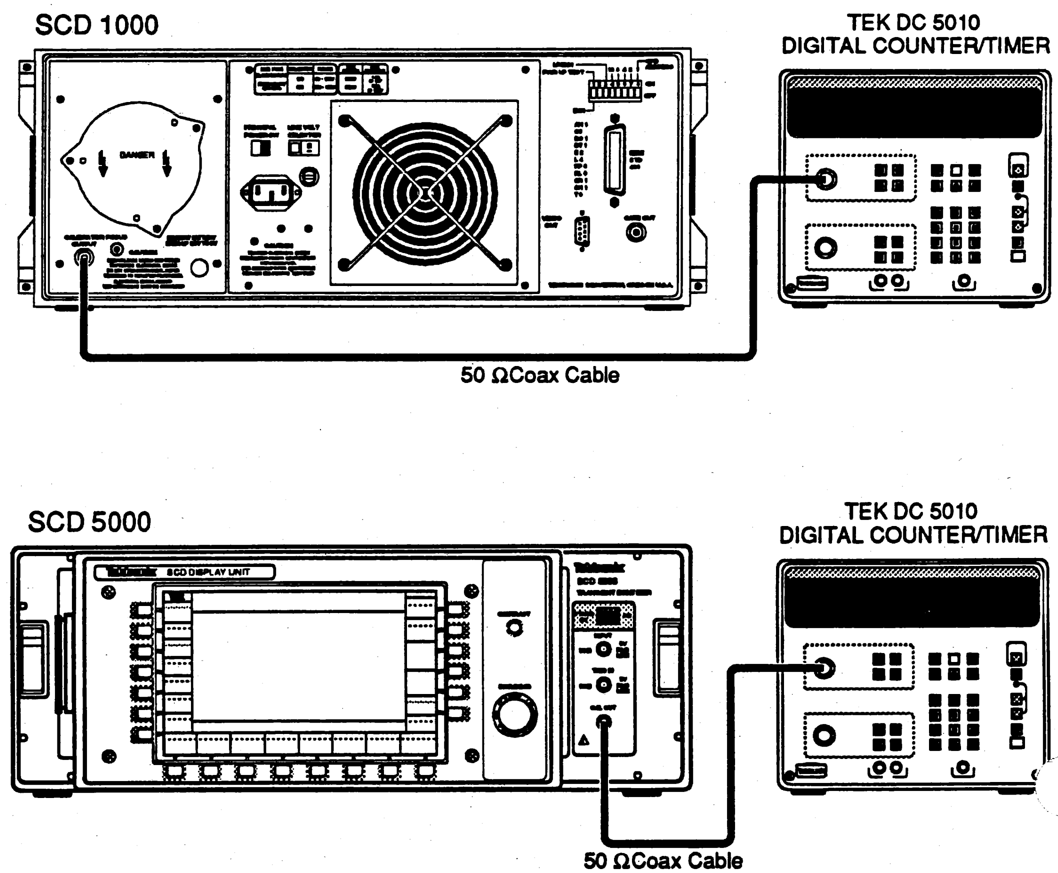


Figure 4-5: Internal Calibrator Reference Frequency Setup

Procedure:

1. Set the counter averaging to AUTO (or the highest accuracy setting available).
2. Go to the fifth level of the Utility menu and select **Ext Cal:Time** or **Cal**, depending on the instrument model.
3. While adjusting the CAL TIME setting according to Table 4-11, verify that the measured periods match the SCD CAL TIME readout value for all settings (4 ns to 80 μs) to within 0.1%.

Table 4-11: Calibrator Timing Measurements

Cal. Time	Min. Period	Max. Period	Frequency	Frequency Tolerance
4 ns	3.9960 ns	4.0040 ns	250.000 MHz	±250 kHz
8 ns	7.9920 ns	8.0080 ns	125.000 MHz	±125 kHz
16 ns	15.9840 ns	16.016 ns	62.500 MHz	±62.5 kHz
40 ns	39.960 ns	40.040 ns	25.000 MHz	±25 kHz
80 ns	79.920 ns	80.080 ns	12.500 MHz	±12.5 kHz
160 ns	159.84 ns	160.16 ns	6.250 MHz	±6.25 kHz
400 ns	399.60 ns	400.40 ns	2.500 MHz	±2.5 kHz
800 ns	799.20 ns	800.80 ns	1.250 MHz	±1.3 kHz
1.6 μs	1.5984μs	1.6016μs	625.0 kHz	±625 Hz
4 μs	3.9960 μs	4.0040 μs	250.0 kHz	±250 Hz
8 μs	7.9920 μs	8.0080 μs	125.0 kHz	±25 Hz
16 μs	15.984 μs	16.016 μs	62.50 kHz	±62.5 Hz
40 μs	39.960μs	40.040 μs	25.00 kHz	±25 Hz
80 μs	79.920μs	80.080 μs	12.50 kHz	±12.5 Hz

Internal Calibrator Reference Voltage

The amplitude of the internal voltage reference is verified using a digital multimeter.

Specification: Range (SCD1000): ±2.5 V, ±2.0 V, ±0.8 V, ±0.40 V, ±0.20 V, ±0.08 V, ±0.04 V, 0 VDC

Range (SCD5000): ±4.0 V, ±3.0 V, ±2.0 V, ±1.0 V, ±0.8 V, ±0.4 V, ±0.2 V, ±0.1 V, 0 VDC

Accuracy: ±(0.1% + 1 mV)

Delta volts, between ±V, for each V: 0.2%

Setup: Press **Init** in the Save Recall menu. For the SCD1000, connect the calibrator output on the rear panel to the DMM input through a 50 Ω coaxial cable with a dual banana-to-BNC adapter.

For the SCD5000, connect a 50 Ω feedthrough termination and BNC to N adapter directly to the calibrator output on the front panel. Connect the TEK DM5120 through a 50 Ω coaxial cable with dual banana-to-BNC adapter to the termination.

			Setting		
			SCD1000	**SCD5000**	**Option 01**
Digitizer	Utility	Ext Cal or Cal Out	Ampl		
	Utility	CalAmpl	2.5 V		
DMM	Mode		DC Volts		
	Range		Auto		

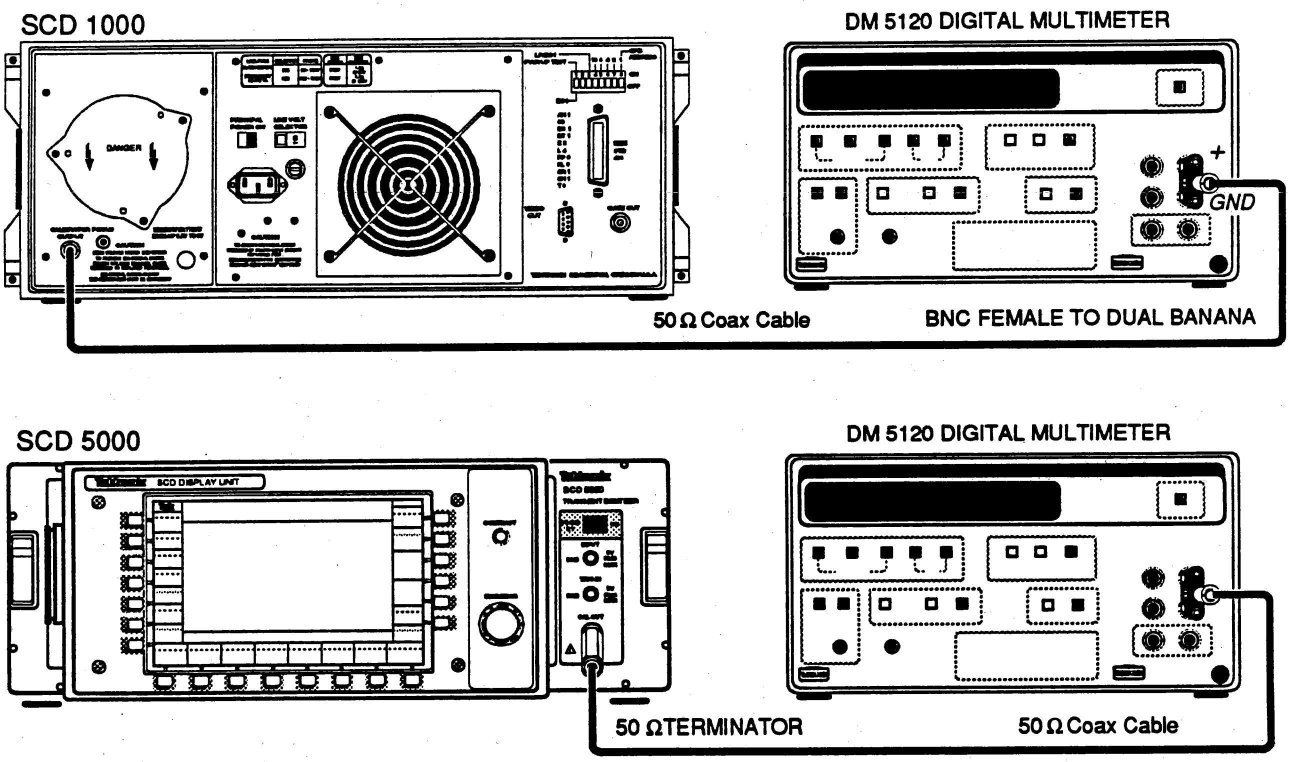


Figure 4-6: Internal Calibrator Reference Voltage Setup

Procedure (SCD1000):

1. Select **Ext Cal:Ampl** from the fifth level of the Utility menu.
2. While adjusting **Cal Ampl** according to Table 4-12, check the calibrator voltage to ±(0.1% + 1 mV) accuracy.

Table 4-12: SCD1000 Calibrator Amplitude

Calibrator Amplitude	Measurement Min.	Max.
+2.5 V	2.4965 V	2.5035 V
+2.0 V	1.997 V	2.003 V
+800 mV	.7982 V	.8018 V
+400 mV	.3986 V	.4014 V
+200 mV	198.8 mV	201.2 mV
+ 80 mV	78.92 mV	81.08 mV
+ 40 mV	38.96 mV	41.04 mV
0.0 V	+1.0 mV	-1.0 mV
- 40 mV	-38.96 mV	-41.04 mV

Table 4-12: SCD1000 Calibrator Amplitude

Calibrator Amplitude	Measurement Min.	Max.
- 80 mV	-78.92 mV	-81.08 mV
-200 mV	-198.8 mV	-201.2 mV
-400 mV	-.3986 V	-.4014 V
-800 mV	-.7982 V	-.8018 V
-2.0 V	-1.997 V	-2.003 V
-2.5 V	-2.4965 V	-2.5035 V

3. For each row in Table 4-13, adjust the **Cal Ampl** to the first of the two values listed in the Calibrator Amplitude column.
4. Record the DVM measurement, DVM = A1.
5. Adjust the **Cal Ampl** to the second of the two values listed in the Calibrator Amplitude column.
6. Record the DVM measurement, DVM = A2.
7. Check that the calibrator delta volts (|A1| – |A2|) is within the specified limits listed in Table 4-13.

Table 4-13: SCD1000 Calibrator Delta Volts Accuracy

Calibrator Amplitude V1, V2	Δ Volts Measurement measured as (|V1| + |V2|) Min.	Max.
+2.5 V, -2.5 V	4.990 V	5.010 V
+2.0 V. -2.0 V	3.992 V	4.008 V
+800 mV, -800 mV	1.597 V	1.603 V
+400 mV, -400 mV	798.4 mV	801.6 mV
+200 mV, -200 mV	399.2 mV	400.8 mV
+ 80 mV, -80 mV	159.7 mV	160.3 mV
+ 40 mV, -40 mV	79.84 mV	80.16 mV

Procedure (SCD5000):

1. Select **Cal Out:Ampl** from the fifth level of the Utility menu.
2. While adjusting **Cal Ampl** according to Table 4-14, check the calibrator voltage to ±(0.1% + 1 mV) accuracy.

Table 4-14: SCD5000 Calibrator Amplitude

Calibrator Amplitude	Measurement Min.	Max.
+4 V	+3.995 V	+4.005 V
+3 V	+2.996 V	+3.004 V
+2 V	+1.997 V	+2.003 V
+1 V	+0.998 V	+1.002 V
+0.8 V	+798.2 mV	+801.8 mV
+0.4 V	+398.6 mV	+401.4 mV
+0.2 V	+198.8 mV	+201.2 mV
+0.1 V	+98.9 mV	+101.1 mV
0.0 V	+ 1.0 mV	- 1.0 mV
-0.1 V	-101.1 mV	-98.9 mV
-0.2 V	-201.2 mV	-198.8 mV
-0.4 V	-401.4 mV	-398.6 mV
-0.8 V	-801.8 mV	-798.2 mV
-1 V	-0.998 V	-1.002 V
-2 V	-1.997 V	-2.003 V
-3 V	-2.996 V	-3.004 V
-4 V	-3.995 V	-4.005 V

3. For each row in Table 4-15, adjust the **Cal Ampl** to the first of the two values listed in the Calibrator Amplitude column.
4. Record the DVM measurement, DVM = A1.
5. Adjust the **Cal Ampl** to the second of the two values listed in the Calibrator Amplitude column.
6. Record the DVM measurement, DVM = A2.
7. Check that the calibrator delta volts (|A1| - |A2|) is within the specified limits listed in the table.

Table 4-15: SCD5000 Calibrator Delta Volts Accuracy

Calibrator Amplitude V1, V2	△ Volts Measurement measured as (|V1| + |V2|) Min.	Max.
+4 V, −4 V	7.984 V	8.016 V
+3 V. −3 V	5.988 V	6.012 V
+2 V, −2 V	3.992 V	4.008 V
+1 V, −1 V	1.996 V	2.004 V
+0.8 V, −0.8 V	1.597 V	1.603 V
+ 0.4 V, −0.4 V	798.4 mV	801.6 mV
+ 0.2 V, −0.2 V	399.2 mV	400.8 mV
+ 0.1 V, −0.1 V	199.6 mV	200.4 mV

Input Resistance (SCD1000 Only)

The input resistance for both input channels is verified using a digital multimeter in a 4-wire Ω measurement mode.

Specification: Power-off & Disconnect: 500 kΩ ±50 kΩ

DC Coupling: 50 Ω ±0.5 Ω

Setup: Press **Init** in the Save Recall menu. Connect a 50 Ω BNC cable to each side of a BNC "T" and connect these cables through BNC-to-Banana-plug adapters into the 4-wire Ω measurement inputs on the DMM.

			Setting
			SCD1000
Digitizer	Vertical	Range	100 mV
		Coup A	Off
		Coup B	Off
DMM	Mode		Ohms
	Range		Auto

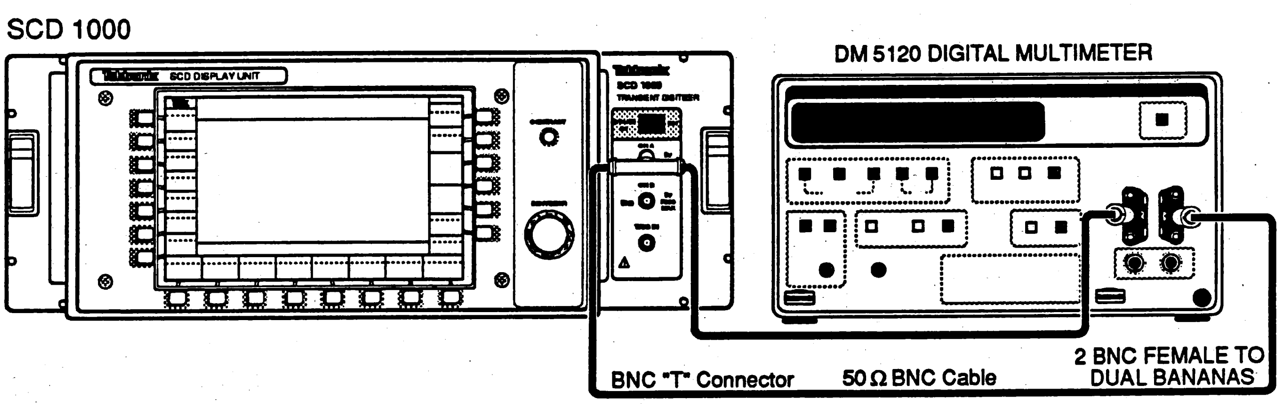


Figure 4-7: Input Resistance Setup

Procedure:

1. Check that the measured resistance on the DMM reads (after stabilization) 500 kΩ ±50 kΩ.
2. Set the SCD vertical channel select to CHB and move the BNC "T" to the SCD channel B input. Set the channel B input coupling off.
3. Check the measured resistance on the DMM reads (after stabilization) 500 kΩ ±50 kΩ.
4. Enable Ω compensation on the DMM. This is *Four-Wire Ohms Measurements, Program 1* on the TEK DM5120 (refer to the *DM5120 Instruction Manual*, part number 070-7240-00, for more information). Press <Program> <1> and <↑> to turn ENABLE on, then press <enter>.
5. Select channel B from the vertical menu, range 100 mV, coupling DC.
6. Check that the measured resistance on the DMM reads (after stabilization) 50 Ω ±0.5 Ω.
7. Repeat step 6 for vertical ranges of 200 mV, 500 mV, 1 V, 2 V, 5 V, and 10 V.
8. Connect the BNC "T" to the SCD channel A input. Select channel A from the vertical menu, range 100 mV, Coupling DC.
9. Repeat steps 6 and 7 for the CHA input.

Input Bias Current (SCD1000 Only)

The magnitude of the input bias currents for both input channels is measured as a voltage developed across the 50 Ω input resistance using a digital multimeter.

Specification: Input Bias Current: less than 10 μA

Setup: Press **Init** in the Save Recall menu. Connect a 50 Ω BNC cable from the input of the SCD channel A input, then through a BNC-to-Banana-plug adapter to the input of the DM5120.

			Setting
			SCD1000
Digitizer	Vertical	Range	100 mV
		Coup	DC
DMM	Mode		Volts
	Range		Auto

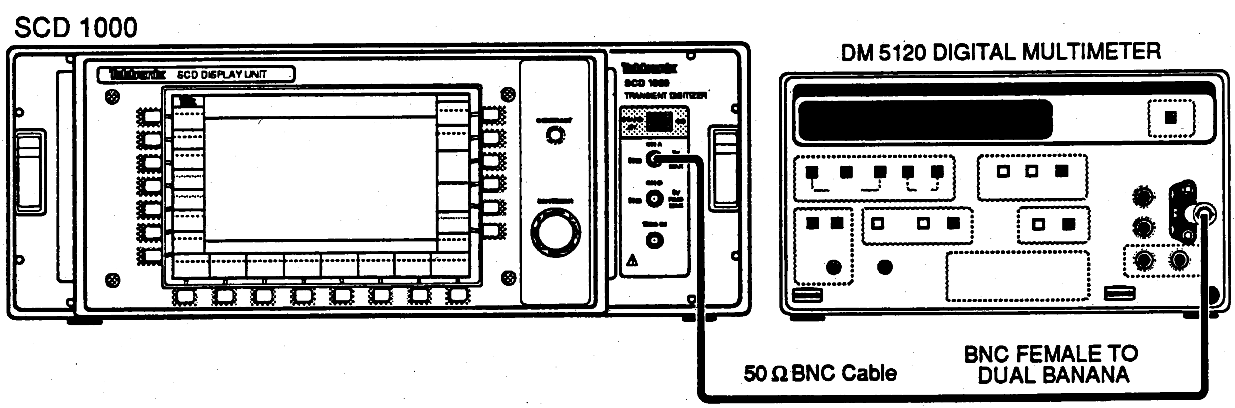


Figure 4-8: Input Bias Current Setup

Procedure:

1. Verify that the voltage across the 50-Ω input resistance is less than ±0.500 mV (10 μA across 50 Ω) while changing the SCD input range from 100 mV to 10 V.
2. Connect the BNC cable to the SCD channel B input. Select channel B from the front panel, range 100 mV, coupling DC.
3. Repeat step 1 for the channel B input.

High Frequency Response (SCD1000 Only)

A reference frequency of 10 MHz is set to give a 70% full-scale displayed output. The frequency is then increased to 1000 MHz and the displayed output is checked for at least 51% full-scale (–3 dB down from the reference frequency) displayed waveform.

Specification: At least 71% of 10 MHz gain at 1 GHz

Setup: Press **Init** in the Save Recall menu. Connect the SG504 output through a 10× attenuator to a BNC-to-N adapter to the SCD1000 Channel A input.

			Setting
			SCD1000
Digitizer	Vertical	Range	100 mV
	Acquire	TimeWin	1 µs
		Length	1024
		HoldNext	On
		Geometry	On
	Trigger	TrigMode	Normal
		Source	CHA
		TrigCoup	AC
	Measure	Measure	On
		Select	Peak-Peak Amp
SG Setup	Frequency		6 MHz (Ref)
	Amplitude		700 mV p-p

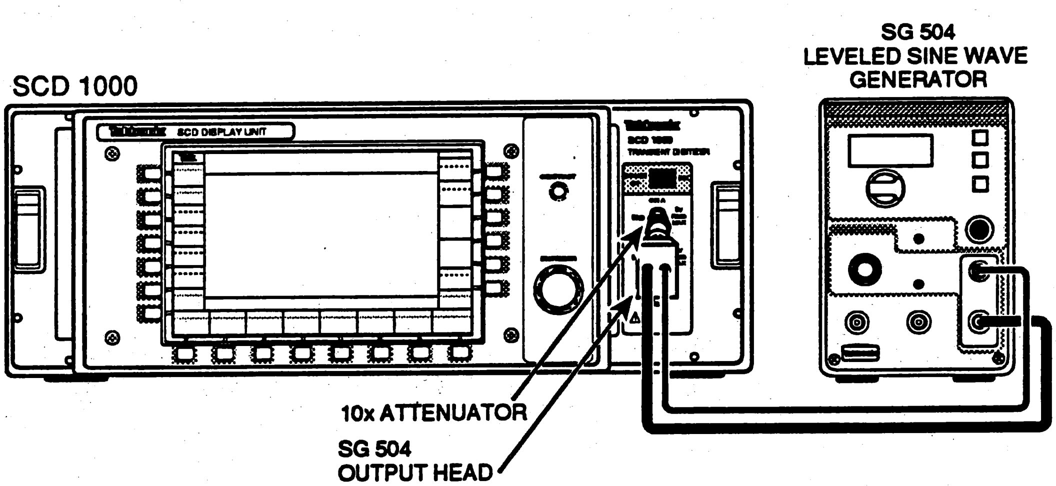


Figure 4-9: SCD1000 High Frequency Response Setup

Procedure:

1. Adjust the signal generator to give 70% full-scale displayed output at the 6 MHz reference frequency. Use the display cursors or the measurement feature to check the peak-to-peak amplitude.
2. Set the acquire time to the first value shown in Table 4-16 (5 ns).
3. Set the input frequency to the first value shown in the table (1000 MHz), acquire the waveform, and check that the display amplitude is greater than specified in the table (51%).
4. Repeat steps 1 through 3 for the remaining input ranges and settings according to Table 4-16. (For the 10 V range, use a reference display amplitude of 40% full-scale, and a minimum displayed amplitude of 29% full-scale displayed signal at 1 GHz.)
5. Connect the signal generator to the CHB input connector, then change internal trigger, vertical mode, and channel select to CHB, and repeat this procedure for the channel B input.

Table 4-16: SCD1000 Frequency Response Limits

Input Range	Acquire Time	SG Ampl.	SG Atten.	Input Frequency	Low Limit	Display Amplitude (70% ref.)
100 mV	5 ns	700 mV	10×	1000 MHz	-3 dB	51% (51 mV)
200 mV	5 ns	1.4 V	10×	1000 MHz	-3 dB	51% (102 mV)
500 mV	5 ns	3.5 V	10×	1000 MHz	-3 dB	51% (255 mV)
1 V	5 ns	700 mV	–	1000 MHz	-3 dB	51% (510 mV)
2 V	5 ns	1.4 V	–	1000 MHz	-3 dB	51% (1.02 V)
5 V	5 ns	3.5 V	–	1000 MHz	-3 dB	51% (2.55 V)
10 V[1]	5 ns	4 V	–	1000 MHz	-3 dB	29% (2.9 V)

[1]For the 10 V range, use a reference amplitude of 40% full-scale, and a minimum measured amplitude of 29% full-scale displayed signal.

High Frequency Response (SCD5000)

A reference frequency of 10 MHz is set to give a 50% full-scale displayed output. The frequency is then increased and the displayed output is checked for at least 36% full-scale (–3 dB down from the reference frequency) displayed waveform. The frequency response curve is constructed from frequencies starting at 500 MHz and increasing in 1 GHz increments to 4.5 GHz.

Specification: SCD5000 Standard: At least 71% of 10 MHz gain at 4.5 GHz

SCD5000 Option 01: At least 71% of 250 MHz gain at 3.0 GHz

Setup: Press **Init** in the Save Recall menu. Set the Frequency Synthesizer output to –10 dBm, and connect the Frequency Synthesizer output to the HP precision power splitter input. Connect one output of the precision power splitter to a precision SMA-N adapter (if standard N connectors are present), then directly to the SCD input. Connect the RF power sensor from the power meter to the other output of the precision power splitter.

			Setting	
			SCD5000	**Option 01**
Digitizer	Vertical	Offset	0 V	
	Acquire	Acq Mode	Normal	
		TimeWin	1 µs	
		Length	1024	
		HoldNext	On	
	Trigger	TrigMode	Normal	
		Source	EXT	
		TrigLvl	0%	
	Measure	Measure	On	
		Select	Peak-Peak Amp	
Synthesizer	Frequency (CW)		0.010 GHz	0.250 GHz
	RFLevel		–10 dBm	
Power Meter	Rel		(10 MHz)	

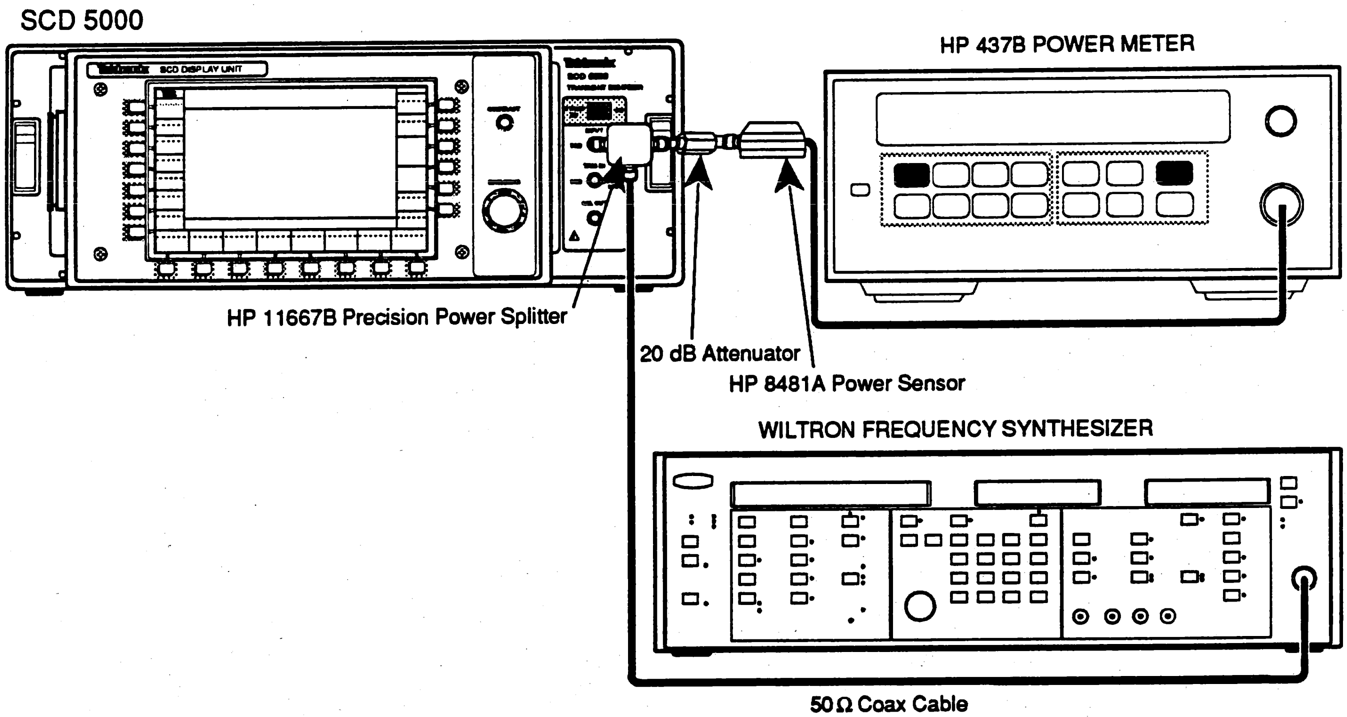


Figure 4-10: SCD5000 High Frequency Response Setup

Procedure:

1. Adjust the signal generator to give 50% (25% for Option 01) full-scale displayed output at the 10 MHz reference frequency (250 MHz for Option 01). Use the display cursors to verify the SCD peak-to-peak amplitude.
2. Set the power meter to relative measurement by pressing the **Rel** button. The power meter readout should be 0.00 dB.
3. Adjust the signal generator to 500 MHz. Set the SCD acquire time window to 5 ns.
4. Set the power meter frequency to 500 MHz. Check that the power meter reading is 0 dB ±0.1 dB. Adjust the synthesizer output level until the power meter reads 0 dB ±0.1 dB.
5. Acquire a waveform and compute the average peak-to-peak amplitude of the waveform by using the SCD measurements (PK-PK) or by taking several cursor measurements across the cycles displayed on screen.
6. Verify that the measured peak-to-peak signal is greater than 45% of full-scale (22% with Option 01).
7. Repeat steps 3 through 6 for a frequency of 4500 MHz for the SCD5000 and 3000 MHz for the SCD5000 with Option 01.

   For the SCD5000 standard with frequency of 4500 MHz, the low limit is -3.0 dB and the peak-to-peak display amplitude (50% ref.) is 35.5%. For the SCD5000 with Option 01 and frequency of 3000 MHz, the low limit is -3.0 dB and the peak-to-peak display amplitude (25% ref.) is 17.8%.

Amplitude Accuracy

This test determines the Δ volts (amplitude) accuracy with the CG 5011 +DC and –DC voltage outputs. The actual amplitude at the input to the SCD is measured by the DM.

Specification: Conditions: 10% to 90% full-scale signal

SCD1000: ±1% of range

SCD5000: ±2% of range

Setup: Press **Init** in the Save Recall menu. Connect the CG output to the CH A input with a BNC "T" connector. Connect the remaining side of the "T" to a DMM with a special filter that limits noise emissions from the DMM (see the equipment list on page 4-17).

			Setting		
			SCD1000	**SCD5000**	**Option 01**
Digitizer	Vertical	Offset	40 V	0 V	0 V
		Range	100 mV	5 V	10 V
		Coup	DC		
	Acquire	Acq Mode	Normal		
		TimeWin	100 μs		
		Length	1024		
		HoldNext	On		
		Geometry	Off		
	Trigger	TrigMode	Auto		
		Source	CHA	CAL	INT
	Measure	Measure	On		
		Select	Mean		
CG5011	Frequency		+DC		
	50 Ω load		OFF[1]	ON	
	Amplitude		80 mV (20 mV/ divx4)	2 V (0.5 V/ divx4)	4 V (1 V/divx4)
DMM	Mode		DC Voltage		
	Range		Auto		

1 This setting is turned off only for the 100 mV and 200 mV ranges because of the CG's low amplitude limitations. These settings for the SCD1000 are used to create an 80 mV DC signal, while the output fo the CG will only go down to 100 mV with the 50 ohm load turned on.

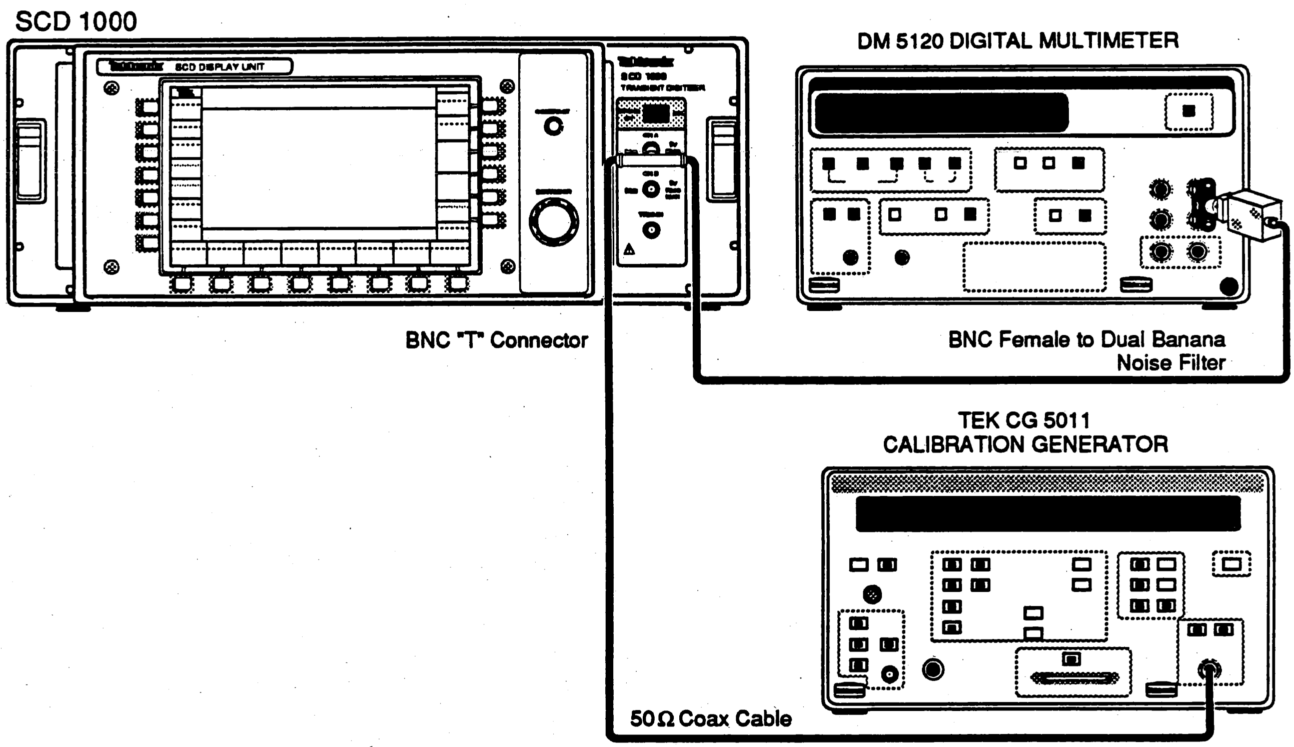


Figure 4-11: Delta Volts Accuracy Setup

Procedure (SCD1000):

1. Measure the signal amplitude on the DMM and record this value as DMM_1.
2. Acquire a waveform on the digitizer and measure the MEAN amplitude of the signal using measurements (MEAN) or cursors. Record this value as $MEAN_1$.
3. Turn the output of the CG5011 to the OFF position.
4. Acquire a waveform on the digitizer and measure the MEAN amplitude of the signal using measurements (MEAN) or cursors. Record this value as $MEAN_2$.
5. Measure the signal amplitude on the DMM and record this value as DMM_2.
6. Verify that the delta volts value given by the equation below is less than ±0.01 (±1%).

   $$\Delta \text{ Volts} = 1 - [(MEAN_1 - MEAN_2) / (DMM_1 - DMM_2)]$$

7. Set the SCD vertical offset to 0 V, and change the input range to 200 mV.
8. Turn the output of the CG back to the ON position.
9. For each row in Table 4-17, set the CG as shown, measure $MEAN_1$ and DMM_1 with the CG frequency set to +DC, and make the $EMAN_2$ and DMM_2 measurements with the CG set to -DC.

Table 4-17: Test Ranges and CG Amplitudes

SCD Range	CG Amplitude	50 Ω Load	$MEAN_1$	$MEAN_2$	DMM_1	DMM_2	Δ Volts
100 mV	20 mV/div × 8	OFF					
200 mV	20 mV/div × 8	OFF					
500 mV	50 mV/div × 4	ON					
1 V	100 mV/div × 4	ON					
2 V	200 mV/div × 4	ON					
5 V	500 mV/div × 4	ON					
10 V	500 mV/div × 5	ON					

10. Connect the CG output head/BNC "T" connector to the SCD channel B input.
11. Repeat steps 1 through 9 for the SCD channel B input.

Procedure (SCD5000):

1. Set the CG to +DC.
1. Measure the signal amplitude on the DMM and record this value as DMM_1.
2. Acquire a waveform on the digitizer and measure the MEAN amplitude of the signal using measurements (MEAN) or cursors. Record this value as $MEAN_1$.
3. Change the CG frequency to –DC setting.
4. Acquire a waveform on the digitizer and measure the MEAN amplitude of the signal using measurements (MEAN) or cursors. Record this value as $MEAN_2$.
5. Measure the signal amplitude on the DMM and record this value as DMM_2.
6. Verify that the delta volts value given by the equation below is less than ±0.02 (±2%).

$$\Delta \text{ Volts} = 1 - [(MEAN_1 - MEAN_2) / (DMM_1 - DMM_2)]$$

Input Offset Accuracy

The DC offset accuracy is checked using the FG5010 offset controls and a DMM to verify the actual offset voltage present at the SCD input vs. the offset measured by the SCD.

Specification: SCD1000
Range: ±(2.5 * input range)
Accuracy: ±(2% + (0.02 * input range))

SCD5000
Range: ±4 V (±8 V with Option 01)
Accuracy: ±(2% + (0.02 * input range))

Setup: Press **Init** in the Save Recall menu. Connect a BNC "T" connector to the SCD channel A input. Connect one side of the "T" through a coax cable to the FG output. Connect the other side of the BNC "T" through a 50 Ω cable, the DMM noise filter, and a BNC-to-Banana-plug adapter to the DMM input.

			Setting		
			SCD1000	**SCD5000**	**Option 01**
Digitizer	Vertical	Range	100 mV	5 V	10 V
		Offset	+250 mV	3.75 V	
		Coup	DC		
	Acquire	TimeWin	100 µs		
		Length	1024		
		HoldNext	On		
		Geometry	On		
	Trigger	TrigMode	AUTO		
		Source	CHA	EXT	
	Measure	Measure	On		
		Select	Mean		
FG5010	Output		On		
	Offset		+500 mV	7.50 V	
	Amplitude		0 V		
DMM	Mode		DC Volts		
	Range		Auto		

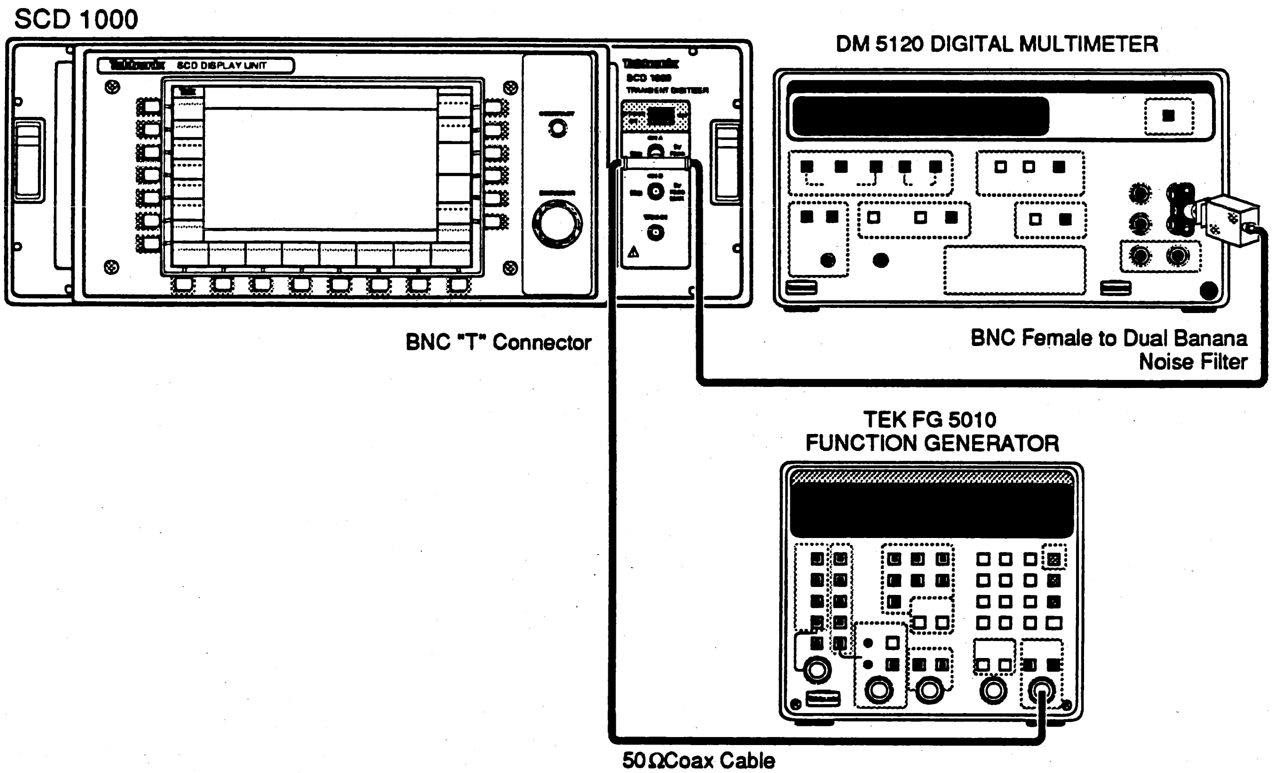


Figure 4-12: Input Offset Accuracy Setup

Procedure (SCD1000):

1. Refer to Table 4-18 and set the SCD vertical range and vertical offset range according to the step number. Acquire the signal on the SCD.
2. Check that the acquired trace is a straight line centered vertically in the display window.
3. Use the DMM to measure the FG offset voltage on the SCD input. Write down that voltage as A1.
4. Measure, using the cursors or measurements (MEAN), the mean offset voltage of the acquired signal on the SCD. Write down this voltage as A2.
5. Verify that the offset accuracy (|A1| – |A2|) falls within the limits given in Table 4-18.
6. Repeat steps 1 through 5 for the remainder of the settings in Table 4-18.
7. Connect the BNC "T" connector to the SCD channel B input. Change the vertical mode to CHB, select CHB, 100 mV, +250 mV offset, trigger source to CHB, AUTO mode.

8. Repeat procedure steps 1 through 6 for the SCD channel B input for the steps in Table 4-18.

Table 4-18: SCD1000 Offset Accuracy Test Limits

Step	Range	SCD Offset	FG Offset	Accuracy (A1 – A2) Minimum	Maximum
1	100 mV	+250 mV	+0.50 V	-7 mV	+7 mV
2	100 mV	+125 mV	+0.25 V	-4.5 mV	+4.5 mV
3	100 mV	0.0 V	output off	-2.0 mV	+2.0 mV
4	100 mV	–125 mV	-0.25 V	-4.5 mV	+4.5 mV
5	100 mV	–250 mV	-0.50 V	-7 mV	+7 mV
6	1 V	+2.50 V	+5.00 V	-70 mV	+70 mV
7	1 V	+1.25 V	+2.50 V	-45 mV	+45 mV
8	1 V	0.0 V	output off	-20 mV	+20 mV
9	1 V	–1.25 V	-2.50 V	–45 mV	+45 mV
10	1 V	–2.50 V	-5.00 V	-70 mV	+70 mV
11	10 V	+3.50 V	+7.00 V	-275 mV	+275 mV
12	10 V	0.0 V	output off	-200 mV	+200 mV
13	10 V	-3.50 V	-7.00 V	-275 mV	+275 mV

Procedure (SCD5000):

1. From Table 4-19, set the SCD vertical offset range according to the step number. Acquire the signal on the SCD.
2. Check that the acquired trace is a straight line centered vertically in the display window.
3. Use the DMM to measure the FG offset voltage on the SCD input. Write down this voltage as A1.
4. Use the cursors to measure the mean offset voltage of the acquired signal on the SCD. Write down this voltage as A2.
5. Verify that the offset accuracy falls within the limits given in Table 4-19.

6. Repeat steps 1 through 5 for the remainder of the steps in Table 4-19.

Table 4-19: SCD5000 Offset Accuracy Test Limits

Step	Range	SCD Offset	FG Offset	Accuracy (A1 – A2) Minimum	Maximum
1	5 V	+3.75 V	+7.50 V	–175 mV	+175 mV
2	5 V	+2.00 V	+4.00 V	–140 mV	+140 mV
3	5 V	0.0 V	output off	–100 mV	+100 mV
4	5 V	–2.00 V	–4.00 V	–140 mV	+140 mV
5	5 V	–3.75 V	–7.50 V	–175 mV	+175 mV

Table 4-20: SCD5000 with Option 01 Offset Accuracy Test Limits

Step	Range	SCD Offset	FG Offset	Accuracy (A1 – A2) Minimum	Maximum
1	10 V	+3.75 V	+7.50 V	–275 mV	+275 mV
2	10 V	+2.00 V	+4.00 V	–240 mV	+240 mV
3	10 V	0.0 V	output off	–200 mV	+200 mV
4	10 V	–2.00 V	–4.00 V	–240 mV	+240 mV
5	10 V	–3.75 V	–7.50 V	–275 mV	+275 mV

Step Response (SCD1000 Only)

A fast rise signal is digitized and the resultant waveform is visually examined (with the aid of cursors) for rise time, aberrations, flatness > 20 ns, and position effect.

Specification: Rise time: less than 0.35 ns (based on calculation from bandwidth)
Aberrations: First 20 ns: ±8%, 12% p-p overall max
Flatness (greater than 20 ns): ±1%
Position Effect: ±2%, 16% p-p overall max

Setup: Press **Init** in the Save Recall menu. Connect the CG Pulse Head output through a BNC-to-type-N connector to the channel A input connector. Connect the trigger output of the CG to the SCD TRIG IN input.

			Setting
			SCD1000
Digitizer	Vertical	Range	2 V
		Offset	1.00 V
	Acquire	Acq Mode	Normal
		TimeWin	5 ns
		Length	1024
		HoldNext	On
	Trigger	TrigMode	Normal
		Source	CHA
		TrigLvl	20%
CG	Mode		Fast Edge
	Rep Rate		100 kHz

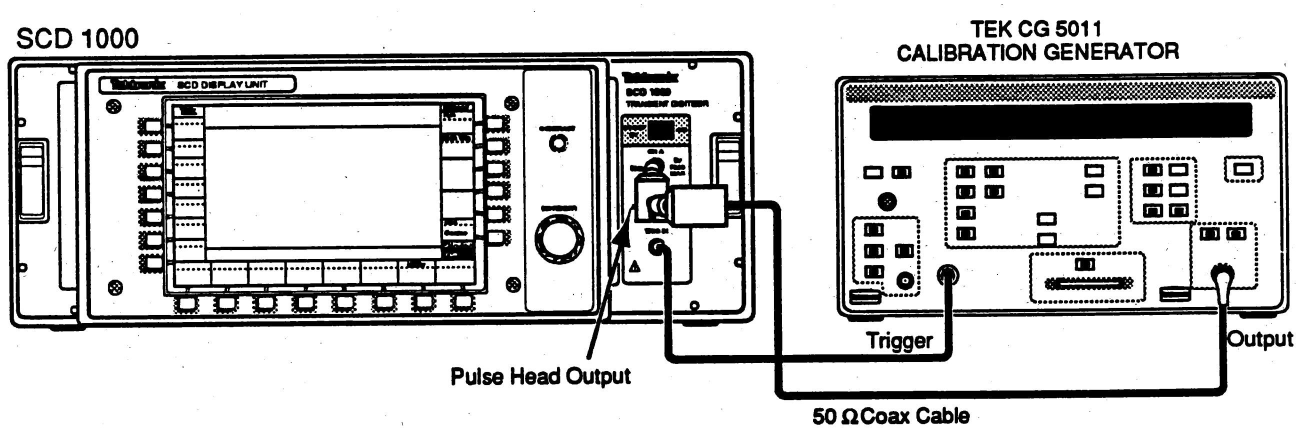


Figure 4-13: Step Response Setup

Procedure:

1. Procedure for instruments with firmware version 1.6 and above.
   a. Set the following measurement parameters:
      - Rise Time
      - Peak-Peak Amp
      - Top Aberration
      - Base-Top Amp
      - Base Aberration

   b. Acquire the fast edge pulse on the SCD.
   c. Adjust the trigger delay to position the rising edge in the first 1/3 of the acquisition window (several acquisitions may be necessary).
   d. Verify that the rise time is less than 0.35 ns, and the top aberrations are less than 12%. Record the Base-Top amplitude.
   e. Change the trigger delay to 20 ns.
   f. Verify that the peak-to-peak amplitude is less than 2% of the Base-Top amplitude measured in step d.
   g. Repeat steps a through f for channel B.

2. Procedure for instruments with firmware version 1.5 and below.
   a. Acquire the fast edge pulse on the SCD.
   b. Adjust the trigger delay to position the rising edge in the first 1/3 of the acquisition window (several acquisitions may be necessary).
   c. Measure the baseline voltage of the pulse using cursor #1. Write down this value as V_{base}.
   d. Use cursor #2 to measure the top of the pulse near the right edge of the window. Write down this value as V_{top}.
   e. Calculate the size of the pulse: $V_{p\text{-}p} = V_{top} - V_{base}$. (This value should be available as the cursor ΔV value at the top of the SCD screen.)
   f. Position cursor #2 at the peak of the overshoot on the positive transition. Note the value at this point and call it V_{peak}.
   g. Position cursor #2 to the first undershot lobe following the positive peak. Note the value at this point and call it V_{valley}.
   h. Calculate the magnitude of the overshoot and undershoot:

      $\%Overshoot = ((V_{peak} - V_{top}) / V_{p\text{-}p}) * 100.$

      $\%Undershoot = ((V_{top} - V_{valley}) / V_{p\text{-}p}) * 100.$

   i. Verify that the %Overshoot is less than +8% , the %Undershoot is less than -8%, and that | %Overshoot | + | %Undershoot | is less than 12%.
   j. Change the trigger delay to 20 ns.

k. Verify that the top of the pulse is flat within ±2% of V_{p-p}.

l. Change the offset to position the top of the pulse near the top of the screen.

m. Repeat steps a through k for the new pulse position.

n. Verify that the %Overshoot is less than +12% , the %Undershoot is less than -12%, and that | %Overshoot | + | %Undershoot | is less than 16%.

o. Change the offset to position to top of the pulse near the bottom of the screen (approximately 20% of the vertical window)

p. Repeat steps l and m for the new pulse position using the previously calculated value of V_{p-p}.

q. Repeat the setup on page 4-43 and steps a through p for channel B.

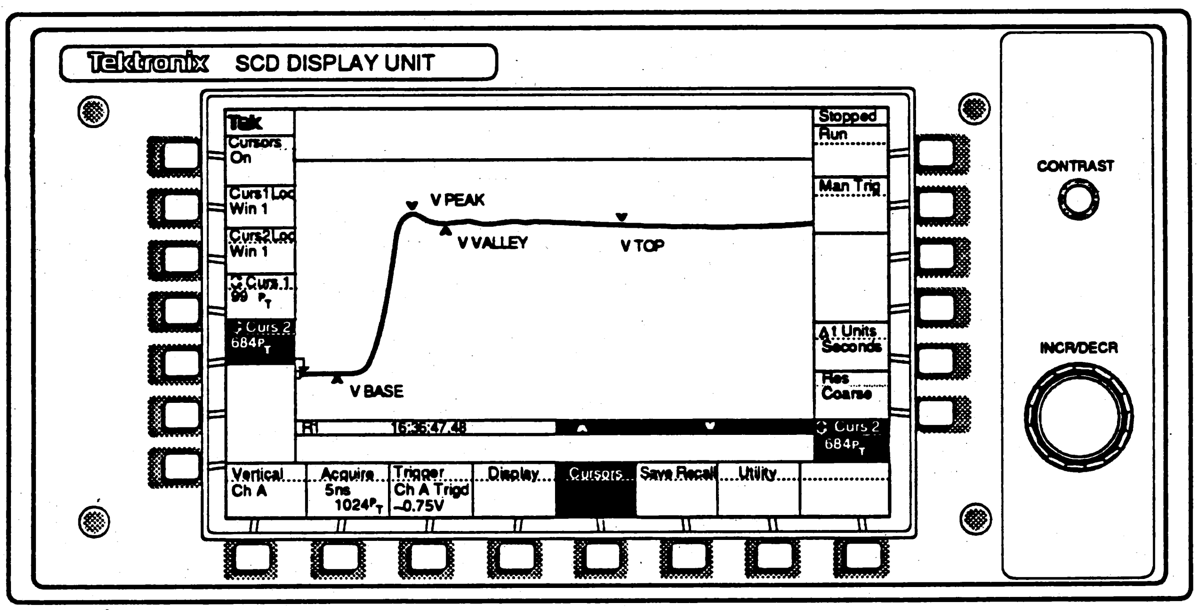


Figure 4-14: Step Response Measurement using Cursors

Low Frequency Linearity

The low frequency linearity is checked using the calibration generator and the SCD offset control to position a 20% full-scale square wave anywhere within the 10–90% full-scale range. The resulting measured amplitudes are then compared for accuracy.

Specification: 1% full-scale or less of compression or expansion when a 20% full-scale signal is positioned anywhere from 10 – 90% of the vertical window.

Setup: Press **Init** in the Save Recall menu. For the SCD1000, connect the CG output to the channel A input of the SCD. For the SCD5000, connect the trigger output to the TRIG IN input.

			Setting		
			SCD1000	**SCD5000**	**Option 01**
Digitizer	Vertical	Range	100 mV	5 V	10 V
		Coupling	DC		
		Offset	0 V		
	Acquire	Acq Mode	Normal		
		TimeWin	100 µs		
		Length	1024		
		HoldNext	On		
	Trigger	TrigMode	Normal		
		Source	CHA	EXT	INT
	Measure	Measure	On		
		Select	Base–Top Amp		
CG	Mode		Volts		
	Ampl		20 mV/div x 1 div	0.25 V/div x 5 divs	0.5 V/div x 5 divs
	Frequency		10 kHz		

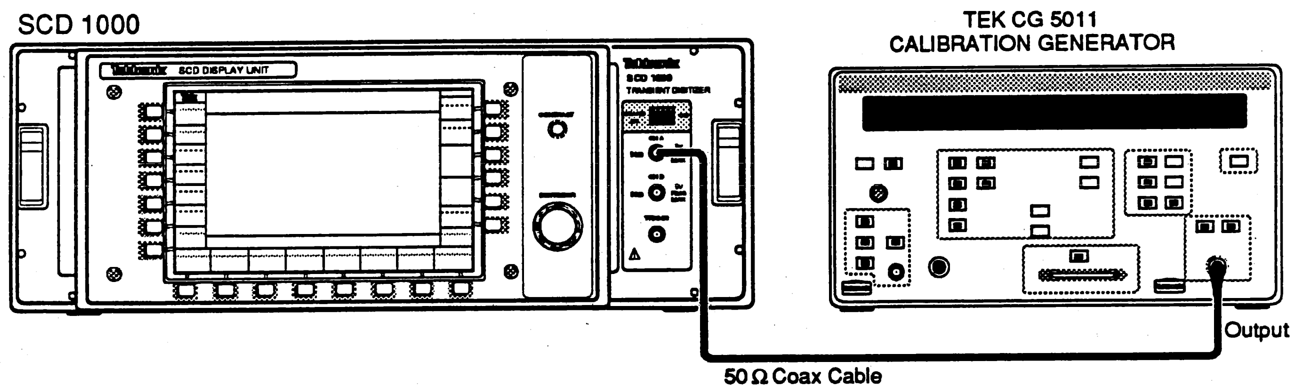


Figure 4-15: Low Frequency Linearity Setup

Procedure:

1. Position the waveform to center screen on the SCD using the offset control.
2. Use the cursors or measurements (Base–Top Amp *bx*) feature to measure the amplitude of the waveform at the center of the display (position the cursors at approximately the 250th and 750th points of the waveform). Write down this amplitude as A1.
3. Use the SCD internal vertical offset to reposition the top level of the waveform to the 90% level of the vertical window. Measure the amplitude at the center of the display screen (be sure to leave the cursors in the same horizontal positions), and write down this amplitude as A2.
4. Verify that A2 = A1 to within 1 mV (1%).
5. Reposition the bottom level of the waveform to the 10% level of the vertical window. Measure the amplitude at the center of the display screen and write down this amplitude as A3.
6. Verify that A3 is within 1 mV (1%) of both A1 and A2.

Common Mode Rejection Ratio (CMRR) (SCD1000 Only)

The channel to channel rejection ratio is measured by injecting a common signal into both channels, inverting one channel, and measuring the ADD mode common signal.

Specification: At least 20:1 DC to 50 MHz

Setup: Press **Init** in the Save Recall menu. Connect the output of the SG503 to a dual BNC connector. Connect each output of the dual BNC connector to each input of the SCD.

			Setting
			SCD1000
Digitizer	Vertical	VertMode	Add
		Range A	1 V
		Range B	1 V
		Offset A	0 V
		Offset B	0 V
		Coup A	DC
		Coup B	DC
		Invert A	OFF
		Invert B	ON
	Acquire	TimeWin	100 ns
		Length	1024
		HoldNext	On
	Trigger	TrigMode	Normal
		Source	CHA
		TrigCoup	AC
SG	Frequency		50 MHz
	Amplitude		3.3 V (1 V p-p into both channels)

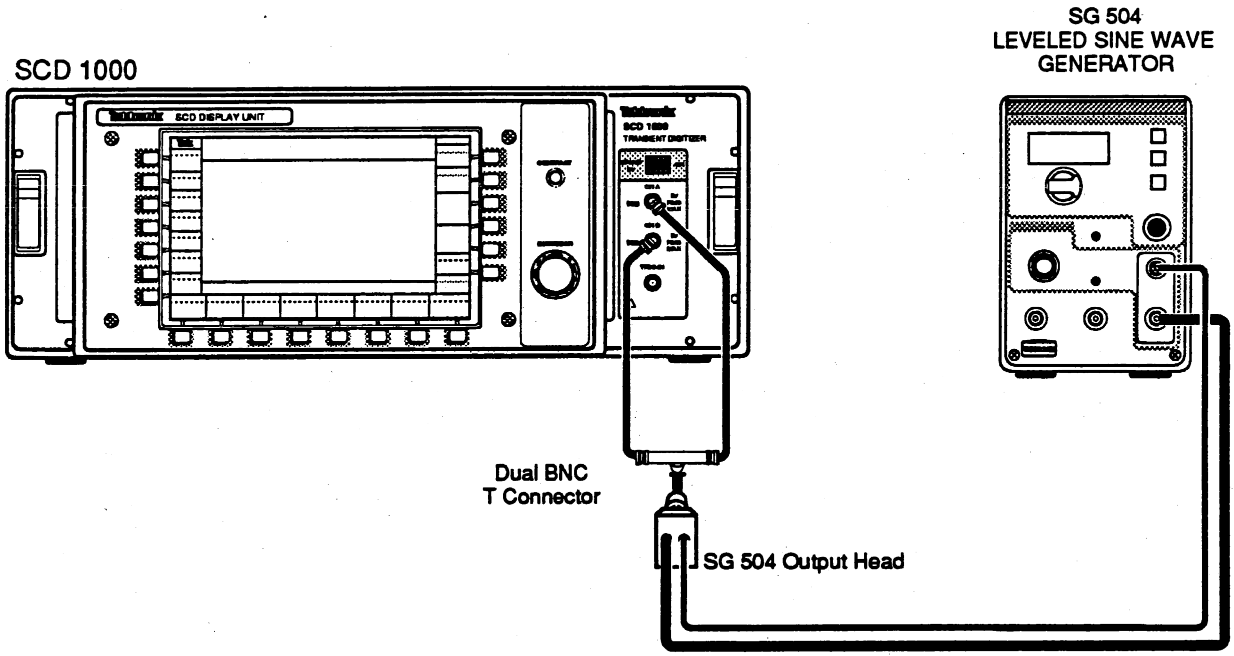


Figure 4-16: Common Mode Rejection Ratio Setup

Procedure:

1. Acquire a waveform on the SCD with the setup shown on page 4-48. This is the common mode waveform.
2. Using cursors or measurements (PK-PK), measure the amplitude of the acquired waveform.
3. Verify that the waveform amplitude measures less than 50 mV p-p.

Rms Noise (SCD1000 Only)

The rms noise is measured with no input to the digitizer (the inputs are terminated). A set of reference acquisitions is averaged together to provide a baseline from which to make the measurements. The measured signal is then acquired and the rms noise is calculated after subtraction from the reference waveform.

Specification: 0.3% of range (verify on 100 mV range) rms
0.45% of range ADD MODE, CHB Inverted (verify on 100 mV range) rms

Setup: Press **Init** in the Save Recall menu. Connect 50 Ω termination to SCD channels A and B. Connect the FG trigger output to the SCD TRIG IN input.

			Setting
			SCD1000
Digitizer	Vertical	VertMode	CHA
		Range	100 mV
		Coup	DC
	Acquire	TimeWin	5 ns
		Length	1024
		HoldNext	On
	Trigger	TrigMode	Normal
		Source	EXT
		TrigDly	0 ns
FG	Frequency		1 kHz
	Amplitude		500 mV

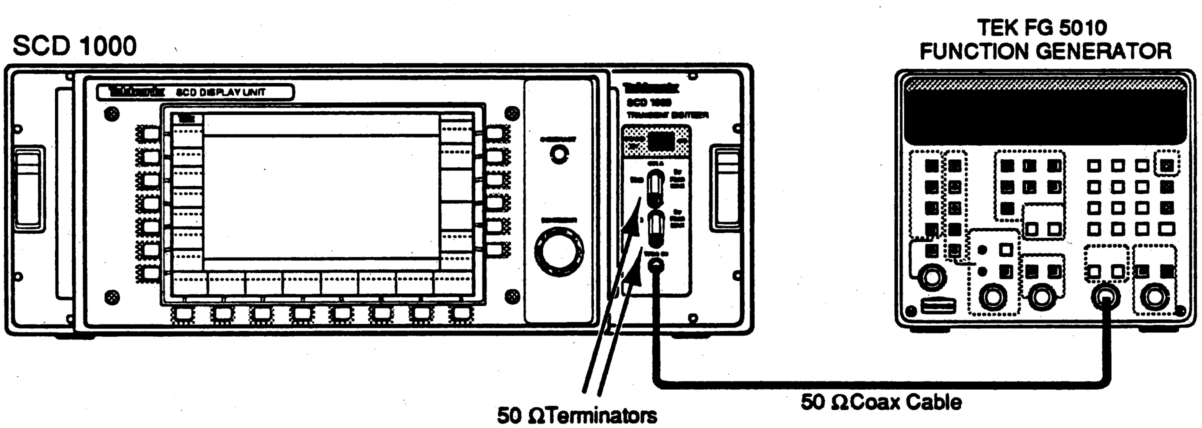


Figure 4-17: RMS Noise Setup

Procedure:

1. Refering to Table 4-21, use the settings shown in each row to measurem the rms noise. Run the rms noise program from the GPIB controller. This fully automated test acquires 32 records from the current vertical channel, averages to find a baseline, and calculates the rms noise based upon this information. The command line to list the syntax is:

   ```
   noise /h
   ```

   The command line used to run the test is:

   ```
   noise /d<nn> /n32 /m32 /g<addr>
   ```

   where <nn> is the percent trigger delay.

2. Verify that the calculated rms noise shown on the bottom of the display is less than the given specification.
3. Change the SCD CHA invert to ON, and repeat steps 1 and 2.
4. Change the SCD vertical mode to CHB, and repeat steps 1 through 3 for teh CHB input.
5. Set the SCD vertical mode to ADD, CHA invert off, CHB invert on, 100 mV on both channels, channel select to CHA, and repeat steps 1 and 2 using 0.45 mV as the maximum noise allowed.

Table 4-21: CH<x>Rms Noise Specifications

Time Window	Trigger Delay (percent)	Normal and Inv Max. rms (mV)	Add Mode Max. rms (mV)
5 ns	0%	0.300	0.450
20 ns	0%, 500%	0.300	0.450
10 ns	0%	0.300	0.450
100 ns	0%	0.300	0.450
100 ns	100%	0.300	0.450

Horizontal Timing Accuracy and Linearity

For this test, each sweep setting acquires time marks with a period of one-tenth of the period of the sweep window. The time difference between the zero crossings nearest the 10% and 90% (of the time window) is measured and compared to the specification. Linearity is measured from the 10% to 90% range of the acquisition window, and is measured as the difference in timing measured from one zero crossing to the 2[nd] crossing of the same slope, measured across the timing window.

Specification: Accuracy: 3% (10% to 90% of window)
Linearity: (all sweeps) 5% (10% to 90%, cycle to 2[nd] cycle)

Setup: Press **Init** in the Save Recall menu. For the SCD1000, connect the CG output to the SCD channel A input. For the SCD5000, connect the CG trigger output to the TRIG IN connector on the SCD front panel.

			Setting		
			SCD1000	**SCD5000**	**Option 01**
Digitizer	Vertical	Range	5 V		
		Coup	AC		
	Acquire	TimeWin	5 ns		
		Length	1024		
		HoldNext	On		
	Trigger	TrigMode	Normal		
		Source	CHA	EXT	
		TrigDly	250%		
	Cursor	Grat	On		
CG	Markers		0.5 ns/div		

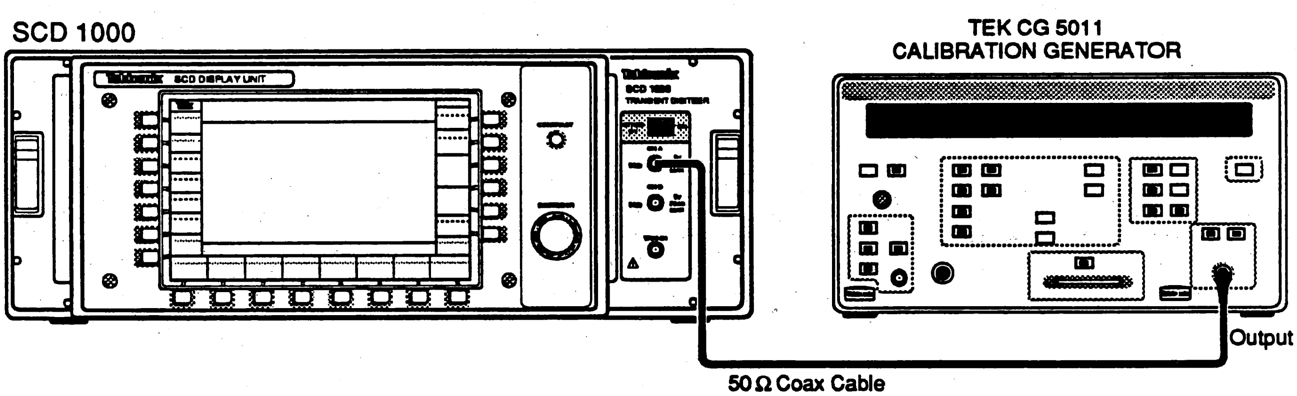


Figure 4-18: Horizontal Timing Accuracy and Linearity Setup

Procedure:

1. Acquire a waveform on the SCD.
2. Using the cursors, measure the time (Δ T in the cursor menu) from the zero crossing nearest the 10% point of the acquisition window to the crossing of the same slope near the 90% point (exactly 8 cycles away).
3. Verify that the time measured is 4 ns ±120 ps.
4. Position cursor #1 on the first zero crossing nearest the 10% point of the acquisition window and cursor #2 on the second zero crossing to the right (of the identical slope). Measure the time difference between the cursors.
5. Verify that the time difference between the reference edge and the second consecutive edge is 1 ns ±50 ps for all cycles between the 10% and 90% points on the screen.
6. Repeat steps 1 through 5 for the SCD settings and measurements shown in Table 4-22.

Table 4-22: Timing Accuracy and Linearity

Acquisition Window	Markers	Timing Accuracy (10% - 90%)		Linearity	
		Min.	Max.	Timing Cyc	Tolerance Cyc 2nd Cyc
5 ns	0.5 ns	3.880 ns	4.120 ns	1.00 ns	± 50 ps
10 ns	1 ns	7.760 ns	8.240 ns	2.00 ns	± 100 ps
20 ns	2 ns	15.68 ns	16.320 ns	4.00 ns	± 200 ps
50 ns	5 ns	39.20 ns	40.80 ns	10.00 ns	± 500 ps
100 ns	10 ns	78.40 ns	81.60 ns	20.00 ns	± 1.00 ns
200 ns	20 ns	156.80 ns	163.20 ns	40.00 ns	± 2.00 ns
500 ns	50 ns	392.0 ns	408.0 ns	100.00 ns	± 5.00 ns
1 μs	0.1 μs	784.0 ns	816.0 ns	200.00 ns	± 10.0 ns
2 μs	0.2 μs	1.568 μs	1.632 μs	400.00 ns	± 20.0 ns
5 μs	0.5 μs	3.920 μs	4.080 μs	1.00 μs	± 50.0 ns
10 μs	1 μs	7.840 μs	8.160 μs	2.00 μs	± 100.0 ns
20 μs	2 μs	15.68 μs	16.320 μs	4.00 μs	± 200.0 ns
50 μs	5 μs	39.20 μs	40.800 μs	10.00 μs	± 500.0 ns
100 μs	10 μs	78.40 μs	81.600 μs	20.00 μs	± 1.00 μs

Trigger Level Range and Accuracy

The trigger level accuracy of the SCD is checked at low frequency using a low frequency sine or triangle wave and comparing the trigger point on the displayed waveform with the trigger level setting.

Specification:

SCD1000		
Internal	AC Range	±vertical range
	DC Range	±vertical range/2
	Accuracy	±(2% + (5% of vertical range))
External	Range	±1.0 V
	Accuracy	±(10% + 50 mV)
SCD5000		
External	Range	±0.5 V
	Accuracy	±(10% + 50 mV)
SCD5000 with Option 01		
Internal	Range	±5 V
	Accuracy	±(10% + 500 mV)
External	Range	±0.5 V
	Accuracy	±(10% + 50 mV)

Setup: Press **Init** in the Save Recall menu. For the SCD1000 and the SCD5000 with Option 01, connect the output of the function generator through a coax cable to the SCD channel A input.

For the SCD5000 (standard), connect the output of the FG through a coax cable to a power divider. Connect one side of the power divider through a 48 ns delay line to the SCD5000 input, and the other side through a 5× attenuator to the TRIG IN input.

			Setting		
			SCD1000	**SCD5000**	**Option 01**
Digitizer	Vertical	Range	1 V	5 V	10 V
	Acquire	TimeWin	5 ns		
		Length	1024		
		HoldNext	On		
	Trigger	TrigMode	Normal		
		Source	CHA	EXT	
		TrigLvl	+0.45 V	+0.5 V	
		TrigCoup	DC		
		TrigDly	0%		
FG	Amplitude		2 V p-p	15 V p-p	
	Frequency		200 kHz	1 MHz	
	Function		Triangle		

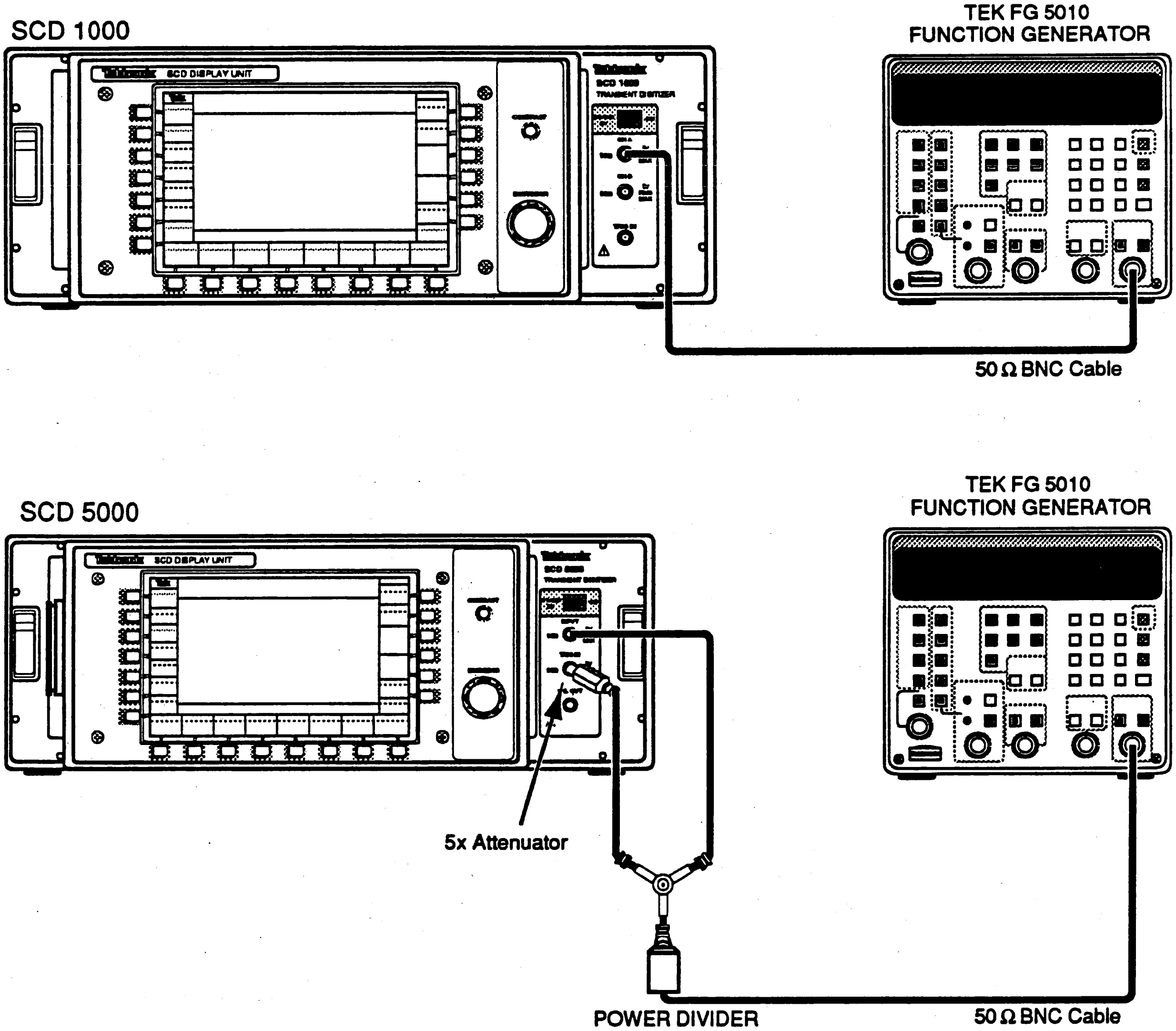


Figure 4-19: Trigger Level Range and Accuracy Setup

Procedure (SCD1000):

1. With the digitizer set as described on page 4-54, acquire a waveform on the SCD with the trigger level set according to Table 4-23, step #1.
2. Set the cursors on the 512th horizontal point, measure the amplitude, and compare it to the values given in Table 4-23.
3. Repeat steps 1 and 2 for the remainder of the steps in Table 4-23.
4. Change the SCD trigger slope to negative and repeat steps 1 through 3.
5. Move the FG output cable from CHA to CHB, and change the trigger source to CHB. Repeat steps 1 through 4 for the SCD channel B input.

Table 4-23: SCD1000 Internal Trigger Level Accuracy

Step	SCD Trigger Level	Cursor Reading Minimum	Cursor Reading Maximum
1	450 mV	391 mV	509 mV
2	250 mV	195 mV	305 mV
3	0 V	-50 mV	+50 mV
4	-250 mV	-305 mV	-195 mV
5	-450 mV	-509 mV	-391 mV

6. Remove the FG output cable from the CHB input and connect the cable to a power divider. Connect one side of the divider to the SCD channel B input, and the other side to the SCD TRIG IN input.
7. Set the SCD channel B vertical range to 2 V, trigger source to EXT, trigger slope (+). Increase the FG output to >6 V (2 V p-p at both CHB and EXT TRIG inputs).
8. With the digitizer set as described above, acquire a waveform on the SCD with the trigger level set according to Table 4-24, step 1.
9. Set a cursor on the 512th horizontal point, measure the amplitude, and compare it to the values given in the Table 4-24.
10. Repeat steps 8 and 9 for the remainder of the steps in Table 4-24.
11. Change the SCD trigger slope to negative and repeat steps 8 through 10.

Table 4-24: SCD1000 External Trigger Level Accuracy

Step	SCD Trigger Level	Cursor Reading Minimum	Cursor Reading Maximum
1	900 mV	760 mV	1.040 V
2	500 mV	400 mV	600 mV
3	0 V	-50 mV	+50 mV
4	-500 mV	-600 mV	-400 mV
5	-900 mV	-1.040 V	-760 mV

Procedure (SCD5000):

1. With the digitizer set as described in the setup procedure, acquire a waveform on the SCD with the trigger level set according to Table 4-25, step 1.
2. Set a cursor on the 512th horizontal point, measure the amplitude, and compare it to the values given in Table 4-25.

NOTE

The value read with the cursors and appearing in the table is five times the amplitude of the true signal at the EXT TRIG input because an attenuator is present on the EXT TRIG input but not on the signal input).

3. Repeat procedure steps 1 and 2 for the remainder of the steps in Table 4-25.
4. Change the SCD trigger slope to negative and repeat procedure steps 1 through 3.

Table 4-25: SCD5000 External Trigger Level Accuracy

Step	SCD Trigger Level	Cursor Reading Minimum	Cursor Reading Maximum
1	450 mV	1.775 V	2.725 V
2	250 mV	0.875 V	1.625 V
3	0 V	–250 mV	+250 mV
4	–250 mV	–1.625 V	–0.875 V
5	–450 mV	–2.725 V	–1.775 V

Procedure (SCD5000 Opt. 01):

1. With the digitizer set as described in the setup procedure, acquire a waveform on the SCD with the trigger level set according to Table 4-26, step 1.
2. Using the cursors set on the 512th horizontal point, measure the amplitude and compare it to the values given in the table.
3. Repeat procedure steps 1 and 2 for the remainder of the steps in Table 4-26.

4. Change the SCD trigger slope to negative and repeat procedure steps 1 through 3.

Table 4-26: SCD5000 Option 01 Internal Trigger Level Accuracy

Step	SCD Trigger Level	Cursor Reading	
		Minimum	Maximum
1	4 V	3.1 V	4.9 V
2	2 V	1.3 V	2.7 V
3	0 V	–0.5 V	0.5 V
4	–2 V	–2.7 V	–1.3 V
5	–4 V	–4.9 V	–3.1 V

5. Remove the FG output cable from the CHB input and connect the cable to a BNC power divider. Connect one side of the divider through a 5× attenuator, and the other side to the SCD TRIG IN input.
6. With the digitizer set as described above, acquire a waveform on the SCD with the trigger level set according to Table 4-27, step 1.
7. Using the cursors set on the 512th horizontal point, measure the amplitude and compare it to the values given in Table 4-27.
8. Repeat steps 5 and 6 for the remainder of the steps in Table 4-27.
9. Change the SCD trigger slope to negative and repeat steps 5 through 8.

Table 4-27: SCD5000 Option 01 External Trigger Level Accuracy

Step	SCD Trigger Level	Cursor Reading	
		Minimum	Maximum
1	450 mV	3.55 V	5.45 V
2	250 mV	1.75 V	3.25 V
3	0 V	–500 mV	500 mV
4	–250 mV	–3.25 V	–1.75 V
5	–450 mV	–5.45 V	–3.55 V

Trigger Jitter

The trigger jitter (uncertainty) of the SCD is checked using a fast-rising edge of a pulse from the CG5011. Sixteen (16) records are accumulated with a common trigger point. The location in time of the zero crossing on the steps rising edge is then averaged, and the trigger jitter error is calculated as the standard deviation of the time position of the zero crossing.

NOTE

This method is consistent with the requirements of IEEE Standards for Digitizing Waveform Recorders

Specification: 30 ps or less, 500 mV p-p square wave with rise time ≤1 ns

Setup: Press **Init** in the Save Recall menu. For the SCD1000, connect the CG pulse head output to a power divider. Using equal lengths of cable, connect one side of the divider to the SCD channel A input, and connect the other side to the SCD **TRIG IN** input.

For the SCD5000, connect one side of the divider through a 48 ns delay line, then to the SCD input. Connect the other side of the divider directly to the **TRIG IN.**

For the SCD5000 with Option 01, connect the CG pulse head output to a power divider. Using equal lengths of cable, connect one side of the divider to the SCD input, and connect the other side to the SCD **TRIG IN** input.

NOTE

This procedure requires some method of calculating mean and standard deviation (such as a calculator with built-in statistics functions).

			Setting		
			SCD1000	SCD5000	Option 01
Digitizer	Vertical	Coup	AC	DC	
	Acquire	Acq Mode	AutoAdv (16)		
		TimeWin	5 ns		
		Length	1024		
		HoldNext	On		
	Trigger	TrigMode	Normal		
		Source	CHA	EXT	INT
		TrigCoup	AC		
		TrigDly	10%		
CG	Mode		Fast Edge		
	Amplitude		1 V (1 V x 1 div.)		

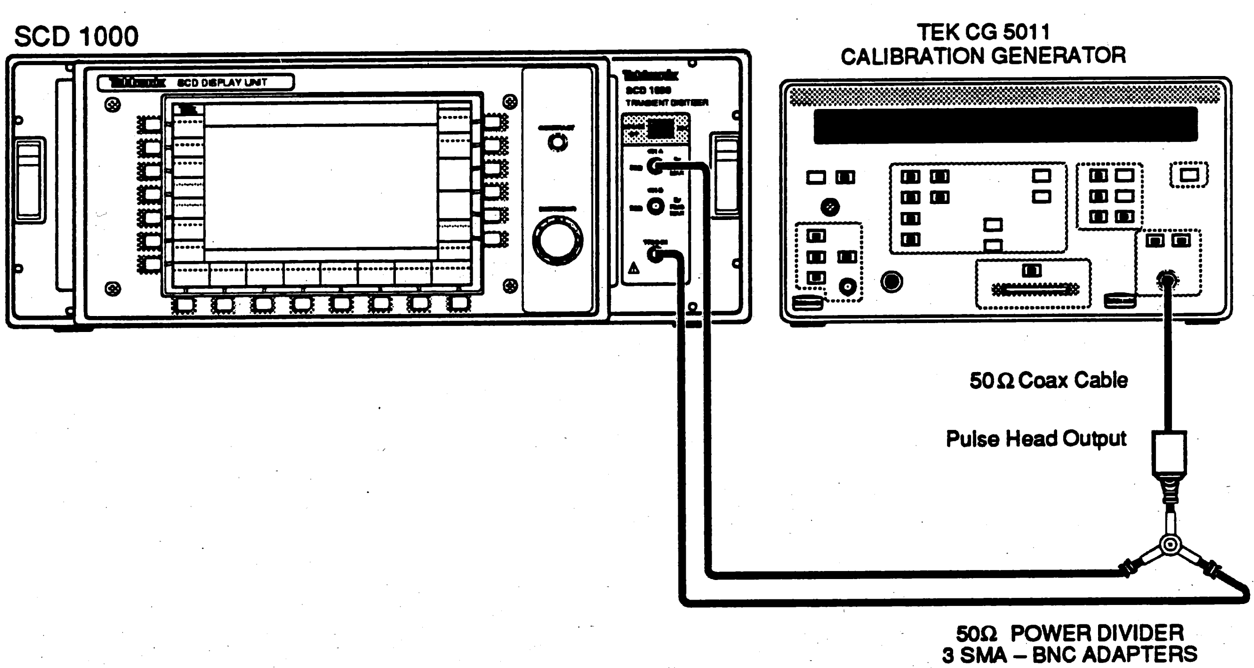


Figure 4-20: Trigger Jitter Setup

Procedure:

1. Acquire 16 waveforms from the SCD using the AutoAdvance mode.
2. Using cursors, find the zero crossing point (or the midpoint of the rising edge) of each waveform, and write down the time position of these zero crossings.
3. Calculate the standard deviation of the zero crossing times using the following formula:

   Formula for standard deviation:

$$s = \sqrt{\frac{\sum_{1}^{N}(x-\bar{x})^2}{N-1}} \qquad \textit{where } \bar{x} = \textit{average value}$$

4. Verify that the standard deviation of the zero crossing times (trigger jitter) is less than 30 ps.
5. For the SCD1000, repeat steps 1 through 4 for CHB and EXT trigger sources.
6. For the SCD5000, repeat steps 1 through 4 for the EXT trigger source.

Trigger Sensitivity

The trigger sensitivity of the SCD is checked using sine waves of various frequencies. The test for the SCD1000 consists of two parts. *Part 1* tests the internal trigger sensitivity and *Part 2* tests the external trigger sensitivity. Each of these parts requires different test setups to obtain the various input frequencies, since no one piece of test equipment covers the entire testing range.

The test for the SCD5000 consists of external trigger sensitivity for all SCD5000's, and the internal trigger sensitivity test for the SCD5000 with Option 01.

Specification:

Internal (SCD1000)	0.05 * range,	DC to 250 MHz
	0.15 * range,	250 MHz to 1 GHz
Internal (SCD5000 with Option 01)		500 mV, 20 kHz to 50 MHz
		1.5 V, 50 MHz to 500 MHz
		3.5 V, 500 MHz to 1 GHz
External (SCD1000, SCD5000 Standard and Option 01)		50 mV, 20 kHz to 50 MHz
		150 mV, 50 MHz to 500 MHz
		350 mV, 500 MHz to 1 GHz

Setup: Press **Init** in the Save Recall menu. For the SCD1000, connect the FG output to the SCD channel A input. Set the measurements for PK-PK.

For the SCD5000 standard, connect the FG output to a power divider. Connect one side of the divider to the SCD input, and the other side of the divider to the TRIG IN input on the SCD fron panel.

For the SCD5000 with Option 01, connect the FG output to the SCD input. Set the measurements for PK-PK.

			Setting		
			SCD1000	**SCD5000**	**Option 01**
Digitizer	Vertical	VertMode	CHA	N/A	
		Range	1 V	5 V	10 V
	Acquire	TimeWin	100 µs		
		Length	1024		
	Trigger	TrigMode	Normal		
		Source	CHA	EXT	INT
		TrigLvl	0.0 V		
FG	Frequency		10 kHz		
	Signal		Sine		
	Amplitude		100 mV (50 mV into 50 Ω)	1.5 V	500 mV

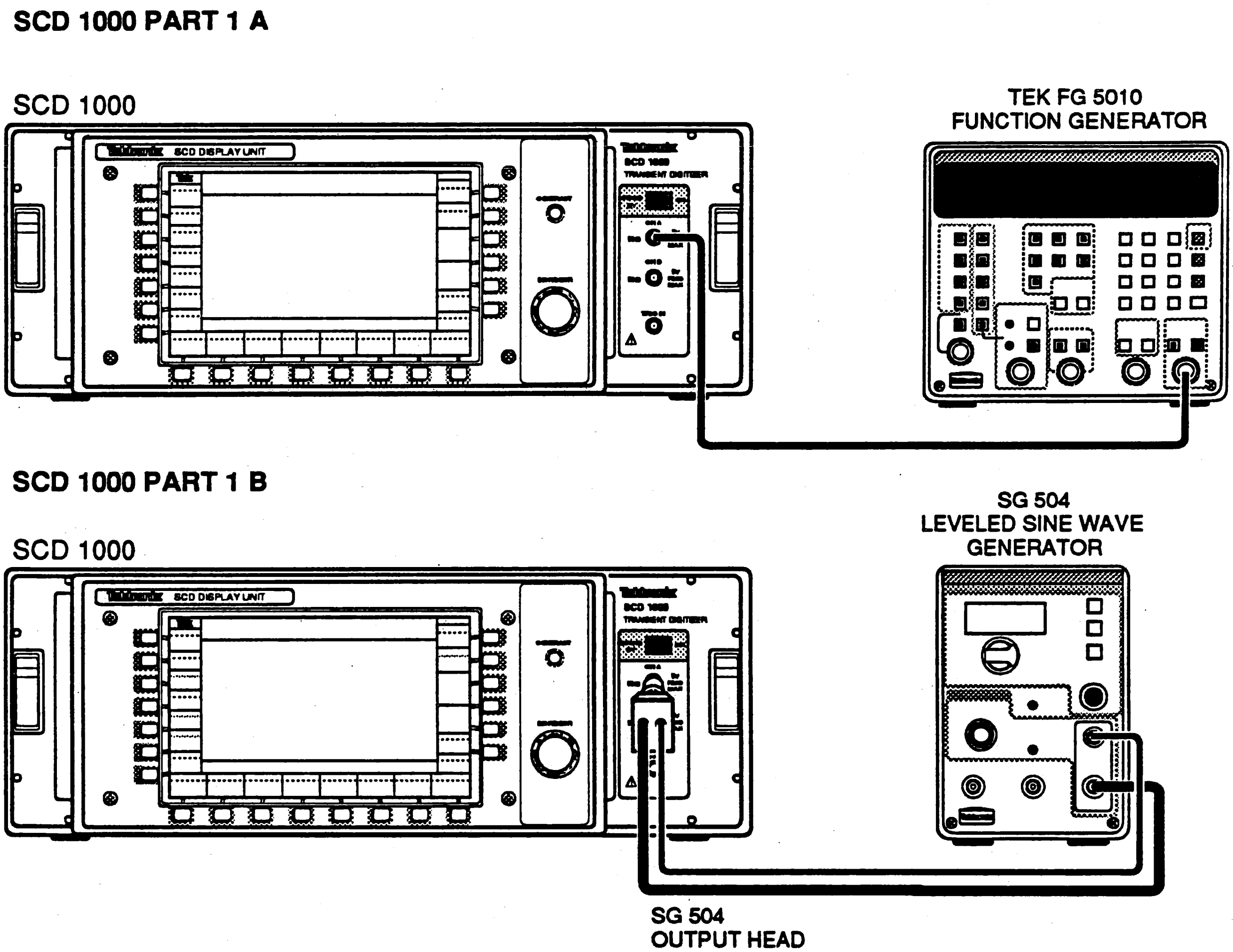


Figure 4-21: SCD1000 Trigger Sensitivity Setup Part 1 (Internal)

Procedure (SCD1000):

Part 1A Internal Sensitivity

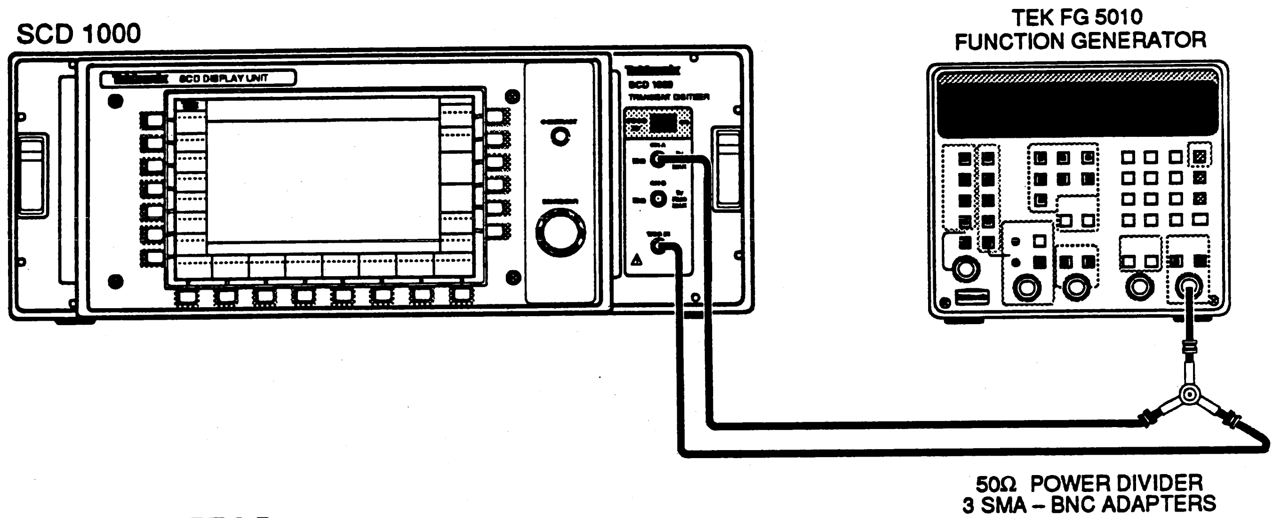
1. Set the SCD aquire state to RUN and the trigger coupling set to DC, and check for a stable display with a consistent trigger point (TRIG'D indicator displayed). Repeat with the trigger coupling set to AC. Adjust the trigger level as necessary to achieve a stable display. Be sure to use the FINE adjustment setting for the trigger level throughout this procedure.
2. Set the triggering slope to negative and repeat step 1.
3. Connect the FG output to channel B input. Set the SCD for trigger source CHB, vertical range 1 V, vertical mode CHB.
4. Repeat steps 1 and 2 for channel B.

Part 1B

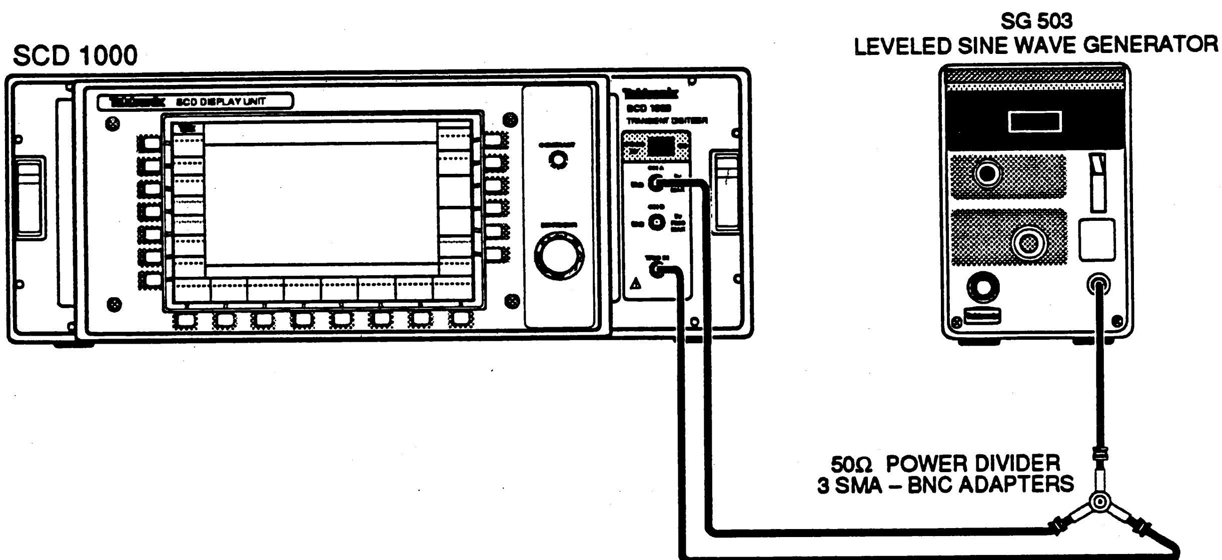
5. Set the SCD time window to 20 ns, trigger slope (+), trigger source to CHA, vertical to 100 mV. Connect the SG504 to the channel A input.

6. Set the SG504 frequency to 249 MHz, and adjust the SG output for a 50 mV p-p signal measured using the SCD cursors. Set the SCD vertical range to 1 V (channel A).
7. Check for a stable display with a consistent trigger point (TRIG'D indicator displayed) with the trigger coupling set to DC. Repeat with the trigger coupling set to AC. Adjust the trigger level as necessary to achieve a stable display.
8. Set the triggering slope to negative and repeat step 7.
9. Connect the SG output to the channel B input. Set the SCD for CHB trigger source and the CHB vertical range to 1 V. Repeat steps 7 and 8.
10. Set the SG504 frequency to 1000 MHz, adjust the SG output amplitude for a 150 mV p-p signal. Set the SCD time window to 5 ns, trigger slope (+), vertical range 1 V.
11. Check for a stable display with a consistent trigger point (TRIG'D indicator displayed) with the trigger coupling set to DC. Repeat for the trigger coupling set to AC. Adjust trigger level as necessary to achieve a stable display.
12. Set the triggering slope to negative and repeat step 11.
13. Connect the SG504 output to the SCD channel B input. Set the SCD trigger source to CHB, trigger slope (+), vert chan. CHB, vertical range 1 V, and repeat steps 11 and 12 for channel B.

SCD 1000 PART 2 A



SCD 1000 PART 2 B



SCD 1000 PART 2 C

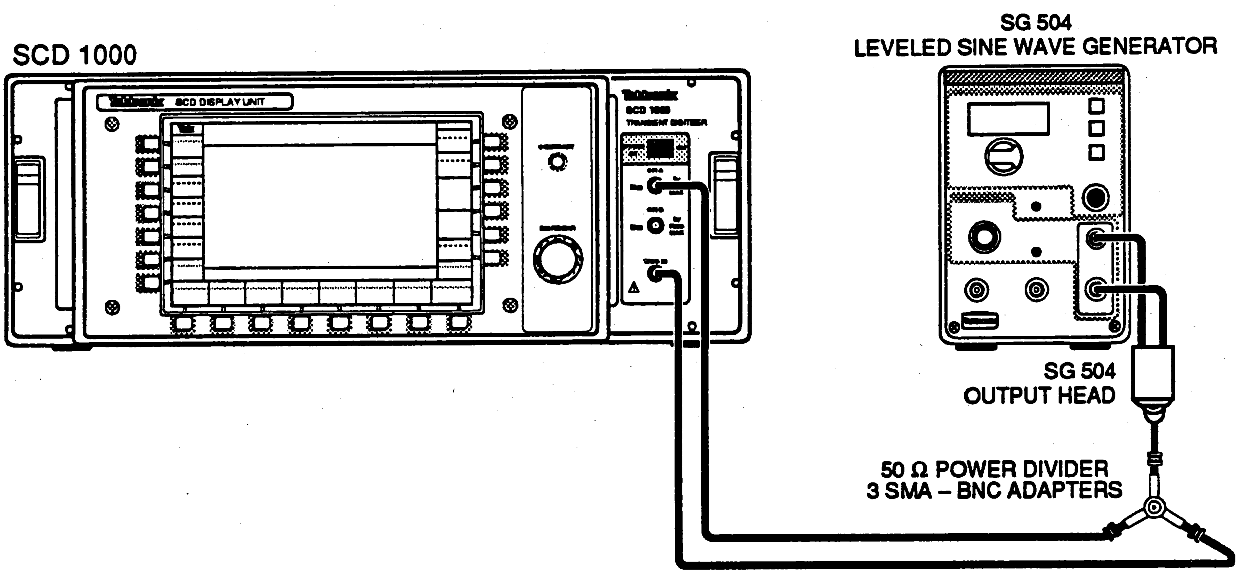


Figure 4-22: SCD1000 Trigger Sensitivity Setup Part 2 (External)

Procedure (SCD1000):

Part 2A External Sensitivity

1. Set the SCD for

time window	100 μs
vertical range	100 mV
vert chan	CHA
trigger coupling	DC
trigger source	CHA

2. Connect the FG output to a power divider. Connect one side of the divider to the TRIG IN input of the SCD, and the other side to the SCD CHA input. Set the FG frequency to 20 kHz, sine wave output. Adjust the FG amplitude for a 50 mV p-p signal (about 150 mV from FG output) as measured with the SCD cursors (50 mV at both TRIG IN and CHA input).
3. Set the SCD trigger source to EXT.
4. Check for a stable display with a consistent trigger point (TRIG'D indicator displayed). Adjust the trigger level as necessary to achieve a stable display.
5. Set the trigger slope to negative and repeat step 4.

Part 2B

6. Remove the FG output cable from the divider and connect the divider to the SG503 output. Set the frequency to 49 MHz. Set the SCD time window to 1 μs. Adjust the FG amplitude for a 50 mV p-p signal as measured with the SCD cursors (50 mV at TRIG IN input).
7. Check for a stable display with a consistent trigger point (TRIG'D indicator displayed). Adjust the trigger level as necessary to achieve a stable display.
8. Set the trigger slope to negative and repeat step 7.

Part 2C

9. Remove the SG503 output cable from the divider and connect the divider to the SG504 output. Set the SCD time window to 5 ns. Set the SG504 frequency to 500 MHz, adjust the output amplitude for a 150 mV signal as measured with the SCD cursors (150 mV at TRIG IN input).
10. Repeat steps 7 and 8 with the new input signal.
11. Increase the SG504 frequency to 1000 MHz, and adjust the output amplitude for a 350 mV signal as measured with the SCD cursors (350 mV at TRIG IN input).
12. Repeat steps 7 and 8 with the new input signal.

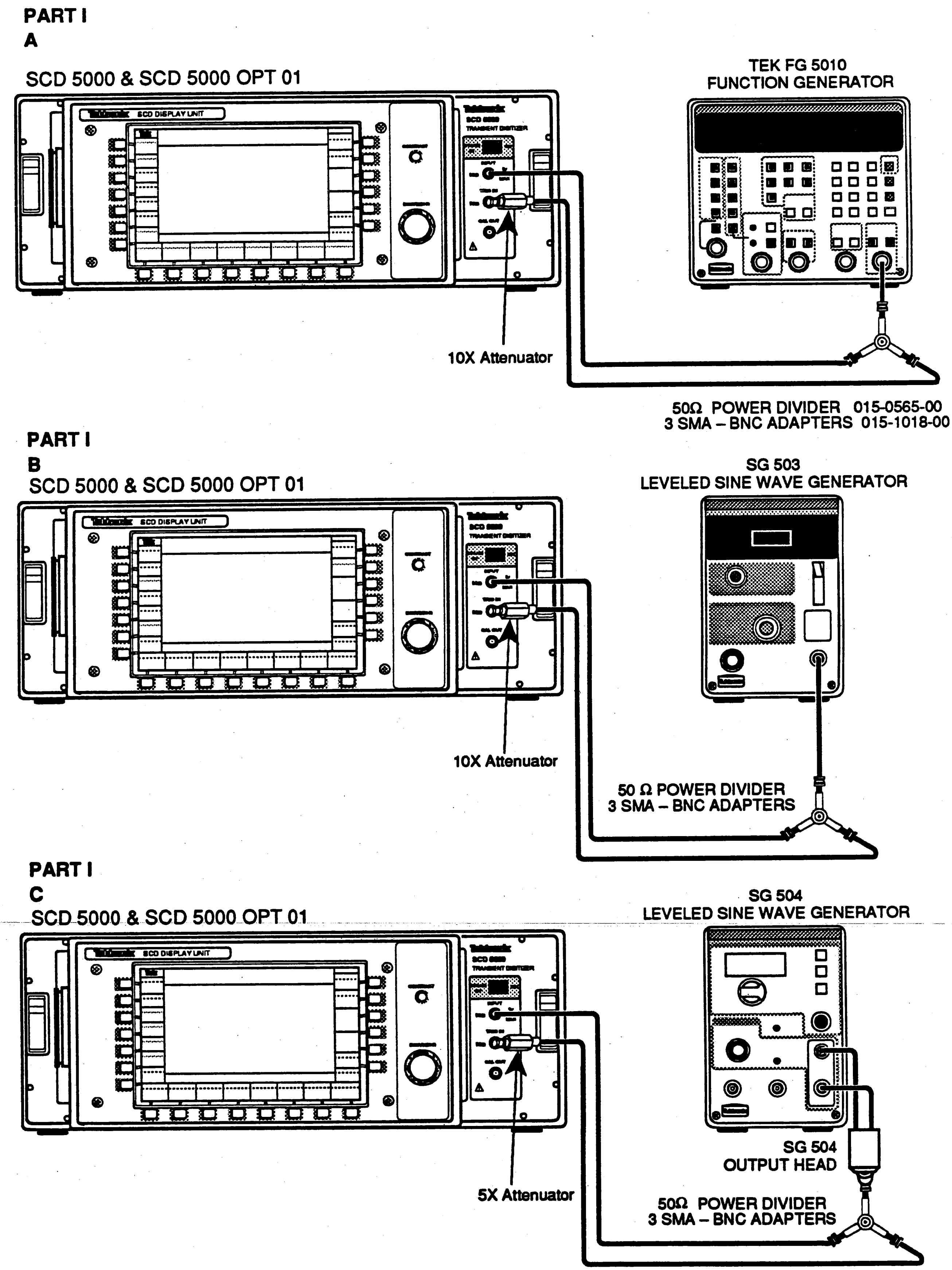


Figure 4-23: SCD5000 Trigger Sensitivity Setup Part 1

Internal Calibration

The internal calibration routines are designed to enhance the accuracy of the instrument and should be run on a regular basis (with the exception of the CRT calibration), particularly prior to critical acquisitions where the enhanced accuracy may be necessary. The internal calibration programs in the instrument firmware generate over 350 calibration (cal) constants and store them in NVRAM on the MPU board. These constants are used to control the instrument's hardware.

The internal calibration routines perform in slightly different manners depending upon the instrument configuration. SCD1000 instruments, with all of the vertical ranges, will take approximately 20 minutes to complete internal calibration. SCD5000 instruments will take about 15-20 minutes to complete calibration. Note that while internal calibration is running, any front panel activity or GPIB activity will automatically abort the calibration and issue a status message indicating that cal was aborted.

Internal calibration will allow you to perform the following operations:

- adjust/calibrate the VERTICAL system (signal amplitude and offset)
- create correction table for CRT vertical GEOMETRY distortion
- adjust/calibrate the HORIZONTAL system (timing and trigger delay)
- adjust/calibrate the TRIGGER system (trigger level)
- adjust/calibrate the INPUT resistance and bias current (SCD1000 only)
- align the CRT orthagonality and adjust its intensity

The descriptions that follow are purely for informational purposes, and only a cursory overview of the actual algorithms used for calibration. They will, however, give the operator a better understanding of what the instrument is doing during calibration and perhaps offer insight as to the cause if the calibration does not pass. The descriptions are written for the SCD1000 instruments, with exceptions provided for the SCD5000 where applicable.

Vertical Calibration

The vertical system calibration for the SCD1000 begins with channel A. The internal calibration DC reference voltage is coupled into the preamp through the Channel A attenuator relay. The calibration then proceeds to Channel B, coupling the calibrator signal through the Channel B attenuator relay. The Vertical System calibration proceeds as follows:

Vertical Offset and Gain

For each vertical range (starting with 100 mV) for each channel, a calibrator voltage of +40% is acquired, then a voltage of –40% of the range is acquired. From these two acquisitions, the vertical accuracy and the DC offset is computed.

- If the offset and accuracy fall within acceptable limits, the program will proceed to the next vertical range.
- If the offset or the accuracy fall outside the limits, (offset: 0.35% + (range x 0.001), gain: 0.4% + (range x 0.001)), then the program adjusts the cal constant(s) using a linear interpolation algorithm repeating the acquisitions and computations until the constants yield acceptable values for offset and accuracy.
- If the search routine is unable to find acceptable values, the calibration for this range will be flagged as failing, subsequent calibration for this vertical range will be suspended, and the program will proceed to the next range.

Ideal cal constant values for this section of calibration should be around 127 for gain and in the range of 0 for offset.

Offset Gain and Invert Offset

For each vertical range for each channel, amplifier INVERT is set to ON. A calibrator voltage is input to the attenuator, and a corresponding offset voltage is input to the preamplifier chip and the resulting signal is acquired. The resulting waveform should appear at center screen. Then the offset setting and the calibrator voltage are both inverted, and a second trace is acquired. From these acquisitions, the invert offset accuracy is computed.

- If the accuracy falls outside of the spec limits (invert offset: 0.35% + (range x 0.001), offset gain: 0.4% + (range x 0.001)), new cal constants are loaded based on a linear interpolation algorithm, and the above process is repeated.
- If the offset gain and invert offset gain fall within acceptable limits, the program will proceed to the next vertical range.
- If the offset gain or the invert offset gain fall outside the limits, which are the same as above for vertical offset and gain, then the program adjusts the cal constant(s) using a binary search algorithm repeating the acquisitions and computations until the constants yield acceptable values for offset gain and invert offset.

- If the search routine is unable to find acceptable values, the calibration of this range will be flagged as failed, and the program will proceed to the next range.

Ideal cal constant values for this section of calibration are around 0.0 for both offset gain and invert offset.

Vertical ADD mode Offset

With the preamplifier mode set to ADD, the vertical offset and the calibrator input signal are both set to zero volts. An acquisition is performed and the error is calculated (from center screen)

- If the Add mode offset does not fall within acceptable limits (offset: 0.35% + (range x 0.001)), a new cal constant is computed using linear interpolation, and the above steps are repeated.
- If the search routine is unable to find acceptable values, the calibration of this range will be flagged as failed, and the program will proceed.

For the SCD5000 and the SCD5000 Option 01 (instruments without a vertical amplifier), the calibration is simplified to the single vertical range available (5 V for the standard SCD5000, 10 V for the SCD5000 Option 01), calibrating only the vertical gain and offset.

Geometry Calibration

The CRT read gun geometry distortion manifests itself primarily as "S-curve" distortion. The "straight baseline" painted on the CRT target by the write-gun appears slightly twisted at both ends (resembling an "S") when scanned off the target by the read gun. The degree of the distortion increases as the vertical offset from the center of the target increases. It is understood that the S-curve distortion of the read gun is dominant primarily in the vertical axis, and is of secondary concern in the horizontal direction. For this reason, geometry distortion correction is compensated for in the vertical axis, using a bi-linear interpolation algorithm.

The geometry calibration creates the "distortion map" used for the bi-linear interpolation by positioning, acquiring, and averaging (10 waveforms at each vertical position) a baseline from 5% to 95% of the vertical window (in 10% steps), comparing the acquired data to the ideal position of the acquired data. The final product of the distortion characterization is an 11 x 30 array (or grid) of correction constants. The grid is utilized by the interpolation algorithm to calculate the amount of correction needed at any digitized point on the target. With geometry correction on, normal acquisitions are processed using the "distortion map" array to place each point within 1% of where its ideal location lies. If the correction required for any one point represents a change in position of 10% of the vertical range (or more), geometry calibration will fail.

It should be noted that geometry distortion is somewhat sensitive to record length. For most applications, the general-purpose geometry calibration (from the Utility menu, Geometry Cal) offers more than sufficient correction. However, for maximum accuracy in geometry distortion correction, it is recommended that geometry calibration be run with the desired instrument settings (from the second level of the Acquire menu), instead of the general-purpose geometry calibration (which uses fixed instrument settings) that is set at the factory.

Horizontal Calibration

The Horizontal system calibration is can be quite sensitive to CRT intensity settings, particularly the minimum trigger delay section. For this reason, CRT intensity calibration is run as the first part of the horizontal system calibration (see CRT calibration for a description of this calibration). Next, the internal calibrator signal is switched to its timing signal and injected into the SCD Channel A attenuator signal path. The horizontal calibration then proceeds as follows:

Sweep Accuracy

For each acquisition window (starting with 5 ns) the timing accuracy cal constant is adjusted.

A timing signal with a period of approximately 1/5 to 1/6 of the window period (except 5 ns and 10 ns, which both use the 4 ns timing signal) is acquired at a fixed trigger delay setting corresponding to approximately 250% delay. From this waveform acquisition, the period of the acquired signal is calculated and compared with the known calibrator period. If on the 5 ns or 10 ns window, the waveform used for calculation is the average of 20 acquisitions, providing greater accuracy for these ranges.

- If the calculated accuracy is within ±0.7% (1.0% is pass/fail limit) of the known calibrator period, the program will proceed to the next acquisition window setting.
- If the calculated accuracy falls outside of the spec limit by more than ±3%, the program adjusts the sweep cal constant using a binary search algorithm repeating the acquisitions and computations until the constant yields an accuracy value that is within ±3%.

Once the calculated accuracy error falls within ±3% (the target is 0% error), the program will fall into a linear search algorithm. In the linear search, the program adjusts the cal constant a fixed amount, and acquires another waveform. This will continue until either the accuracy falls within ±0.4%, or the program overshoots the target of 0%. If overshot, the fixed amount of cal constant change will be halved, and the direction will be reversed.

- If after 10 tries, the accuracy does not meet the pass/fail limit of ±0.7%, the sweep calibration of this window will be flagged as failed, all subsequent horizontal cal routines will be suspended for this window, and the program will proceed to the next setting.

Minimum Trigger Delay

For each acquisition window (starting with 5 ns) the minimum delay (pretrigger) cal constant is adjusted.

A timing signal with a period of approximately 1/5 to 1/6 of the window period is acquired at fixed trigger delay setting. The amplitude of the signal is calculated, and a signal with a fast-rise edge is acquired again using this calculated amplitude. The position of the 50% point of the rising edge is then positioned to 2.5 ns into the window, within ±0.5% (0.75% is the pass/fail limit). For the slower sweeps where 2.5 ns is not discernable at the left edge of the screen, the position of the second rising edge (instead of the barely-visible first edge) is positioned accordingly in the window.

- If the rising edge is positioned accordingly but the acquisitions still experience missing data (for any of a number of reasons - z-axis, horizontal linearity, writing rate, etc), the routine will do one of two things. If there are more than 50 missing points at the start (left edge) of the sweep, the routine will flag this setting as failed, and proceed to the next setting. If there are less than 50 missing points, the routine will attempt to "walk" the signal to the left (using incremental cal constant steps) in an attempt to get rid of the missing data. The routine will keep track of whether the number of missing points decreased after each incremental step. If missing points decreased for a particular step, that increment will be flagged as good. The routine will stop after 10 incremental steps if there is still missing data. If after 10 steps there is still missing data, the minimum trigger delay cal will add the number of "good" increments to the cal constant and proceed to the next window.
- If the search routine is unable to find acceptable cal constant value to meet the pretrigger spec without missing data, the minimum trigger delay calibration of this window will be flagged as failed, all subsequent horizontal cal routines will be suspended for this window, and the program will proceed to the next window.

This portion of the horizontal calibration is particularly susceptible to CRT intensity. For most of the acquisition windows, the routine actually searches for missing data at the left edge of the window (to find the true beginning of the sweep), only then will the program search for the rising edge. Also, once the rising edge is positioned correctly, there should be no missing data present in the acquisition.

Maximum Trigger Delay

For each acquisition window (starting with 5ns) the maximum delay (post-trigger) cal constant is adjusted.

A timing signal with a fast-rise edge is acquired at the previously calibrated 0% trigger delay position. Then based upon the calibration signal period, the correct number of rising edges is counted while delaying the sweep by a constant amount. Upon acquiring the correct number of rising edges to give the 500% trigger delay range, the final rising edge is positioned accordingly in the acquisition window within ±0.5% (2.5% is the pass/fail limit).

- If the search routine is unable to find acceptable cal constant value to meet the post- trigger spec, the maximum trigger delay calibration of this window will be flagged as failed and the program will proceed to the next window.

For the SCD5000 Option 01, the horizontal calibration description above holds true. However, for the standard SCD5000, the trigger event takes place approximately 45 ns before the true start of the sweep occurs, thus the pretrigger and post-trigger calibrations are slightly different. For both pre-trigger and post-trigger calibration, this 45 ns must be taken into account. The known period of the calibrator signal is used to compute the constant needed to position the trigger event 45 ns prior to the start of the sweep. The result involves slightly more complicated math, but the actual methodology is identical to that described above. Likewise for the post- trigger calculations, the 45ns is taken into account, but the methodology is the same as is used for the SCD1000 described above.

Trigger Calibration

Calibration of the trigger system for the SCD1000 begins with channel A. The internal calibration DC reference voltage is coupled into the preamp through the Channel A attenuator relay and the calibration proceeds as follows:

For each trigger function, the gain and ± offset cal constants are adjusted.

For each setting, set the trigger level to the desired calibration point. The calibrator voltage is then ramped through its range, and the voltage at which the trigger event occurred is recorded. This trigger voltage is than compared with the desired trigger level.

- If the trigger level falls within acceptable limits for the setting (±1.0%), the program will proceed to the next vertical range.
- If the trigger level falls outside the limits for the setting, then the program adjusts the cal constant(s) using a linear interpolation algorithm repeating the acquisitions and computations until the constants yield acceptable trigger level values.
- If the search routine is unable to find acceptable values, the calibration of this setting will be flagged as failed, and the program will continue to the next setting.

The SCD1000 trigger calibration covers the following internal trigger settings:

- CHA – DC coupled + slope offset

  DC coupled –slope offset

  DC coupled gain

  AC coupled +slope offset

  AC coupled –slope offset
- CHB – DC coupled +slope offset

  DC coupled –slope offset

DC coupled gain

- ADD – DC coupled +slope offset

  DC coupled –slope offset

NOTE

An external signal and controller program must be used to calibrate the External trigger ± slope offset and gain because the External trigger is AC-coupled only.

The SCD5000 trigger calibration uses the same algorithms as described above, except that the calibrator signal must be manually connected at the front panel. The SCD5000 also has an AC- coupled-only external trigger input, and a non-calibrated internal trigger from the calibrator signal. The SCD5000 and 5000 Option 01 trigger calibration covers the following functions:

- EXT AC coupled +slope offset
- EXT AC coupled –slope offset
- Opt 01 Internal DC coupled +slope offset
- Internal DC coupled –slope offset
- Internal DC coupled Gain

An external controller program calibrates the External trigger gain as well as the Option 01 Internal gain.

Input Calibration (SCD1000 Only)

Input Calibration is actually two separate calibration procedures. The first calibration is Input Current cal and the second is Input Resistance cal. These two procedures are very interactive and must be run iteratively until no further adjustment is necessary by either calibration. Also both calibration are very sensitive to user signals that are connected to the SCD1000 inputs therefor all input signals must be disconnected prior to running this calibration process. It should be noted that this calibration is not part of the system calibration, but for maximum accuracy this calibration should be run prior to a system calibration.

Input Calibration Process:

1. Calibrate Channel A input.
   a. Calibrate Input Current for channel A.
   b. Calibrate Input Resistance for channel A.
   c. If either step a or b required adjustment, repeat both steps.
2. Calibrate Channel B input.
   a. Calibrate Input Current for channel B.

b. Calibrate Input Resistance for channel B.

c. If either step a or b required adjustment, repeat both steps.

Input Current Calibration

This procedure makes the assumption that with the coupling set to AC, the input bias current will generate a voltage across the 50-Ω input resistance. This induces a shift in the waveform that is measurable by the SCD acquisition. With the calibrator source set to zero Ω source impedance and the coupling is set to DC, this algorithm assumes that no shift occurs due to the input bias current. Thus the difference between the DC coupled measurements and the AC coupled measurements is then due to the input bias current.

Current calibration is performed using the 100 mV vertical range, with DC coupling. The internal DC calibrator is set to Zero Ωs source, Zero Volts. Measure the calibrator output by averaging several acquisitions. The input coupling is then set to AC (to give us the true offset of the system without the input current) and the calibrator output is again measured by averaging several acquisitions.

Determine the difference between the DC-coupled and AC-coupled measurements. The current is calculated as:

current = ((meas_AC_coupling – meas_DC_coupling) / 50 Ω)

If the input current is not within tolerance (±4 μA spec limit, ±9 μA is the pass/fail limit), adjust the input current cal constant and repeat the measurements.

Input Resistance Calibration

Resistance calibration is performed using the 100 mV vertical range, DC coupling. The routines then makes the listed four setups and measurements, averaging several acquisitions at each setting.

- calibrator 450 Ω source, calibrator voltage 400 mV
- calibrator 0 Ω source, calibrator voltage 40 mV
- calibrator 450 Ω source, calibrator voltage –400 mV
- calibrator 0 Ω source, calibrator voltage –40 mV

For all of these measurements. computing the target resistance ratio using the equation below should yield an ideal value of zero.

$$resistance\_ratio = \frac{(meas\_0\_plus - meas\_0\_minus)}{(meas\_450\_plus - meas\_450\_plus)}$$

This is based on the assumption that when a 400 mV signal is placed across divider formed by the 450 Ω source in calibrator and 50 Ω in the SCD input the measurement will yield the same results as placing 40 mV from a 0 Ω source across the SCD's 50 Ω input resistance.

If the input resistance is not within tolerance 0.15 Ω (0.25 Ω pass/fail limit), the program adjusts the resistance cal constant and repeats the steps shown above

If either the input current or resistance is adjusted during the course of one iteration, the entire process will be repeated for that channel until no adjustment of either parameter is necessary.

CRT Calibration

The CRT calibration is designed to set up the CRT parameters that are controllable by the internal processor. Unlike the previous routines which are designed for regular use to enhance instrument accuracy, this routine is designed for use with the External calibration procedure, and does not need to be run except at the designated 6 month or 1000 hour calibration interval, or when CRT orthagonality is critical to the measurement. CRT calibration adjusts the default (INIT) CRT intensity values for each sweep speed. This procedure assumes that the CRT grid bias, focus, alignments, and read gun ramps have all been previously calibrated. The intensity cal constants are then adjusted in the following manner:

CRT Intensity Calibration

For each acquisition window, The INIT intensity cal constant from the previous (smaller) time window is used as a starting point (starting with the maximum allowable intensity for the 5 ns window). A baseline is then acquired (tilt control is disabled for this, so the baseline may be somewhat tilted). The average width of the baseline trace is measured relative to the overall vertical size of the screen.

If the trace width is between 4% and 5% of the overall screen height , the program moves to the next acquisition window.

If the trace width is either less than 4% or greater than 5%, the, the program adjusts the intensity cal constant using a linear search algorithm repeating the acquisitions and computations until the constant yields an acceptable value.

If the search routine is unable to find acceptable cal constant value to meet the trace width (intensity) spec, the measurement is compared against the pass/fail limit of 2.5% to 5.5%. If it does not pass this spec, the intensity calibration of this window will be flagged as failed and the program will proceed to the next window.

The CRT cal will then begin calibration of the CRT orthagonality, beginning with X-tilt.

X-Tilt Calibration

For X-tilt calibration, a “straight” baseline is acquired and its tilt angle is calculated.

If the X-tilt is less than ±0.5° from horizontal (1.1° is the pass/fail limit), the program will proceed to Y-tilt calibration.

If the tilt does not meet the specification (1.1 °), the program adjusts the X-tilt cal constant using a binary search algorithm repeating the acquisitions and computations until the constant yields an acceptable value.

Again if the search routine fails to find and acceptable value, the X-tilt calibration will be flagged as failed, and the program will proceed to Y-tilt calibration.

Y-Tilt Calibration

The final stage of the CRT calibration, Y-tilt calibration, requires and external sine wave signal source - a Tektronix SG503 or equivalent that can generate the following signals:

- 1 MHZ at 80 mV p-p for the SCD1000
- 1 MHZ at 3 V p-p for the SCD5000
- 1 MHZ at 6 V p-p for the SCD5000 with Option 01

The CRT Y-tilt calibration acquires the sine wave and computes the average slopes of the rising and falling edges. The average positive slope should be equal to the average negative slope of the sine wave within 0.5° (0.6° is the pass/fail limit).

If the + slope matches the -slope within the spec, the CRT calibration routines will exit back to normal instrument operation.

If the tilt does not meet the specification, the program adjusts the Y-tilt cal constant using a binary search algorithm repeating the acquisitions and computations until the constant yields an acceptable value.

Again if the search routine fails to find and acceptable value, the Y-tilt calibration will be flagged as failed.

System Calibration

The SCD system calibration performs all of the above routines with the exception of CRT cal and INPUT cal. Running (and passing) system calibration will ensure maximum accuracy of the instrument. The calibration routines are run in the following sequence:

- Vertical calibration
- Geometry calibration
- Horizontal calibration
- Trigger calibration

Internal calibration does not replace the External Calibration Procedure, which should be performed at the recommended calibration interval by a qualified service technician. The External Calibration Procedure involves adjusting hardware inside the instrument, and requires test equipment and external programs run on a PC-compatible GPIB controller. Use the External Calibration Procedure after replacing any acquisition-related components, or if the instrument fails the Performance Verification Procedure.

Procedure

Perform the *Internal Calibration Procedure* as follows:

1. Turn on the instrument and let it warm up for at least 20 minutes.
2. For the SCD5000 only, connect a cable, Tektronix part number 012-0118-00, from the CAL OUT signal on the front panel to the signal input.
3. Run Input Cal first by sending the command:

   ```
   CALIBRATE INPUT
   ```

   or by setting Cal Mode to Input in the Utility menu.
4. If using a controller, invoke the calibration routines by sending the GPIB command:

   ```
   CALIBRATE ALL
   ```

   If using the Display Unit, invoke the calibration routines by selecting **Utility** mode and setting the **Cal Mode** key to system.
5. If any of the calibration routines fail return the instrument to Tektronix for servicing.

Error Messages

The internal calibration procedures routines error messages if they have a problem calibrating the instrument. Table 5-1 lists the possible calibration error messages.

Table 5-1: Internal Calibration Errors

Error Message	Meaning
aborting	A front-panel button was pressed during the calibration procedure or a GPIB message was sent to the SCD.
could not acquire, skipping	The calibration acquisition could not be completed.
Vertical: [<ch>: Input][<ch>: Input]	SCD1000 Only. Vertical input calibration query response string indicating channels and ranges that failed. where <ch> ::= CHA | CHB
Vertical: [<ch>: <range>[,...]] [<ch>: <range>[,...]]	Vertical calibration query response string indicating channels and ranges that failed. where <ch> ::= CHA | CHB | ADD | CH <range> ::= 100 mv | 200 mv | ...5v

Table 5-1: Internal Calibration Errors (Cont.)

<table>
<tr><th>Error Message</th><th>Meaning</th></tr>
<tr><td>Horizontal: { <rate> <faultop> }...</td><td>Horizontal calibration query response string indicating sweep rates and operations that failed.

where <rate> ::= 5ns | 10ns | ...100μs
<faultop> ::= i | s | l | h
i ::= intensity calibration failed
s ::= sweep calibration failed
l ::= minimum trigger delay failed
h ::= maximum trigger delay failed</td></tr>
<tr><td>setting failed</td><td>Settings failed to calibrate properly.</td></tr>
<tr><td>out of dac range</td><td>Dac value out-of-range.</td></tr>
<tr><td>no leading crossing</td><td>Couldn't find a zero crossing point.</td></tr>
<tr><td>no leading edge</td><td>Couldn't find a zero crossing point.</td></tr>
<tr><td>no positive edge</td><td>Couldn't find positive edge.</td></tr>
<tr><td>edges out of sync</td><td>The positive edge was found before the negative edge.</td></tr>
<tr><td>No Trigger Error Skipping</td><td>Trigger level calibration setting failed.</td></tr>
<tr><td>Geometry: Failed – Timeout</td><td>The operator did not respond to disconnect message within allotted time.</td></tr>
<tr><td>Geometry: Failed – Abnormal Acquisition</td><td>Instrument timed out during acquisition</td></tr>
<tr><td>Geometry: Failed – Excessive Missing Points</td><td>A large number of missing points were detected in the acquisition</td></tr>
<tr><td>Geometry: Failed – Constants Outside Limits</td><td>Some of the cal constants are unusually large.</td></tr>
<tr><td>setting out of spec</td><td>Current setting failed Intensity Calibration.</td></tr>
</table>

External Calibration

The External Calibration Procedure involves adjusting hardware inside the instrument, and requires special test equipment and external programs loaded onto a controller. Perform the adjustment procedure after replacing any acquisition-related modules, or if the instrument fails the Performance Verification Procedure. Refer to Table 6-2 for guidelines on which calibration sections to perform after module replacement.

The external calibration procedure provides a logical sequence of checks and adjustment steps for calibrating the whole instrument. However, subsystems can be calibrated individually. To calibrate the whole instrument, perform all of the procedures in this section. To calibrate a subsystem, do the following:

1. Read *Controller Software Installation* and install the calibration software on the controller.
2. Perform the *Setup for All Procedures.*
3. Perform all steps under the appropriate subheading (such as *Read Gun Calibration* or *High Voltage Calibration*).
4. Perform the *Post Calibration Procedure*.

The procedure for calibrating the SCD5000 is slightly different than the procedure for the SCD1000. The differences are noted in the text.

Refer to *Calibration Utilities* later in this section for information about external programs, putting the SCD into video mode, and disabling parts of the internal calibration routines. Be sure to read the section *GPIB Talker/Listener Programs* which describes how to send GPIB commands to the SCD.

WARNING

The procedures described in this section should be done only by a qualified service technician.

Do not service alone. *Do not perform internal service or adjust this instrument unless another person capable of rendering first aid and cardio-pulmonary resuscitation is present.*

Use extreme care when servicing with power on. *Dangerous voltages exist at several points inside this instrument. To avoid injury, do not touch exposed connections or components while the power is on. Disconnect power before removing protective panels or replacing components.*

WARNING

Wear safety glasses and use care when inserting and removing cables on the Scan Converter CRT pins. Lateral movement of the pins could crack the CRT glass, causing the tube to lose its vacuum or implode.

CAUTION

Static discharge can damage semiconductor components in this instrument.

CAUTION

The Scan Converter CRT is fragile and requires special handling. Do not use magnetized tools near the Scan Converter CRT. Magnetic fields can significantly degrade the CRT performance, and special tools are required to demagnetize the CRT shield.

Do not deviate from the given procedures when testing and adjusting the write beam. Using excessive write beam intensities or leaving the beam on the target too long can permanently damage the target.

Required Test Equipment

The following table lists the equipment required for the complete calibration procedure. The same equipment is required for both the SCD1000 and the SCD5000 except for the Sine Wave Generator (the SCD5000 requires a higher frequency generator).

In the table, TM500(0) indicates that either a TM500 series or a TM5000 series power module can be used for the plug-in unit. Two TM5000 series power modules are preferred since they are compatible with all of the plug-ins, but the calibration can be done with only one.

Table 5-2: Required Test Equipment

Description	Minimum Specification	Recommended Equipment
Test Oscilloscope	200 MHz bandwidth minimum, diff. measurement capabilities.	Tektronix 7904(A) Scope, with 7A26, 7A13 Amplifiers, 7B10 Time Base, 3 P6136 10× probes Tektronix 11401A Scope with 11A72 plug-in amplifier, 11A33 differential comparator, and 3 PG136 10× probes Tektronix 2465B Scope with 3 6136 10× probes
T V Monitor	Video Input, NTSC or PAL std.	Tektronix 634 or Video Monitor
Digital Multimeter	200 V Range, 0.01% accuracy, 4 digits minimum	Tektronix DM5120 (requires TM5000 module)
Leveled Sine Wave Generator	250 kHz to 250 MHz, Variable amplitude, 50 kHz reference	Tektronix SG503 Leveled Sine Wave Generator, TM500(0) module
High Frequency Leveled Sine Wave Generator	250 MHz to 4.50 GHz, Variable amplitude, 10 MHz reference	Wiltron Model 6722A-20 Frequency Synthesizer (required for SCD5000 only) with attenuator option Tektronix SG504 Leveled Sine Wave Generator for SCD1000, TM500(0) module
Calibration Generator	0.25% amplitude accuracy, Fast rise output, 0.5 ns time marks	Tektronix CG5011 Calibration Generator (requires TM5000 module)
Calibration Generator	Fast rise step, 1% aberrations	Tektronix PG506 Calibration Generator (requires TM500(0) module with 067-0681-01 TD Pulser)
Controller	IBM Compatible, GPIB capable with GPIB Software	IBM Compatible PC with the National Instrument PC2A GPIB controller package, and a color EGA/VGA monitor
Counter/Timer	250 MHz freq. measurement minimum, 1 ps period resolution	Tektronix DC5010 Counter/Timer
Function Generator	Square wave and Sine wave outputs, DC to 20 MHz frequency range, 15 V output	Tektronix FG5010 Function Gen., requires TM5000 Power Module Tektronix FG504 Function Gen., TM500(0) power module
TM5006 power module	6-slot mainframe, two preferred but one is okay	Tektronix TM5006(A) power module
Amplifier plug-in	500 MHz, 10 mV minimum sensitivity	Tektronix 7A19 or 11A52 Amplifier; other 7000-series amplifiers may be used for some steps.

Table 5-2: Required Test Equipment (Cont.)

Description	Minimum Specification	Recommended Equipment
Amplifier plug-in	200 MHz, 5 mV minimum sensitivity, dual trace amplifier, 1 MΩ input	Tektronix 7A26 or 11A34 Dual Trace Amplifier
Differential Amplifier plug-in	100 MHz BW, 1 mV minimum sensitivity balanced inputs with CMRR 20,000:1	Tektronix 7A13 or 11A33 Differential Comparator
Time Base Plug-in	0.5 ns fastest sweep rate, triggering to 500 MHz	Tektronix 7B15 Time Base Tektronix 7B92 Dual Time Base
Variable Transformer	0 – 130 VAC, adjustable, current and voltage meters	General Radio, model W10MT3W
High Voltage Probe	1000 MΩ input impedance, 1–20 kV, 2% accuracy	Tektronix High Voltage Probe, part number 010-0277-00 or Fluke 80k-40 High Voltage Probe
Coaxial Cable	50 Ω, 42 inches, BNC connectors	Tektronix part number 012-0057-01 (three required)
Coaxial Cable	75 Ω, 42 inches, BNC connectors	Tektronix part number 012-0074-00 (one required)
Coaxial Cable	50 Ω, 1 ns (8 inches RG58), BNC connectors	Tektronix part number 012-0118-00 (one required for SCD5000)
Adapter	BNC to Dual Banana Plug	Tektronix part number 103-0090-00 (two required)
Termination	50 Ω, feedthrough, BNC connectors	Tektronix part number 011-0049-01 (two required)
Alignment Tool	JFD Adjustment Tool 5284	Tektronix part number 003-0489-00
Adapter	N male to BNC female	Tektronix part number 103-0045-00 (two required, three recommended)
Cable	BNC to Peltola	Tektronix part number 067-0709-00
Adapter	BNC "T" connector	Tektronix part number 103-0030-00
Power Divider	50 Ω power divider	Tektronix part number 015-1014-00
Attenuator	10×, BNC connectors	Tektronix part number 011-1059-02
Attenuator	5×, BNC connectors	Tektronix part number 011-1060-02
Attenuator	2×, BNC connectors	Tektronix part number 011-1069-02
Coaxial Cable	12 inch long peltola connectors	Tektronix part number 174-9487-00
Jumper		Tektronix part number 131-1270-00
Delay Line	48 ns	Tektronix DL-11

Controller Software Installation

The calibration procedures require software supplied with this manual. This manual assumes a familiarity with the DOS operating system.

NOTE

The controller must also have the National Instruments PC2A GPIB controller package.

Install the controller calibration software onto your hard disk drive as follows:

1. Make a backup copy of the *Calibration Software Disk* and put the original in a safe place away from heat, magnetic fields, etc.
2. Create a directory named SCD on the hard disk drive. Within the SCD directory create a subdirectory named BIN, and copy the following files into C:\SCD\BIN:
   - CALTRIG.EXE
   - CONIO.EXE
   - CCRD.BAT
   - CCWR.BAT
   - FIND.EXE
   - FINDA.BAT
   - FINDB.BAT
   - FINDCAL1.BAT
   - FINDCAL5.BAT
   - FINDA.SET
   - FINDB.SET
   - FINDCAL.SET
   - FINDHELP.DOC
   - LINACC.EXE
   - MAXINTE.EXE
   - NOISE.EXE
   - SENTINTE.EXE
   - SETGBCAL.EXE
   - TALK.EXE
   - WGZACAL.EXE
3. Copy the files TALK.EXE and GPI.EXE into the SCD\BIN directory of the C: drive.

4. Use the DOS utility EDLIN or a word processor to enter the following lines into the controller's AUTOEXEC.BAT file:

```
Set GPIB0=PC2A 0 0 0
Set AD=<GPIB address of the Digital Multimeter>
Set MAN=ON
Set DM=<T for Tek DM5120>
       <F for Fluke 8842> (refer to FIND program information)
```

5. Add the paths C:\SCD\BIN to the controller's AUTOEXEC.BAT file to allow the calibration utilities to execute from any directory.

6. Install the ANSI.SYS driver in your CONFIG.SYS file. (ANSI.SYS is provided on your original MS-DOS operating system diskettes.) For example, if the ANSI.SYS driver on your controller is located in the directory C:\DOS you would add the following entry to your CONFIG.SYS file:

```
device = C:\DOS\ANSI.SYS
```

Refer to *Calibration Utilities* for more information about using the calibration programs.

Setup for All Procedures

Perform this procedure before any calibration.

WARNING

Turn off power and remove the power plug from the outlet when removing or installing circuit boards, moving jumpers, removing or installing the front panel, or removing any instrument covers. Hazardous potentials exist on several circuit boards. Use extreme caution when handling or probing the Front Panel LED board, Read Gun board, Write Gun board, Converter board, Video Preamplifier board, and particularly the High Voltage board.

NOTE

The ambient temperature must be 20° to 30° C (68° to 86° F) during calibration.

1. Turn off the power and remove the power plug from the outlet. Remove the instrument from the rack, place it on a static-free workbench.
2. Turn the eight screws that hold down the top cover one quarter turn counterclockwise and remove the cover. (The screws are locked when the slots are lined up with the dot.) Similarly remove the bottom cover.
3. Remove the side covers, identifying right and left sides for later reassembly. The vent holes should be positioned towards the front of the instrument. Remove the card cage locking bracket.
4. Record the rear panel switch positions so that the instrument can be returned to the user's desired settings after calibration.
5. Inspect any replacement boards for parts inserted incorrectly, solder bridges, open connections, overheated parts, and loose screws.

CAUTION

Be sure to disable the High Voltage board power supply by moving jumper JP1 to HVOFF if any new boards have been installed. This protects the scan converter target from any gross misadjustments due to the new hardware.

6. Move jumper JP1 on the High Voltage board onto pins 1-2 HVOFF to disable the High Voltage Power Supply. (See Figure 5-12)

CAUTION

Do not adjust the pots on boards you do not intend to calibrate.

7. Adjust all pots on newly-installed boards to their centered position except for R10 (Grid Bias) on the High Voltage board.

   If you are calibrating any part of the Write Gun system, adjust R10 (Grid Bias) on the High Voltage board so that TP4 (Grid) is maximum voltage to ensure that the CRT Writing Gun beam will be completely cut off.

   If you are calibrating any part of the Read Gun system, turn the Geometry pots R401 thru R408 on the Read Gun board fully counterclockwise.

8. Check that the low-voltage power supply 6 A, 250 V fuse is still intact. Replace the fuse if it is burned out.

9. Set the GPIB address switches on the rear panel to address 7, EOI termination.

10. Set the rear-panel power-up test switch to off.

11. Close the MPU board DIP switch 1 to enable factory calibration commands.

12. Set the DVM to Ω, autorange (if the autorange feature is available on the DVM).

13. Tip the SCD up onto its left side to provide easier access to the Converter board.

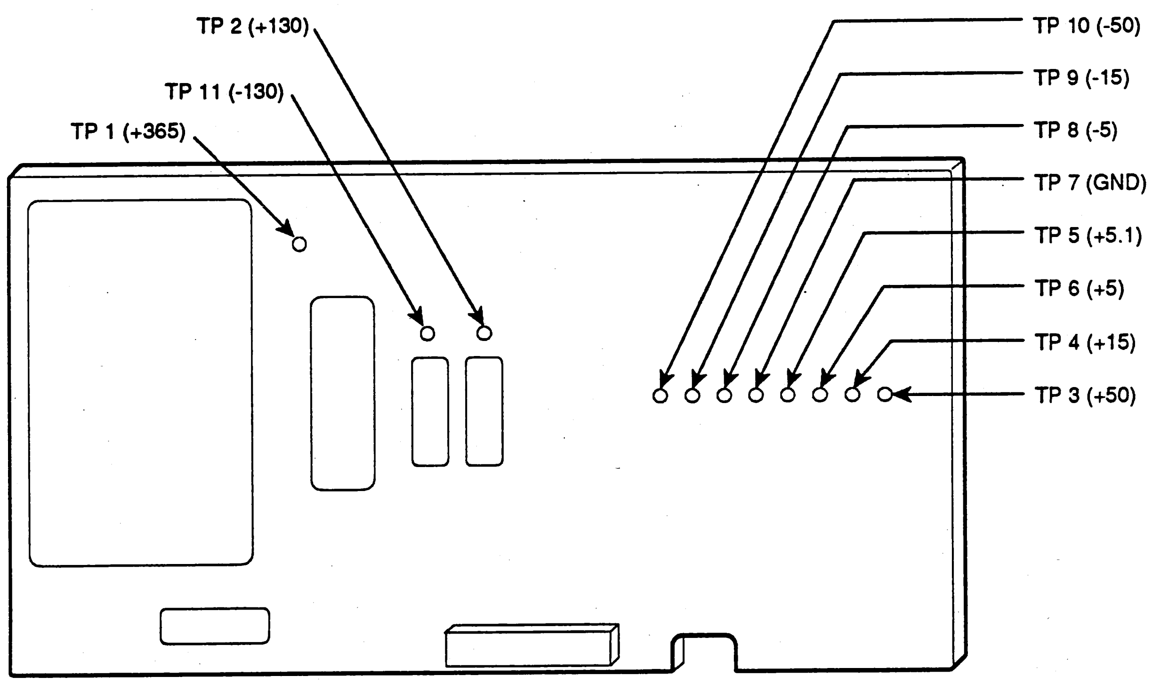


Figure 5-1: Converter Board Test Points

14. Connect the common lead of the DVM to TP7 (GND) on the Converter board.
15. Check the resistance of the regulated supplies on the Converter board according to Table 5-3. If any of the resistance measurements do not fall within 10% of the given measurement, find and correct the problem before proceeding. This ensures that any newly-installed boards will not short out the power supply.

NOTE

This resistance check table was created using the TEK DM5120 meter. Using a different meter (with a different measurement current for resistance) can yield slightly different results, especially on the higher resistance ranges.

Table 5-3: SCD1000 Power Supply Resistances

Supply	DVM Range	Measurement	Test Point
+365 V	300 k	40 kΩ	+365 (TP1)
+130 V	30 k	6.5 kΩ	+130 (TP2)
+50 V	3 k	490–520 Ω	+50 (TP3)
+15 V	300k	60–80 Ω	+15 (TP4)
+5.1 V digital	300	8–10 Ω	+5.1 (TP5)
+5 V analog	300	50–60 Ω	+5 (TP6)
-5 V	300	140–150 Ω	-5 (TP8)
–15 V	300	245–265 Ω	–15 (TP9)
-50 V	3 k	640 Ω	-50 (TP10)
–130 V	3 k	370 Ω	–130 (TP11)

Table 5-4: SCD5000 Power Supply Resistances

Supply	DVM Range	Measurement	Test Point
+365 V	300 k	40 kΩ	+365 (TP1)
+130 V	30 k	6.5 kΩ	+130 (TP2)
+50 V	3 k	490–520 Ω	+50 (TP3)
+15 V	300k	90–110 Ω	+15 (TP4)
+5.1 V digital	300	8–11 Ω	+5.1 (TP5)
+5 V analog	300	170–190 Ω	+5 (TP6)
-5 V	300	190–210 Ω	-5 (TP8)
–15 V	300	265 Ω	–15 (TP9)
-50 V	3 k	670 Ω	-50 (TP10)
–130 V	3 k	370 Ω	–130 (TP11)

16. Reinstall all the covers on the instrument.
17. Reconnect the power cord to the rear-panel receptacle.
18. Switch on the VARIAC power.
19. Turn the VARIAC front-panel voltage knob to 110 VAC.
20. Set the principal power switch on the rear of the SCD to ON.
21. Switch on the SCD front-panel power switch.

22. Let the SCD warm up for at least one hour with the covers installed.
23. Adjust the test oscilloscope front-panel gain and sweep calibration and the compensation of all probes.
24. Perform an internal diagnostic test on the instrument to ensure that the system is in working order before beginning calibration. If the diagnostics fail, replace the defective module and repeat the above steps.

Power Supply Calibration

+5.1 V Check/Adjust

1. Remove the instrument top, bottom, and right side covers.
2. Set the DVM to volts, autorange (if the DVM has that feature).
3. Connect the DVM high lead to TP5 (+5.1 V) on the Power Converter board. Connect the low (negative) lead of the DVM to TP7 (GND) on the Power Converter board.
4. Check that the +5.1 V supply measures between +4.95 V and +5.2 V.
5. If necessary, adjust R800 (+5.1 V digital supply) to read between +4.95 V and +5.2 V and adjust nominally to 5.1 V. Access this pot on the low-voltage power supply through the hole in the write-gun board and the hole in the CRT assembly chassis, as shown in Figure 5-2.

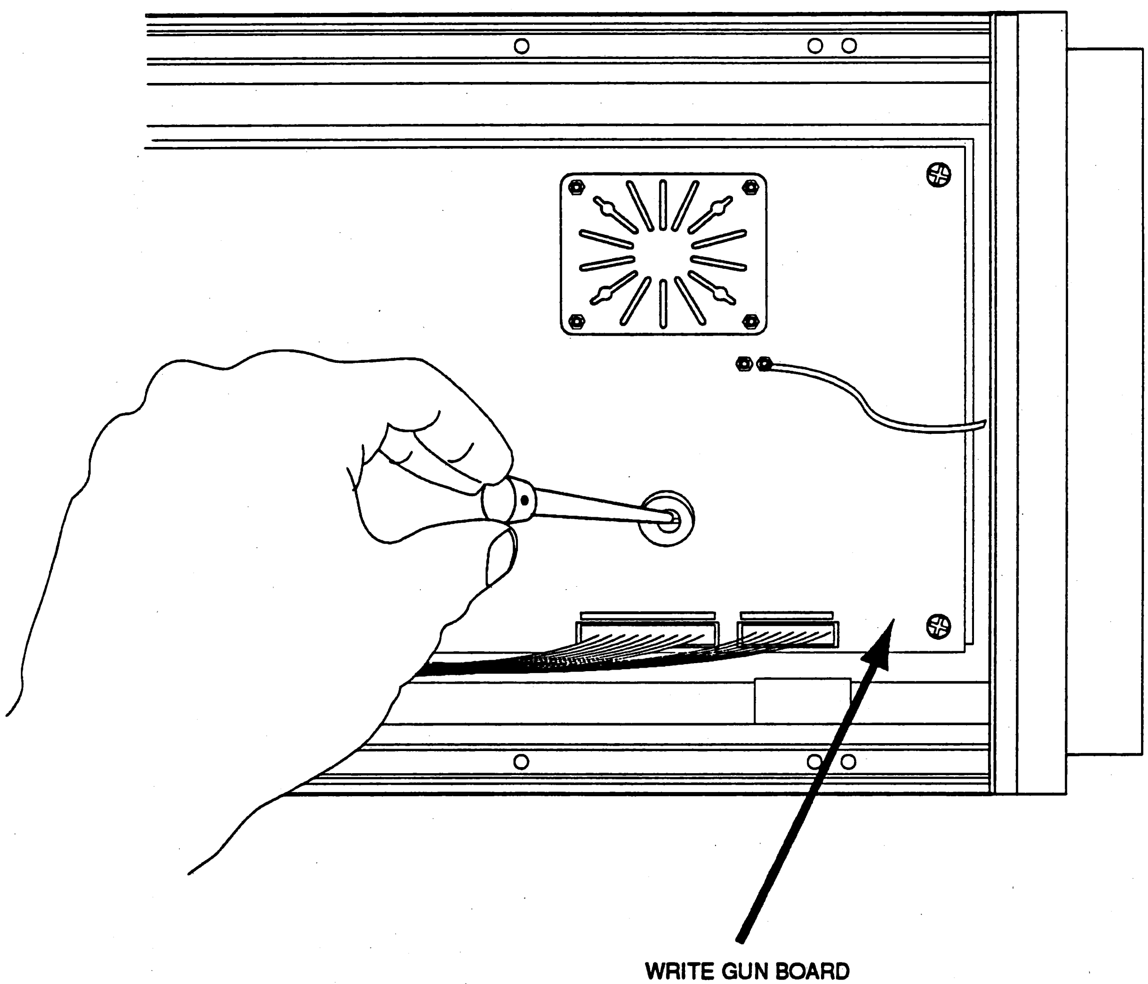


Figure 5-2: +5.1 V Power Supply Adjustment Pot

-50.0 V Check/Adjust

1. Connect the DVM high lead to TP10 (-50 V) on the Power Converter board. Connect the low (negative) lead of the DVM to TP7 (GND) on the Power Converter board.

2. Check that the -50 V supply measures between -49.95 V and -50.25 V.

3. If necessary, adjust the -50 V supply with R730 to 50.00 V ±0.50 V. R730 is located under the power supply on the regulator board. It may be necessary to slide the power supply partially out to make this adjustment, as shown in Figure 5-3.

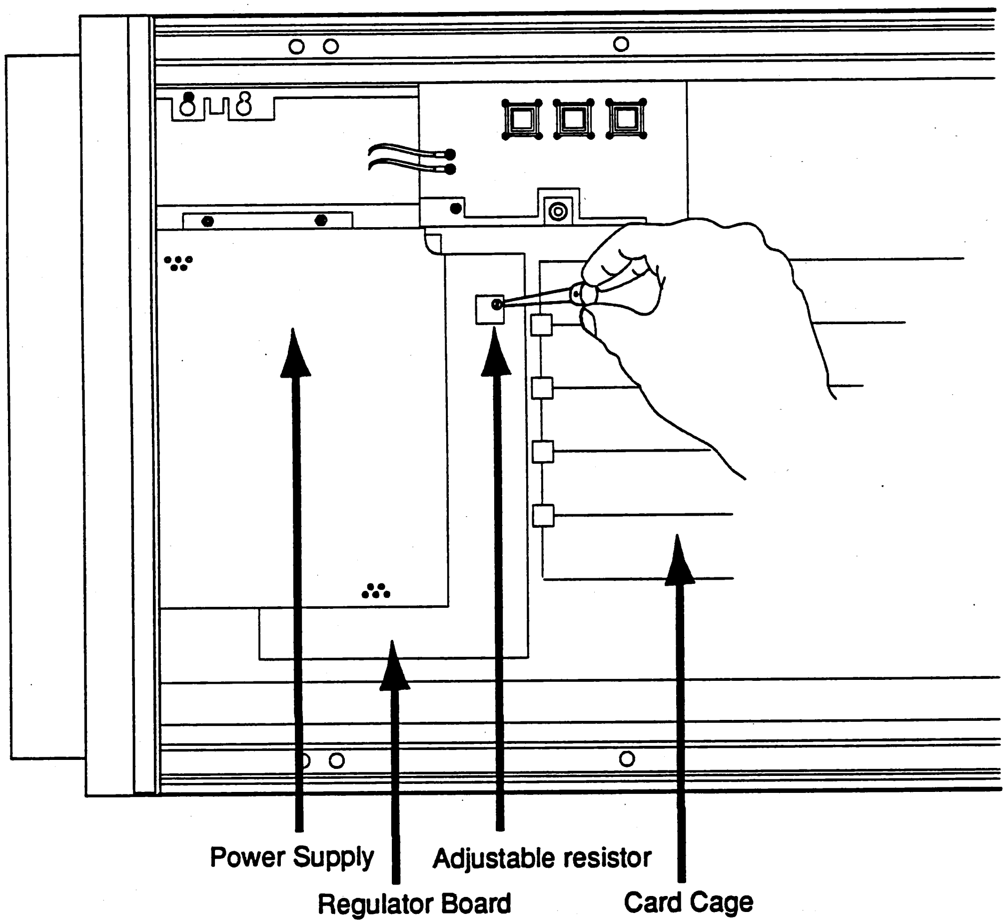


Figure 5-3: -50.0 V Power Supply Adjustment Pot

4. With the low (negative) lead of the DVM still connected to TP7 (GND) on the Power Converter board, use the high lead to check that the low-voltage power supply potentials on the Power Converter board are within the tolerances indicated in Table 5-5. If these supplies are not within the tolerances shown, service the Power Supply or Regulator board. Service the Converter board if the ±130 V or +365 V supplies are out of tolerance.

5. Disconnect the meter leads, reinstall the instrument covers, and set the instrument on the benchtop surface.

Table 5-5: Power Supply Tolerances

Supply	DVM Range	Measurement Min.	Measurement Max.	Test Point	
+365 V	1000 V	350.4 V	379.6 V	+365	(TP1)
+130 V	200 V	124.8 V	135.2 V	+130	(TP2)
+50 V	200 V	49.5 V	50.5 V	+50	(TP3)
+15 V	20 V	14.85 V	15.15 V	+15	(TP4)
+5.1 V digital	20 V	4.95 V	5.2 V	+5.1	(TP5)
+5.0 V analog	20 V	4.9 V	5.1 V	+5	(TP6)
-5.0 V	20 V	-5.1 V	-4.9 V	-5	(TP8)
-15 V	20 V	-15.15 V	-14.85 V	-15	(TP9)
-50 V	200 V	-50.25 V	-49.75 V	-50	(TP10)
-130 V	200 V	-135.2 V	-124.8 V	-130	(TP11)

Internal Reference Signal Calibration

Check the SCD's internal calibrator waveform before performing any calibration procedures that use the calibrator. Do this as follows:

Calibrator Timing Signal

1. Connect the Counter/Timer to the Calibrator Output connector located on the rear of the SCD1000 or the front of the SCD5000. (The calibrator output signal can also be accessed from J8 on the analog board.)
2. On the Display Unit Utility menu, select **Ext Cal**: Time for the SCD1000 or **Cal Out**: Time for the SCD5000, **Cal Time**: 4 ns.
3. For the SCD1000, set the Counter/Timer to:

   Coupling: DC
   Attenuation: 1×
   Termination: 50 Ω
   Trigger Level: 0.68 V (auto)
   Mode: period

   For the SCD5000, set the Counter/Timer to:

   Coupling: DC
   Attenuation: 5×
   Termination: 50 Ω
   Trigger Level: 2.1 V (auto)
   Mode: period

4. Verify that the measured period matches the SCD CAL TIME readout value given in Table 5-6 for all settings (4 ns to 80 μs) within 0.10% tolerance.

   NOTE

   Refer to the last column in the table when using a DP501 divide-by-16 digital prescaler with the digital counter. Couple frequencies lower than 100 MHz directly to the counter.

5. The calibrator timing signal is not adjustable. Its frequency is based upon the Control board generated 25 MHz clock. If the timing signal does not meet the specifications, check the clock frequency on the SCD1000 Analog board test point or the SCD5000 Trigger board Test point (J1937 pin 1). If the clock frequency is correct but the timing signal is out of tolerance, the Analog (or Trigger) board needs servicing.

Table 5-6: Calibrator Timing Measurements

Cal Range	Mesial Period		Freq.	Freq. Tol.	/16 Period
	Min.	Max.			(Center)
4 ns	3.996 ns	4.004 ns	250 MHz	±250 kHz	64 ns
8 ns	7.992 ns	8.008 ns	125 MHz	±125 kHz	128 ns
16 ns	15.984 ns	16.016 ns	62.5 MHz	±62.5 kHz	256 ns
40 ns	39.96 ns	40.04 ns	25 MHz	±25 kHz	
80 ns	79.92 ns	80.08 ns	12.5 MHz	±12.5 kHz	
160 ns	159.84 ns	160.16 ns	6.25 MHz	±6.25 kHz	
400 ns	399.6 ns	400.4 ns	2.5 MHz	±2.5 kHz	
800 ns	799.2 ns	800.8 ns	1.25 MHz	±1.3 kHz	
1.6 μs	1.5984 μs	1.6016 μs	625 kHz	±625 Hz	
4 μs	3.996 μs	4.004 μs	250 kHz	±250 Hz	
8 μs	7.992 μs	8.008 μs	125 kHz	±125 Hz	
16 μs	15.984 μs	16.016 μs	62.5 kHz	±62.5 Hz	
40 μs	39.96 μs	40.04 μs	25 kHz	±25 Hz	
80 μs	79.92 μs	80.08 μs	12.5 kHz	±12.5 Hz	
40 μs	39.9964 μs	40.0036 μs	25 kHz	±2.25 Hz	
80 μs	79.9928 μs	80.0072 μs	12.5 kHz	±1.13 Hz	

Calibrator Amplitude

The calibrator amplitude is controlled internally by firmware cal constants. These cal constants are set using a GPIB controllable DVM, the controller, and the FIND utility routines. (Refer to *Calibration Utilities* for information about FIND and the accompanying batch files.)

To set the Calibrator Amplitude cal constants:

1. For the SCD1000, connect a Tek DM5120 DMM to the Calibrator output connector using a coaxial cable and a banana-to-BNC adapter.

   For the SCD5000, connect a 50 Ω termination (feedthrough) to the calibrator output. Connect to the DVM using dual banana-to-BNC adapter and 50 Ω coaxial cable.

2. Run the program FINDCAL1 for the SCD1000 or FINDCAL5 for the SCD5000 following the instructions in *Calibration Utilities* or FIND-HELP.DOC.

3. Verify that FINDCAL adjusts the cal constants to give ±0.1% accuracy on all ranges according to Table 5-7 for the SCD1000 and Table 5-8 for the SCD5000.

Table 5-7: SCD1000 Calibrator Amplitude

Calibrator Amplitude	Min. Measurement	Max. Measurement
2.5 V	2.4975 V	2.5025 V
2 V	1.998 V	2.002 V
800 mV	0.7992 V	0.8008 V
400 mV	0.3996 V	0.4004 V
200 mV	199.8 mV	200.2 mV
80 mV	79.92 mV	80.08 mV
40 mV	39.96 mV	40.04 mV
0.0 V	0.50 mV	-0.50 mV
-40 mV	-39.96 mV	-40.04 mV
-80 mV	-79.92 mV	-80.08 mV
-200 mV	-199.8 mV	-200.2 mV
-400 mV	-0.3996 V	-0.4004 V
-800 mV	-0.7992 V	-0.8008 V
-2 V	-1.998 V	-2.002 V
-2.5 V	-2.4975 V	-2.5025 V

Table 5-8: SCD5000 Calibrator Amplitude

Calibrator Amplitude	Min. Measurement	Max. Measurement
4 V	3.995 V	4.005 V
3 V	2.996 V	3.004 V
2 V	1.997 V	2.003 V
1 V	0.998 V	1.002 V
0.8 V	798.2 mV	801.8 mV
400 mV	398.6 mV	401.4 mV
200 mV	198.8 mV	201.2 mV
100 mV	98.9 mV	101.1 mV
0 V	1 mV	–1 mV
–100 mV	–101.1 mV	–98.9 mV
–200 mV	–201.2 mV	–198.8 mV
–400 mV	–401.4 mV	–298.6 mV
–800 mV	–801.8 mV	–798.2 mV
–1 V	–1.002 V	–0.998 V
–2 V	–2.003 V	–1.997 V
–3 V	–3.004 V	–2.996 V
–4 V	–4.005 V	–3.995 V

Video Preamp Calibration

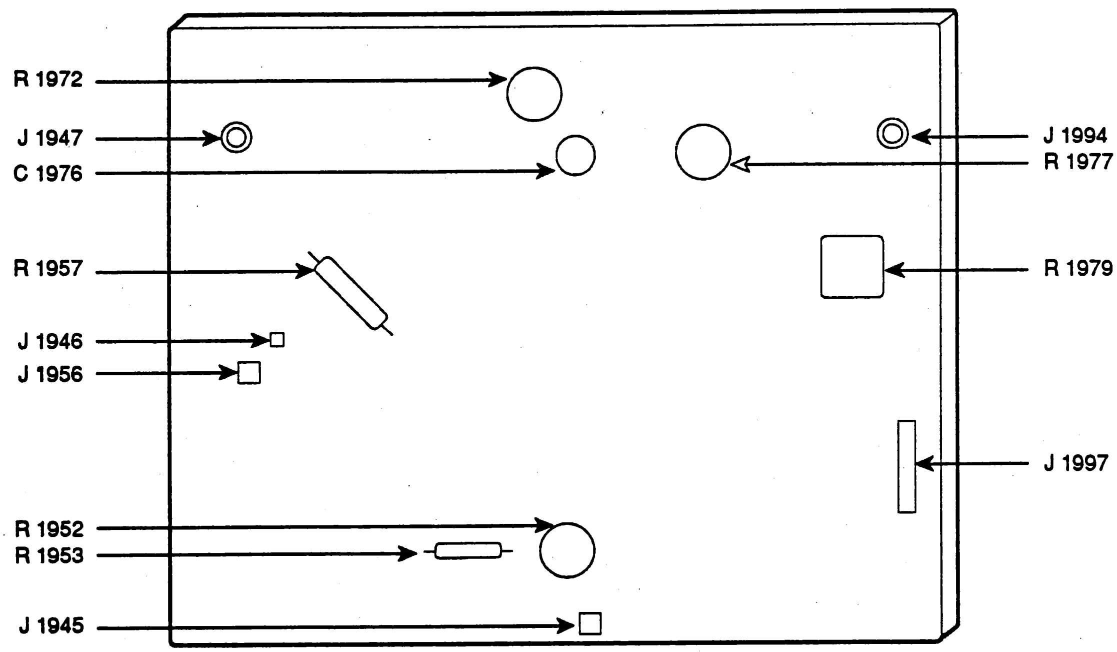


Figure 5-4: Video Preamp Adjustment Points

CAUTION

Do not use magnetized tools when working near the scan converter CRT. Magnetizing the CRT shield or surrounding chassis components can significantly degrade instrument performance.

Target Level

1. Remove the instrument top cover and remove the black metal shield covering the Video Preamp board.
2. Set the DVM range to 20 VDC.
3. Connect the DVM LO lead to chassis GND and the HI lead to the end of R1953 nearest the pot R1952 on the Video Preamp board.
4. Adjust R1952 (Target Level) on the Video Preamp board to give a reading of 13 V ±0.1 V.
5. Disconnect the DVM leads.

Video Preamp DC Output Level

1. Insert a 7A19 or 7A29 vertical amplifier into the test oscilloscope vertical compartment.
2. Set the test oscilloscope for:

   V/division: 50 mV/division
   Input coupling: DC
   Time/division: 1 μs
   Triggering: INTernal

3. Connect a short jumper between J1946 and J1956 on the Video Preamp board.
4. Disconnect the (white) coax cable from J1994 on the Video Preamp board.
5. Connect the test oscilloscope to the Video Preamp board from J1994 through a coax (Peltola) cable to a Peltola-to-BNC adapter. If you are using a vertical amplifier with 1 Ω input, you must use a 50 Ω feedthrough termination.
6. Connect J1947 on the Analog board (or SCD5000 Trigger board) to J1947 on the Video Preamp board using the 12" coax (Peltola) cable.
7. Set the calibrator **Cal Time** to 400 ns.
8. Establish a ground reference on the test oscilloscope display (center screen).
9. Wait at least five minutes for the Video Preamp DC output level to stabilize.
10. Adjust the test oscilloscope trigger level and holdoff for a stable triggered display.
11. Check for a 200 mV waveform centered about the ground reference level within ±10 mV.
12. Adjust R1979 (Video DC level) on the Video Preamp board to center the waveform about the ground reference level.

Video Preamp Gain Check

Check the test oscilloscope waveform for a peak-to-peak amplitude of 200 mV ±10 mV (4 division ±0.2 division) measured at the center of the pulse top and bottom levels. This verifies a gain of 10 (into 50 Ω) through the amplifier.

Video Preamp High- frequency Compensation

1. Place the Video Preamp cover upside down on the four metal posts on the board. Bare metal on the cover must contact at least one post to simulate normal Video Preamplifier stray capacitance.
2. Check that the positive transition has aberrations no greater than ±2%. Change the test oscilloscope time/division as necessary to observe the aberrations.
3. Adjust R1977 (H.F.) for a waveform with the least amount of oscillation as shown in Figure 5-5.

TEK OSCILLOSCOPE SCREEN

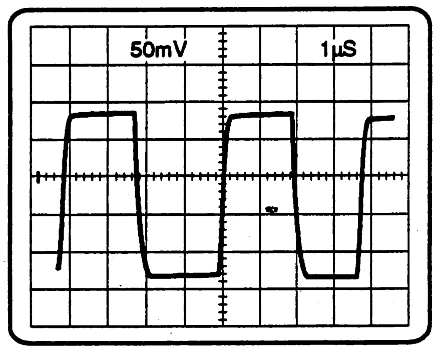


Figure 5-5: Video Preamp High-Frequency Adjustment

4. Adjust R1972 (Loop Gain) and R1957 for a minimum of aberrations, while maintaining a rise-time of less than 150 ns. Adjust R1957 by moving the body of the resistor closer to or farther from the metal etched on the printed circuit board. If much movement is necessary, it is best to turn off and unplug the SCD and resolder the resistor body closer to or farther from the circuit board.
5. Adjust C1976 (H.F.) for a minimum of aberrations and noise or oscillation riding on the square wave, while maintaining a rise-time of <150 ns. Adjust the test scope trigger level as necessary to view the H.F. noise riding on the square wave. You can reduce this noise by adjusting C1976.
6. Check that the front corner aberrations (which should be slightly rolled off) are still within ±2%, 3% overall.
7. Remove the short jumper strap, the cable to J1994, and the cable between J1947 on the Video Preamp and J1947 on the Analog board.
8. Reconnect the (white) coax cable to J1994 on the Video Preamp.
9. Install the black metal shield. Take care not to pinch any wires under the cover. Install the instrument top cover.

Read Gun Calibration

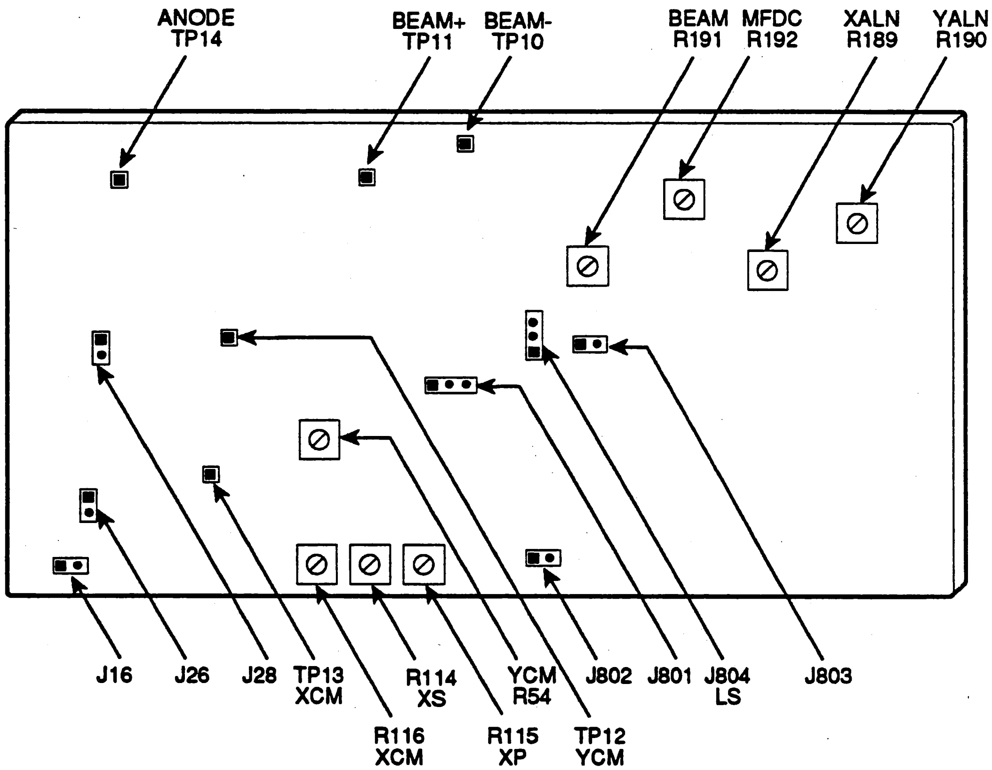


Figure 5-6: Read Gun Board Adjustment Points

WARNING

This procedure exposes high voltages.

Read Gun Anode Voltage

1. Remove the instrument right side cover (when facing the instrument).
2. The SCD must be in digital scan mode for this procedure. Set the following jumpers on the Read Gun board to configure the SCD in digital scan mode:
   - J801 – pins 1-2 marked N
   - J802 – not jumpered
   - J803 – not jumpered on SCD1000; jumper installed on SCD5000

- J804 – pins 1–2 marked L for SCD1000; pins 1–2 marked S for SCD5000

3. Set the DVM to DC volts and the range to AUTO (if present) or 300 V.
4. Connect the DVM negative lead to chassis ground, and the DVM positive lead to TP 14 (ANODE) on the Read Gun board.
5. Check for a reading of +259 volts, ±3 V. If the reading is different, check the regulating circuit (U15 and associated parts) on the Read Gun board.

WARNING

This procedure exposes high voltages.

Common Mode Setup

1. Set the DVM to DC volts and the range to 20 V.
2. Connect the DVM HI (positive) lead to TP 14 (ANODE) and the DVM LO (negative) lead to TP13 (XCM).
3. Adjust R116 (XCM) for a DVM reading of +15 V ±1 V. (This sets the X common mode voltage to 244 volts, 15 volts below the anode's 259 volts. Do not measure TP13 to ground, because the test point impedance is high enough to cause a significant error in the reading.)
4. Connect the DVM positive lead to TP14 (ANODE) and the DVM negative lead to TP12 (YCM).
5. Adjust R54 (YCM) for a DVM reading of +15 V ±1 V.

Read Gun Cathode Current

1. Set the DVM to DC volts and the range to 20 V.
2. Connect the DVM HI (positive) lead to TP11 (BEAM+) and the DVM LO (negative) lead to TP10 (BEAM–.)
3. Adjust R191 (BEAM) for a DVM reading of +3.75 V ±0.180 V. This sets the read gun cathode current to 750 μA. If the CRT has a fluorescent sticker saying "READ GUN I_K = 1.0 mA", adjust R191 for a reading of 5 V ±0.25V.

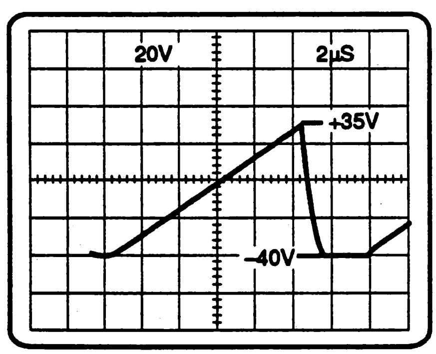
SCD1000 Initial Y-ramp Adjustment

1. Insert the 7A13 Differential Comparator into the right vertical channel of test oscilloscope.
2. Make sure jumper J804 is on pins 2–3 (marked L) on the Read Gun board.
3. Set the 7A13 amplifier and the test oscilloscope for:

   vertical: 20 V/division
   vertical coupling: DC (both 7A13 inputs)
   vertical offset: 0 V
   trigger source: right vertical
   time/division: 2 μs
   trigger coupling: AC
   trigger mode: NORM

   Using the GPIB talker/listener, set cco 12:127 and cco 13:127.
4. Adjust the trigger level as needed for stable triggering.
5. Connect two properly compensated and calibrated 10x probes from the 7A13 to J28-1 and J28-2 on the Read Gun board (-Y and +Y), or attach the probes to the right side of LR1 and LR2 on the Read Gun board.
6. Adjust cal constant 10 to position the waveform about the center oscilloscope display line as shown in Figure 5-7, with the lowest point at –40 V and the highest point at 35 V. (Refer to *How to Change Cal Constants With CCO* in *Calibration Utilities*.)

TEK OSCILLOSCOPE SCREEN



A) for SCD 1000

Figure 5-7: SCD1000 Y-Ramp Position

7. Use the GPIB talker/listener program to adjust cal constant 17, Y-ramp amplitude, for a 75 V p-p signal, adjust cco10 to move the bottom level of the waveform to –40 V and the top level to +35 V.

SCD5000 Initial Y-ramp Adjustment

1. Insert the 7A13 Differential Comparator into the right vertical channel of the test oscilloscope.
2. Verify that jumper J804 is on pins 1–2 (marked S) on the Read Gun board. Remove the jumper from J803.
3. Set the the test oscilloscope for:

   vertical: 5 V/division
   vertical coupling: DC (both 7A13 inputs)
   trigger source: right vertical
   time/division: 2 μs
   trigger coupling: AC
   trigger mode: NORM

4. Adjust the trigger level as needed for stable triggering.
5. Connect properly compensated and calibrated 10× probes of the 7A13 to J28–1 and J28–2 on the Read Gun board (-Y and +Y) or attach the probes to the right side of LR1 and LR2 on the Read Gun board.
6. Adjust T789 (Saver) on the Trigger board to the center of its range.
7. Adjust cal constant 10 to position the waveform about the center oscilloscope display line similar to Figure 5-8. Set the low level to –19 V and the top level to +16.5 V. (Refer to *How to Change Cal Constants With CCO* in *Calibration Utilities*.)
8. Use the GPIB talker/listener program to adjust cal constant 17, Y-ramp amplitude, for a 35.5 V p-p signal.
9. Reinstall the jumper on J803. Adjust R227 (YPC) on the Read Gun board to set the waveform levels as described in step 7.

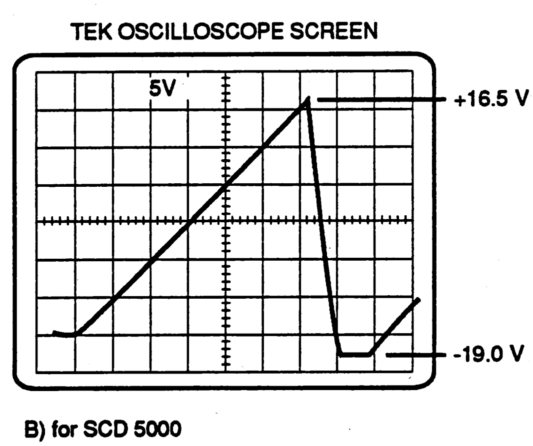


Figure 5-8: SCD5000 Y-Ramp Position

X-Ramp Centering and Amplitude

WARNING

This step exposes high voltages.

1. Set the the test oscilloscope for:

   vertical: 50 V/division
   vertical coupling: DC (both 7A13 inputs)
   vertical offset: 0 V
   trigger source: right vertical
   time/division: 2 ms
   trigger coupling: AC
   trigger mode: NORM

2. Adjust the trigger level as needed for stable triggering.
3. Connect the positive lead probe to J26–1 on the Read Gun board (+X), or connect the negative lead probe to J26–2 on the Read Gun board (–X), or connect the probes to the right side of LR4 and LR3 respectively on the Read Gun board.
4. Verify that the X Read ramps are running.
5. Establish a ground reference on the test oscilloscope. Return the test scope coupling to DC.
6. Adjust R115 XP (position) on the Read Gun board to center the waveform about the center oscilloscope display line.
7. Set the 7A13 + and – inputs to GND.
8. Set the vertical range to 5 V, and the comparison 7A13 voltage (VC) to +291 V.
9. Adjust the position control for a centered trace. This will be the reference point used to calculate ramp amplitude.
10. Set the 7A13 positive (+) input to DC and the negative (–) input to VC.
11. Adjust R115, XP (X position), to move the top of the ramp to the center screen reference level on the test oscilloscope as shown in Figure 5-9.
12. Adjust the 7A13 comparison voltage to 197 V.
13. Check that the bottom of the ramp is at the reference level ± 1 V as shown in Figure 5-10.

TEK OSCILLOSCOPE SCREEN

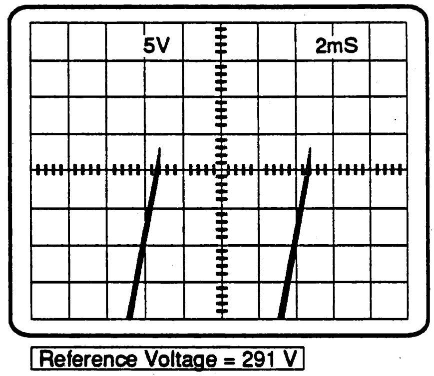


Figure 5-9: X-Ramp Centering

TEK OSCILLOSCOPE SCREEN

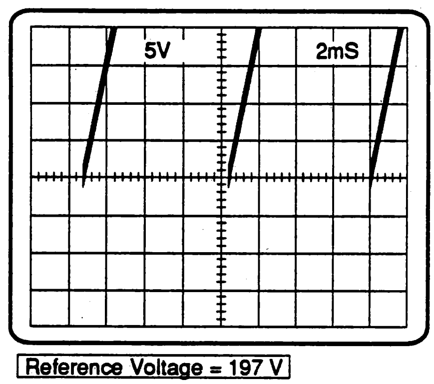


Figure 5-10: X-Ramp Gain

14. Adjust R114, XS (X size), so that the bottom of the ramp is at the reference level.
15. Repeat the X-ramp centering procedure if the X-ramp amplitude is changed.
16. Remove the probes from the Read Gun board and reinstall the SCD covers.

Read Gun X & Y Alignment

1. Set up the SCD and the Read Gun board for video mode operation (see *Calibration Utilities*, *How to get into Video Mode*, for instructions).
2. Connect J400 on the Control board to the analog video monitor through the coax (Peltola) cable, Peltola-to-BNC adapter, and 75 Ω BNC cable.
3. Disconnect the blue harmonica cable connector J16 (Mag Focus) on the Read Gun board.
4. Center R192 (MFOC) on the read gun board
5. Adjust R189 (XALN) and R190 (YALN) while observing the write trace on the video monitor. Adjust the X and Y alignment to get the brightest possible "blot" on the video screen as shown in Figure 5-11. The "blot" should appear near the center of the video monitor, but adjust the alignments to maximize the intensity, not to center it. This corresponds to a maximum amount of read gun beam current passing through the first anode aperture. (The Read Gun Ramps, Cathode Regulator, Video Preamp, Control Board Video Processor, and the 68010 MPU system must all be operational in order to see this display).

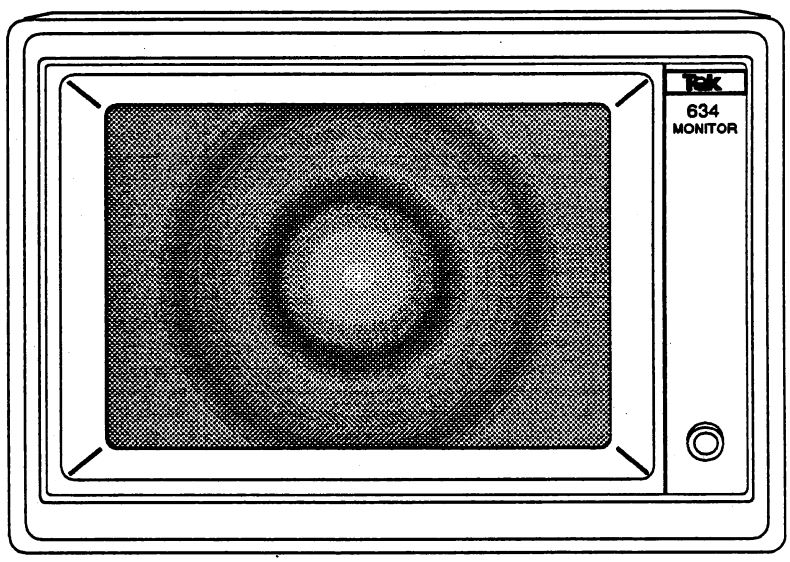


Figure 5-11: Setting the Maximum Read Gun Current

NOTE

The X & Y alignment adjustments are critical to the proper operation of the CRT Read Gun. Use care in adjusting these parameters.

6. Reconnect J16 (Mag Focus) on the Read Gun board.
7. Return the SCD to Digital Mode operation (see *Video Mode*). Reinstall the instrument covers.

High Voltage Calibration

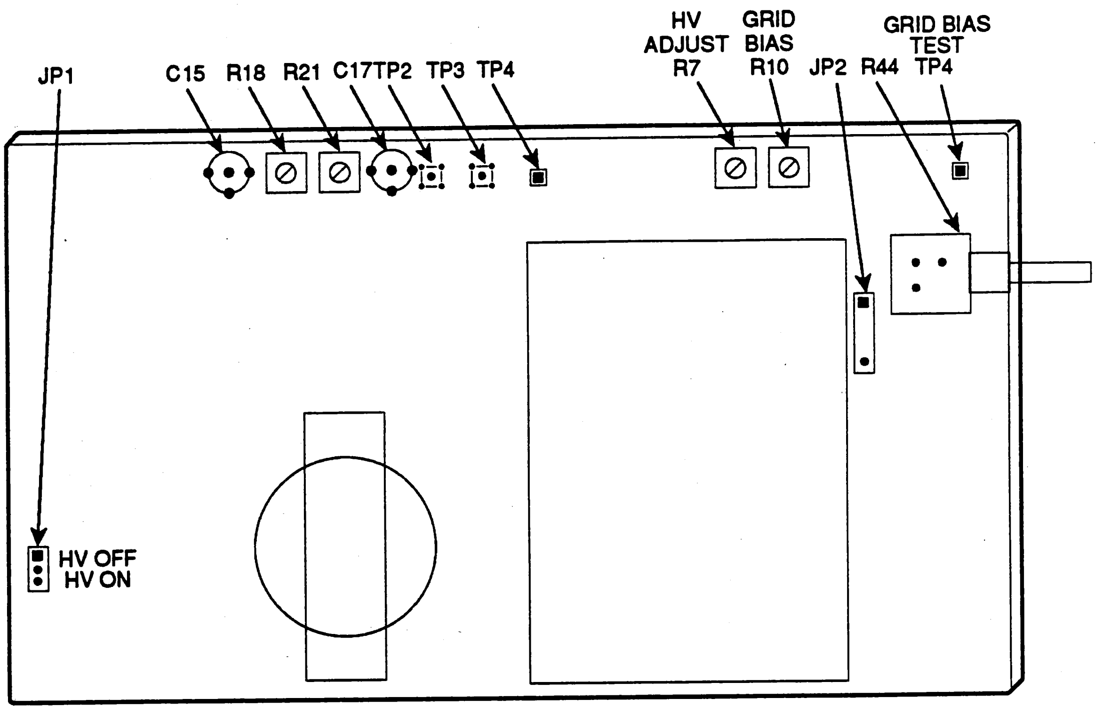


Figure 5-12: High Voltage Board Adjustment Points

Z-axis Transient Response

CAUTION

Be sure that the CRT high-voltage supply is disabled (jumper JP1 is installed between pins 1-2 marked HVOFF) before performing this step, or serious damage to the diode array target may result.

1. Tip the SCD up on its left side and remove the bottom cover to allow access to the High Voltage board.
2. Set the test oscilloscope for the following:

   7A26 Display Mode: CH1
   vertical gain: 1 V/division
   coupling: AC
   horizontal: 20 ns

3. Set the SCD for calibration of the Z-axis by running the following program from the GPIB controller:

   ```
   wgzacal 5ns /d0 /g<addr>
   ```

4. Connect the CH1 10× test probe to TP3 on the High Voltage board.

5. Adjust C15 and R21 (High frequency compensation) on the High Voltage board to give the sharpest front corner with the least amount of aberrations as shown in Figure 5-13.

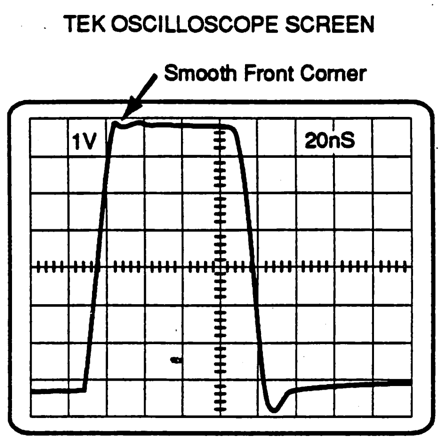


Figure 5-13: High Frequency Compensation Adjustment

6. Set the test oscilloscope horizontal to 10 ns.
7. Check that the aberrations are less than 2% overall, and that the rise time is less than 15 ns.
8. Set the SCD acquisition window to 10 ns and repeat step 7.
9. Set the SCD acquisition window to 100 ns. Set cco23:220. (Refer to *How to Change Cal Constants With CCO*.)
10. Move the test probe to TP2 on the High Voltage board. Set the test scope vertical to 10 V/division (at the probe tip).
11. Adjust R18 and C17 (Z-axis compensation) for a flat top with a minimum of aberrations as shown in Figure 5-14.

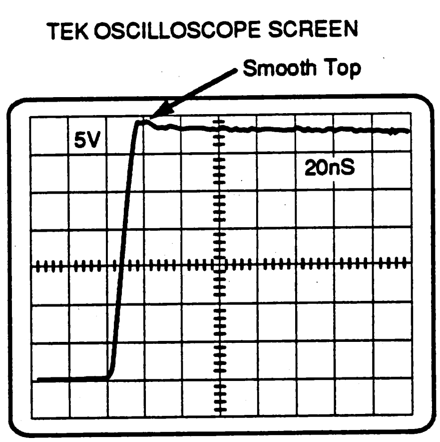


Figure 5-14: Z-Axis Compensation Adjustment

12. Set the test oscilloscope horizontal to 200 ns.
13. Check that the pulse is flat ±1% throughout the positive pulse duration. If the Z-axis pulse does not meet these performance specifications, readjust the high frequency compensation network.
14. Return the SCD to Digital Mode operation using the GPIB talker/listener program to send the command `VID OFF`.

High Voltage (–10 kV)

WARNING

This step exposes high voltages.

1. Check that the jumper JP1 on the High Voltage board is installed between pins 1–2 (HV OFF). In the SCD Utility menu, set the Focus to 50%.
2. For the SCD1000, check that a jumper is *not* installed in J2.

   For the SCD5000, check that a jumper is installed in J2.
3. Set the DMM to measure DC volts. Connect the DMM positive (+) lead to TP4 on the High Voltage board, and connect the negative (–) lead to chassis ground.
4. Adjust R10 (Grid Bias) on the High Voltage board fully counterclockwise to maximize the DMM voltage reading. This ensures that the Writing Beam is fully extinguished.

CAUTION

Do not use magnetized tools when working near the scan converter CRT. Magnetizing the CRT shield or surrounding chassis components can significantly degrade instrument performance.

5. Make sure that instrument power is off.
6. Remove the High Voltage cover (CRT HV shield) on the rear of the instrument by loosening the two screws on the topside of the shield using a non-magnetic screwdriver. Remove the small section of the shield. Using the non-magnetic screwdriver, remove the three screws on the rear panel and carefully slide out the CRT HV shield. Remove the clear plastic cap on the CRT rear socket.

WARNING

Read steps 7 through 16 before proceeding. Carefully locate all of the test points (without touching them) and adjustment locations. Be EXTERMELY careful, you will be measuring 10,000 V which can be fatal.

7. Set the DVM to the 20 V range.
8. Connect the high voltage probe to the DVM. Insert the probe into the back of the CRT socket on pin 2, CATHODE (red wire between brown and another red wire). See Figure 5-15.

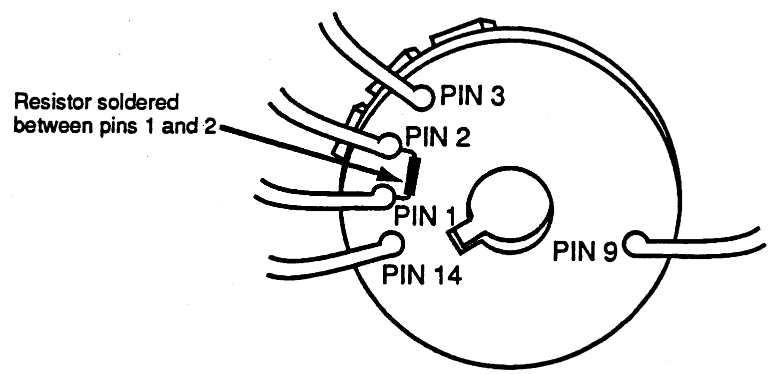


Figure 5-15: CRT Write Gun Socket Pin Numbers CRT Calibration

CAUTION

Be sure to ground the probe ground lead. Hold the probe steady on the solder lug.

9. Move the jumper JP2 on the High Voltage board to pins 2–3 (HV ON), enabling the high voltage, then turn on the instrument.
10. Check the DVM reading for −10.000 V ±0.100 V (the probe divides by 1000). For the SCD5000, check the meter for a reading of −10.250 V ±0.100 V. If necessary, adjust R7 (High Voltage) for a DVM reading of −10.000 V ±0.050 V (SCD1000) or −10.250 V ±0.050 V (SCD5000).

CAUTION

Perform the next step quickly to prevent excessive arcing.

11. Carefully but quickly remove the High Voltage probe from pin 2 (some arcing may occur, but moving quickly will reduce it).
12. Carefully insert the High Voltage probe onto pin 9 on the Write Gun Socket (FOCUS) as shown in Figure 5-15.
13. Check the DVM for a reading of –5.86 V ±0.150 V (SCD1000) or –6.12 V ±0.150 V (SCD5000).
14. If necessary, adjust R44 (Coarse Focus) for a DVM reading of –5.860 V ±0.05 V (SCD1000) or –6.12 V ±0.05 V (SCD5000). This will center the coarse focus in its range. This pot is reached via rear panel access hole using a small flat-blade screwdriver.
15. Remove the high voltage probe.
16. Disconnect the high voltage probe ground lead.
17. Turn off the SCD power and wait about 10 seconds for the High Voltage capacitors to discharge before reinstalling the CRT socket cap, the CRT High Voltage shield, and the instrument covers.

CRT Bias Calibration

Initial Grid Bias Adjust

NOTE

The CRT must have a minimum of 30 minutes warm-up before beginning this procedure (2 hours is recommended). If the instrument has already warmed up, allow at least 15 minutes for the tube to stabilize since the instrument was last powered-on.

Remove the instrument bottom and left side covers. The following operations are most easily performed with the instrument standing on its left side.

1. Set up the SCD and the Read Gun board for video mode operation (See *Video Mode* for instructions.) Connect a video monitor to J400 on the Control board through a Peltola cable, and Peltola to BNC adapter.
2. Set the SG 503 to 50 kHz (reference) at approximately 2.5V p-p (5 V p-p for the SCD5000). For the SCD5000, connect the SG output to the splitter, one output to the SCD input, and the other to the **TRIG IN** connector.
3. Set the SCD acquisition window to 100 μs, the vertical range to 5 V, and the trigger source to CHA or INT for the SCD5000 with Option 01. For the SCD5000, set the trigger source to EXT.
4. Adjust the SCD trigger level for a stable trigger.
5. Set cco23:250. (Refer to *How to Change Cal Constants With CCO*.)

CAUTION

The Grid Bias adjustment is very sensitive, so turn it slowly. Misadjustment of the Grid Bias can cause severe damage to the diode array target.

6. Set the DMM to measure the DC volts. connect the positigve lead to TP4 (Grid Bias) and connect the negative lead to chassis ground.
7. Carefully turn R10 (Grid Bias) on the High Voltage board reduce the grid bias voltage measured at TP4. Keep a constant eye on the video monitor for signs of the trace appearing. Adjust this pot until the trace is just barely visible.

CRT Focus Adjust

NOTE

Be sure that the video monitor is correctly focused before beginning this procedure.

1. Check that jumper J3 on the Write Gun board is correctly installed on pins 2–3 (SCD1000) or pins 1–2 (SCD5000).
2. Set the the SCD for:

   vertical range: 1 V (SCD1000 only)
   vertical mode: CHA (SCD1000 only)
   input coupling: AC (SCD1000 only)
   acquisition window: 1 μs
   focus: 50.2% (from Utility menu)

3. For the SCD1000, set the SG504 for a 1000 MHz, 500 mV p-p signal and connect the SG504 output to the channel A input.

   For the SCD5000, set the generator for a 4.5 GHz, 2.5 V p-p signal and connect the SG504 output to the channel A input.

   For the SCD5000 with Option 01, set the generator for a 3.0 GHz, 3.0 V p-p signal and connect the SG504 output to the channel A input.

4. Adjust the following for the best overall focus of the signal on the video display:
   - R192 (MFoc) on the Read Gun board
   - R44 (Focus) on the High Voltage board, through the rear panel
   - R121 (Astig) on the Write Gun board
   - R157 (SHLD) on the Write Gun board
   - R161 (AST2, SCD5000 only) on the Write Gun board

Final CRT Write Gun Grid Bias Adjust

1. Set the SCD:

   acquisition window; 100 μs
   vertical range: 5 V
   trigger source: CH A (SCD1000)
   trigger source: EXT (SCD5000 Standard)

2. Connect the SG output to the SCD input. For the SCD5000 Standard, connect the SG output to a signal splitter; connect one output fo the splitter to the SCD input, and the other splitter output to the SCD trigger input.

3. Adjust the SG output:

   2.5 V p-p (SCD1000)
   5 V p-p (SCD5000)
   Frequency: 50 kHz (ref)

4. Adjust the SCD trigger level for a stable trigger.

5. Run the program SETGBCAL from the GPIB controller, using the following command line syntax:

   ```
   SETGBAL /g <addr> [/p/b/DOT]
   ```

CAUTION

The Grid Bias adjustment is very sensitive, so turn R10 slowly. Misadjusting the Grid Bias can severely damage the diode array target. The Grid Bias adjustment will affect writing range and CRT lifetime. Use care in adjusting the GRID BIAS.

6. Carefully turn R10 (Grid Bias) on the High Voltage board clockwise. Keep a constant eye on the video monitor for signs of the trace appearing. Adjust this pot until the trace is just barely visible.

7. Set cco23:255 and verify that the trace is fully extinguished.

8. Set the DVM to the 200 V range.

9. Place the low (–) DVM lead on chassis GND, and the high (+) lead to TP4 (Grid Bias) on the High Voltage board. (Grid Bias voltage may also be found on the right side of CR1 on the High Voltage board).

10. Write down the Grid Bias voltage as measured on the DVM.

11. Run the utility program MAXINTE from the DOS prompt on the controller by entering:

    ```
    MAXINTE <nnn.n> /g<addr>
    ```

    where <nnn.n> is the measured grid bias voltage. MAXINTE sets up the maximum intensity cal constants required to prevent damage to the CRT.

12. Set the SCD and the Read Gun board back to Digital Mode (see *Video Mode* for instructions.)

13. Remove the DVM leads. Reinstall the instrument covers and set the instrument back down on the test bench.

Video Pulse Response Adjust

1. Set the SCD:

   acquire length: 1024
   acquire time: 100 μs
   hold next: off
   trigger source: EXT
   trigger mode: NORM
   Focus: 50.2%
   display mode: Raw (from Utility menu)

2. Set the acquire mode to running and adjust the intensity to show a trace that is at between 1/2 and 1 1/2 divisions in width.
3. Adjust R100 (Video Clamp) on the Control board clockwise until the background noise appears on the Target Image display screen.
4. Check that a shadow does not appear beneath the main trace (this shadow would be small in width, running most of the length of the trace). If a shadow is present, adjust C1976 on the Video Preamp board to eliminate the shadow.

Video Clamp Level

1. Set the SCD for

   acquire length: 1024 pt, 5 ns
   hold next: off
   trigger source: CH A (Cal for SCD5000)
   trigger mode: AUTO
   display mode: Target Image
   Threshold: 0

2. Set the DVM to DC volts, range to 2 V. Ground the negative DVM lead on the Control board near TP200.
3. Connect the DVM to TP202 on the Control board. Verify that it measures +1 V ±0.03 V.
4. Connect the DVM to TP201 on the Control board. Adjust R128 for a DVM reading of 0 V ±5 mV.
5. Connect the DVM to TP200 on the Control board. Adjust R1oo for a DVM reading of −1.05 V ±10 mV.
6. Set the SCD intensity to minimum and the acquisition state to run.
7. If random video noise appears on the SCD screen, adjust R100 very slightly in the counterclockwise (more negative voltage) direction to eliminate all random noise displayed on the screen.

NOTE

Random noise will manifest itself as small, single-pixel aberrations that are not consistent in location on the Target Image display of the SCD. Anything larger than 6 pixels and relatively stable in location should be considered a target defect, and be subject to the specified defect criteria.

R100 should not be adjusted to try to eliminate defects, as this will significantly reduce CRT Writing Speed.

8. After all visible random video noise has been eliminated, run the SETREF routine from the SCD Utility menu or by using the GPIB command `SETREF RUN` for the GPIB talker/listener program on the controller.
9. If random noise appears on the SCD screen while SETREF is running, slightly adjust R100 in the counterclockwise direction and repeat the SETREF test. Iterate this process until there is no random noise displayed on the SCD screen.

NOTE

This adjustment can affect overall digital mode writing speed of the instrument. Improper adjustment may either cause spurious noise to appear on the Target Image display, or may reduce overall writing speed if adjusted too far in the other direction. Please exercise proper case in determining its setting.

10. For Control board with version -00 version numbers, measure the voltage at TP200, and then adjust R100 to make the voltage at TP200 more negative by 50 mV.

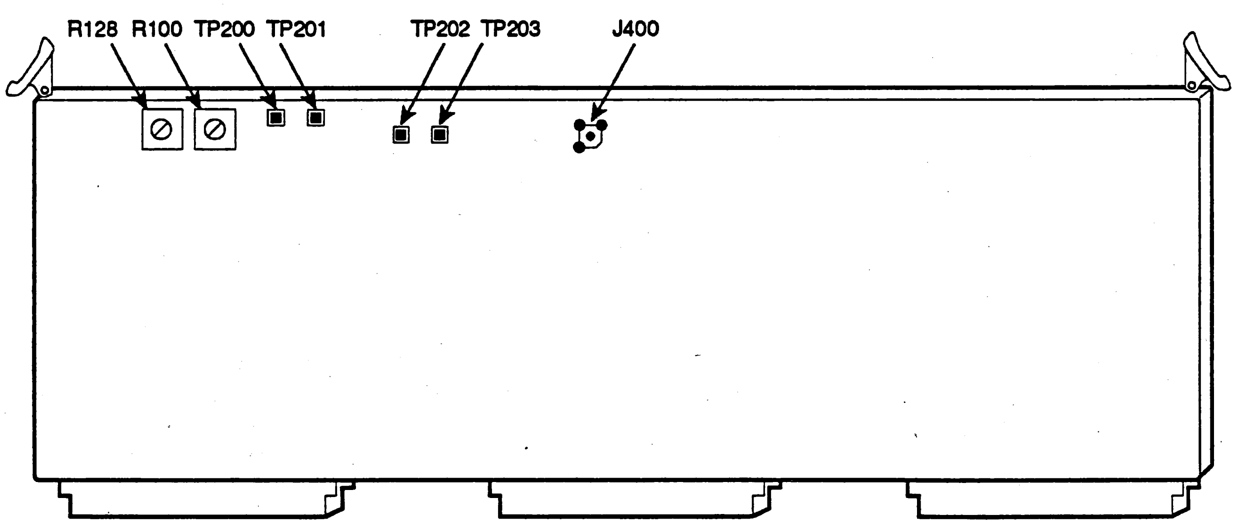


Figure 5-16: Control Board Adjustment Points

Internal CRT X & Y Tilt Calibration

1. For the SCD1000, set the SG503 for 1 MHz, 80 mV p-p signal amplitude.

   For the SCD5000, set the SG to 1 MHz, 3 V p-p amplitude (into 50 Ω).

   For the SCD5000 with Option 01, set the SG to 1 MHz, 6 V p-p amplitude (into 50 Ω).

2. Set CAL MODE to CRT from the SCD Utility menu (second Level Utility menu).

3. Press the **CAL STOPPED** button and follow the instructions that appear in the SCD Status area. Intensity calibration will run first, then X-tilt calibration, then Y-tilt calibration. Y-tilt calibration will prompt for the SG signal to be connected.

4. Wait for the prompt (SCD bell will prompt for user to connect external signal), then connect the SG signal to the channel A input. Wait for the calibration to finish before proceeding. Verify that CRT calibration complete successfully.

Read Gun Alignment Check

1. Set the SCD:

   acquire length: 512
   acquire time: 100 µs
   hold next: off
   trigger source: EXT
   trigger mode: NORM
   Focus: 50.2%
   display mode: Raw (from Utility menu)

2. Set the acquire mode to running and adjust the intensity to show a trace that is at between 1/2 and 1 1/2 divisions in width.

3. Check that the trace has clean, well-defined straight edges, and that there is no smearing above or below the trace.

4. If the instrument does not pass step 3, adjust the READ GUN X and Y alignments to eliminate the smearing of the trace. This can usually be done by slight adjustments of the R189 (XALN) on the Read Gun board.

Target Defects Check

1. Set the SCD for 1024-point record length. Send the GPIB commands `PATH ON` and `LONGFORM ON` using the GPIB talker/listener program.

2. Run the SETREF routine from the SCD Utility menu or by using the GPIB command `SETREF RUN` from the GPIB talker/listener program.

3. Use the controller to query the SCD for the list of defects found on the CRT target by entering the command: `REFLIST?`

4. Make sure none of the defects on the corner point list are larger than 144 pixels (in any shape), and that there are less than seven defects appearing on the screen. See the *SCD1000/SCD5000 Instruments Interface Guide* for a description of the `REFLIST` command.

   The defect map can be viewed on the SCD Target Image display (Utility menu) by sending the `RAW REFA` command. Be sure to restore the instrument to regular oeration by sending the RAW LINA command.

Target-Saver Adjustment (SCD5000 Only)

The Target-Saver Adjustment is a procedure for moving the write and read gun scanning areas to a defect-free portion of the target. It is available only for the SCD5000.

1. If the CRT passed the *Target Defects Check* procedure above, skip the rest of this procedure and go to the *Writing Speed Check/Adjustment* procedure.
2. If the CRT does not pass the Target Defects Check procedure, the Target-Saver Adjustment may allow you to position the violating defect(s) out of the useable target area, thus saving the CRT from being scrapped due to excessive defects or defect size.
3. Set the SCD5000 to:

   Display: Target Image data (Utility menu, first level)
   Intensity: 0%
   Acquire length: 1024
   acquire time: 100 μs
   acquire state: RUN

4. Examine the position of the offending defects. Keep in mind that the Target-Saver Adjustment allows the read scan to be vertically repositioned by approximately 2 times the vertical height of the display screen.
5. Adjust R227 (YPC, the coarse Y-position) on the Read Gun board to vertically position the offending defect(s) out of the scanned target area. If the defect is (or the majority of the defects are) in the top 1/2 of the screen, move the defect(s) up by rotating R227 counterclockwise. If the defect is (or the majority of the defects are) in the bottom 1/2 of the screen, move the defect(s) down by rotating R227 clockwise.
6. Adjust the CRT intensity to a usable level.with either the GPIB INTE command or the Utility menu on the Front Panel Display unit.
7. Set cco2: 2048 and cco10:127 (refer to *How to Change Cal Constants With CCO*). This will center the SCD5000 vertical offset constants.
8. Adjust R789 (SAVER) on the Trigger board to exactly center the displayed trace on the screen. Cursors may be used to help make this measurement. Be sure to perform the geometry adjustment and checks after adjusting the target saver.
9. Reinstall instrument covers.
10. Repeat the *Target Defects Check* procedure on page 5-51.

Writing Speed Check/Adjustment

For this procedure, the SCD1000 can use either the SG504 or the Wiltron sine wave generator listed in the Required Equipment table, but the SCD5000 must use the Wiltron.

1. Set the SCD1000 for:

   Vertical Mode: CHA
   Vertical Range: 1 V
   Vertical Offset: 0 mV
   Trigger Mode: Normal
   Trigger Source: CHA
   Time Window: 5 ns
   Hold Next: off

   Set the SCD5000 for :

   Vertical Range: 5 V
   Vertical Offset: 0 mV
   Trigger source: EXT

   Set the SCD5000 with Option 01 for :

   Vertical Range: 10 V
   Vertical Offset: 0 mV
   Trigger source: INT

2. Connect the sine wave generator output to the SCD input.
3. For the SCD1000, set the signal to 1000 MHz at 800 mV p-p.

   For the SCD5000, set the signal to 4.5 GHz at 2.0 V p-p and connect the frequency reference output to the SCD external trigger input.

   For the SCD5000 with Option 01, set the signal to 3.0 GHz at 4.0 V p-p and connect the frequency reference output to the SCD external trigger input.
4. Set the SCD to view the Target image (in the Utility menu) to show a graticule (grid) overlay.
5. Increase the intensity to 100%, and set the SCD to ACQUIRE: running.
6. Verify that the trace is missing data for no more than 6.25% of the screen height at any one point, as shown in Figure 5-17. (Adjust the front-panel focus for the best results.) Note that the writing speed is not verified in the first 10% and the last 10% of the sweep window.

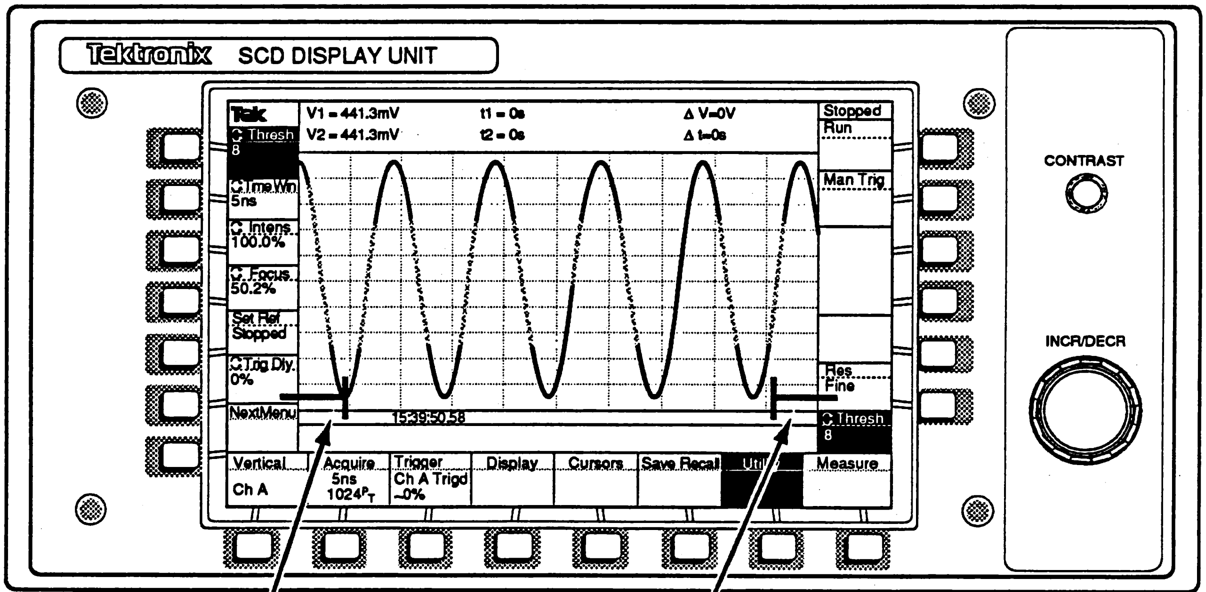


Figure 5-17: Writing Speed Adjustment

If the SCD fails the Writing Speed Check/Adjustment, readjust the following parameters while observing the SCD acquisitions on the Target Image waveform display. Try the adjustments in the order that they appear here. Check for improved writing rate after each procedure has been completed:

- Front-Panel CRT Focus adjustment
- R20 (ASTIG) on the Write Gun board
- R22 (SHLD) on the Write Gun board
- R44 (FOCUS) on the High Voltage board, through the rear panel.

If the above steps do not improve the writing rate, as a last resort try adjusting R189 (XALN) and R190 (YALN) and R192 (MFOC) on the Read Gun board.

NOTE

Adjusting the Alignment or Magnetic Focus parameters will require calibration (or recalibration) of CRT X & Y Tilt, Horizontal Cal, Vertical Cal, and Trigger Cal, and may require readjusting the focus/alignment parameters listed above. Use these adjustments to improve writing rate ONLY AS A LAST RESORT.

These adjustments should improve writing speed in most cases. Do not attempt to adjust the CRT target level to improve the writing rate. The nominal value of the CRT target level is + 13 VDC, and should not increase above this voltage. If the writing rate does not meet the specifications in the performance verification section, please contact your local Tektronix service representative.

Geometry Calibration

S-Curve Correction

The read gun may have an s-curve geometric distortion that can be compensated by varying the position of the Y-scans as a function of the X-scan. This is similar to the tilt adjustment function, which is a linear addition of a fraction of the X-scan to the Y-scan position. Geometry correction is done by adding a nonlinear fraction of the X-scan to the Y-scan position.

The S-curve distortion is more pronounced for the SCD5000 than for the SCD1000. The nonlinear correction approximates the s-curve of the tube using a piecewise-linear function. The correction has four breakpoints, two on the left side and two on the right. Each breakpoint location is horizontally adjustable, and the magnitude (slope) of the correction of each breakpoint is adjustable as shown in Figure 5-18. This gives eight pots to adjust:

- R404 LOM Left Outer Magnitude
- R402 LIM Left Inner Magnitude
- R401 RIM Right Inner Magnitude
- R403 ROM Right Outer Magnitude
- R407 LOL Left Outer Location
- R406 LIL Left Inner Location
- R405 RIL Right Inner Location
- R408 ROL Right Outer Location

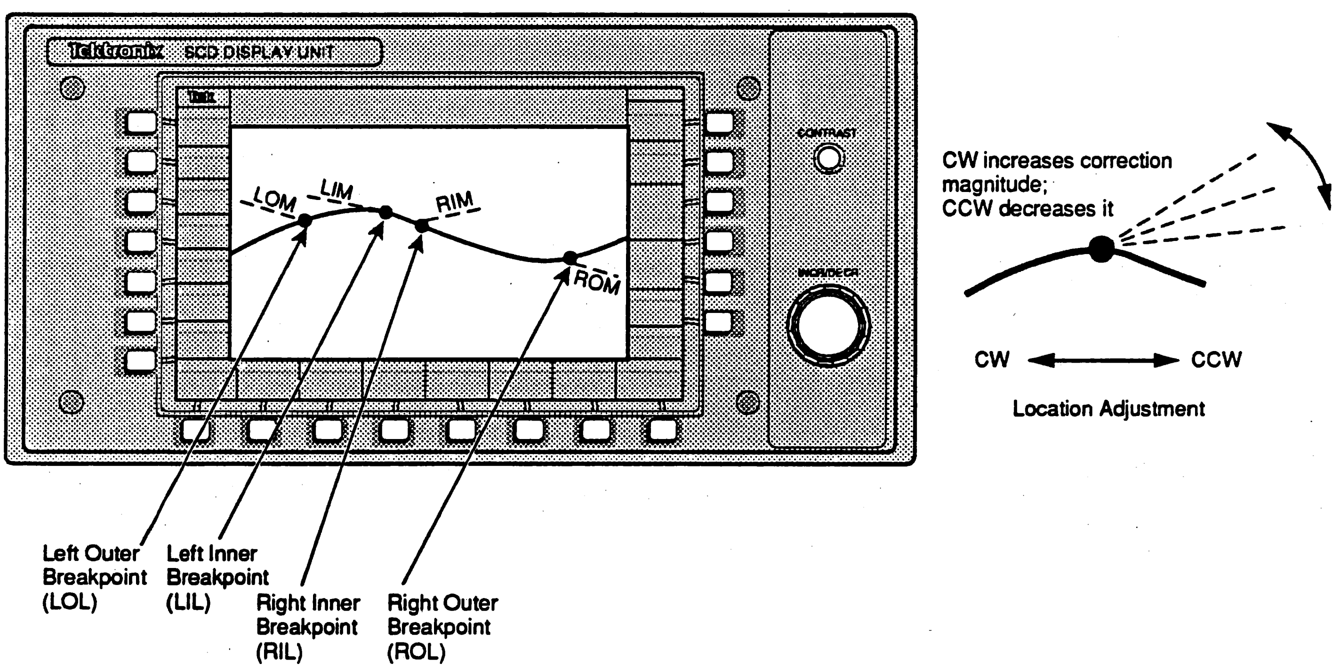


Figure 5-18: S-Curve Geometry Adjustments

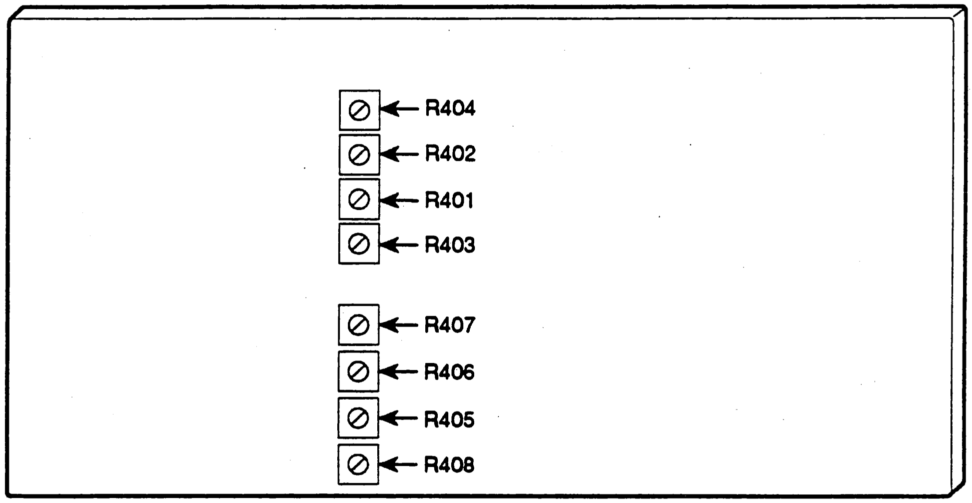


Figure 5-19: Read Gun Board S-Curve Adjustment Points

The "inner" breakpoint can be moved horizontally between approximately the center of the screen to four divisions from the center. The "outer" breakpoint can be moved from approximately 2 divisions from the center of the screen to 2 divisions off the screen.

The pots are connected so that clockwise rotation increases the amount of S-curve correction. In the case of the location pots, this means that clockwise rotation moves the breakpoint closer to the center of the screen.

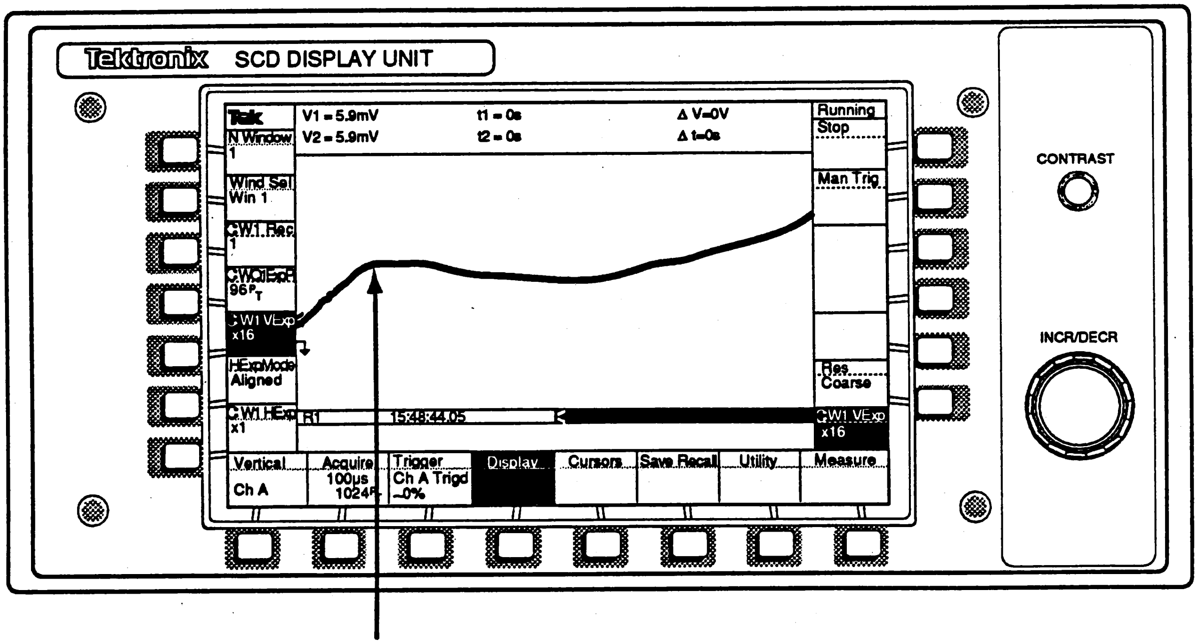
Adjust the S-curve distortion as follows:

1. Set the SCD for:

   Vertical window: 5 V
   Hold next: off
   Acquire length: 1024
   Trigger mode: AUTO
   Acquire state: RUN
   Geometry correction: OFF
   Acquire window: 5 μs

2. Set the eight S-curve pots on the Read Gun board fully counterclockwise (R401 to R408).

3. Observe a flat line centered vertically on the screen as shown in Figure 5-20. There will be some S-curve visible. The center portion of the trace, although straight, may have a slight tilt to it, because CRT X Tilt cal is confused by the curving ends. In Figure 5-20, distortion has been exaggerated for demonstration purposes.



ESTIMATED BREAKPOINT LOCATION
(LIL OR LOL)

Figure 5-20: S-Curve Distortion

4. Set the display options to expand about the EXP PT: 512th point, VEXP to ×16. This best displays the S-curvature to be corrected. The breakpoints aren't visible, so their positions must be estimated.

5. Adjust R402 (LIM) 1/2-turn clockwise and note the position of the breakpoint where LIM takes affect. Adjust R406 (LIL) to move the location of this breakpoint to 1 division right of the start of the downward curve on the left side of the trace (center of the screen to 3 or 4 divisions left of center). Adjust R402 (LIM) to straighten this section of the trace with respect to the rest of the trace.

6. Adjust R404 (LOM) 1/2-turn clockwise and note the position of the breakpoint where LOM takes affect. Adjust R407 (LOL) to move the location of this breakpoint to 1 division right of the start of the downward curve on the left side of the trace (3 or 4 divisions left of the screen center to the left edge).

7. Adjust R404 (LOM) to straighten the left outer portion of the trace with respect to the rest of the trace. Note that the outer s-curve correction pots may not need to be adjusted on the SCD1000. DO NOT adjust the s-curve pots to correct for an overall tilt of the trace; adjust to get a straight line and use CRT tilt adjustment to adjust the CRT trace tilt (as described in step 10).

8. Adjust R401 (RIM) 1/2-turn clockwise and write down the position of the breakpoint where RIM takes affect. Adjust R405 (RIL) to move the location of this breakpoint to 1 division left of the start of the downward curve on the right side of the trace (center screen to 3 or 4 divisions right of center). Adjust R401 (RIM) to straighten the trace with respect to the left half the screen.

9. Adjust R403 (ROM) 1/2-turn clockwise and write down the position of the breakpoint where ROM takes affect. Adjust R408 (ROL) to move the location of this breakpoint to 1 division left of the start of the downward curve on the right side of the trace (3 or 4 divisions right of center screen to the right edge). Adjust R403 (ROM) to straighten the end of the trace with respect to the rest of the trace.

10. Check that the waveform is a straight line with no more than 16% deviation of the ×16 expanded vertical screen (24% for SCD5000), measured as peak deviation from a straight line. The trace may be somewhat tilted, so adjust cco13 (X Tilt) to make the baseline as flat as possible (refer to *How to Change Cal Constants With CCO*).

11. Check that the trace is level and straight to within 16% (24% for SCD5000). Repeat the above adjustments as necessary to further straighten the trace.

12. Run CRT calibration from the Utility menu or using the GPIB talker/listener program on the controller, as described in *Internal CRT X & Y Tilt Calibration*.

13. The Internal CRT X & Y Tilt Calibration and S-curve Geometry Correction adjustments interact with each other. Repeat both of these procedures to achieve a straight, level baseline.

14. Turn vertical expansion to ×1. Position the trace, using offset, near the 90% vertical position of the screen. Set vertical expansion back to ×16, and adjust R156 (GEOM) on the Write Gun board to eliminate "bowing" without significantly shifting the vertical position of the trace.

The Bowing and Pincushion geometry adjustment affects the S-Curve geometry adjustment and may also slightly affect the overall focus, so two iterations of these procedures may be necessary to achieve the best overall focus and geometry.

Internal Geometry Calibration

From the fourth level of Utility menu, run the Internal Geometry Calibration routine. Press the **Cal Mode** button until Geometry appears, then press **Cal**. Wait for the calibration to complete before continuing.

Horizontal Calibration

Initial Write Gun Board Checks

1. Check all of the jumper settings on the board, making sure that they are all in the correct position.

- J1 NORM
- J2 NORM
- J3 Set for appropriate instrument (SCD1000 or SCD5000)
- J4 No jumper installed

2. Check for the presence of the correct reference voltages on the board:

- U842 pin 11 +10.0V ± 0.10V
- Q411 pin 1 +32.0V ± 1.5V

Initial Horizontal High Frequency Compensation Adjust

1. Set the test oscilloscope to:

   Sweep: 200 ns/div
   Trig: NORM
   Trigger Slope: (+)
   Trigger Source: CH1
   Vertical Range: 20V/div
   Vert. Coupling: DC
   BW: Full
   Display Mode: ALT

2. Connect the 7A26 probes to TP7 (ch1) and TP8 (ch2) on the Write Gun board.

3. Run the Write-Gun/Z-axis calibration routine on the PC controller at the DOS prompt.

```
wgzacal 5ns /d250 /g<addr>
```

4. Adjust C331 and C341, 20ns timing (caps), So that the ramp is peaked at the end of sweep, just below the point where the peaking drives the transistor into saturation. Be careful not to overcompensate the circuit when adjusting these caps--excessive compensation will saturate the transistors and noticeably increase the ramp recovery time.

5. REMOVE the probes from the Write Gun board test points and return the instrument to Digital Mode operation

Internal Horizontal Calibration

1. Set Cal Mode to Horiz from the SCD Utility menu (3rd level menu). For the SCD5000, connect the front panel calibrator output signal to the signal input using the 8" calibration cable, Tektronix part number 012-0118- 00.
2. Press the Cal button and wait for the calibration to finish (about 5 minutes).

NOTE

If horizontal calibration fails in as SCD1000, it may be due to offset of the vertical or read system. If the calibrator signal appears offset during calibration, adjust Vertical Size And Position, and try running Horizontal Calibration again.

20 ns Linearity Adjustment

1. the synthesizer frequency to 500 MHz, amplitude to approx 2.5 V p-p (RF level approx 8 dBm).
2. the sweep linearity/accuracy program from the PC controller for the 20 ns window

```
linacc 20ns /d250 /g<addr> [/f /c /l /a /b]
```

3. Check that the sweep accuracy is < ±0.50%. Adjust the sweep accuracy calibration constant so that the sweep accuracy is < ±0.50%. This can be accomplished from the linear program by using the cc command from the keyboard.
4. Adjust C331 and C341 (20 ns Adjust) for a LINACC linearity measurement of less than ±3.5%. The yellow linearity line should be about +2.0% at the left side of the display, decreasing to about -2.0% at fight side of the display. Note the measured sweep accuracy given beneath the graticule.
5. Adjust the sweep accuracy calibration constant so that the sweep accuracy is < ±0.50%. This can be accomplished from the linear program by using the cc command from the keyboard.
6. Set the trigger delay to 0% and Check that the difference between the sweep accuracy at 250% delay is within 1.00% of the sweep accuracy at 250% delay.
7. Adjust C331 (top), for less than 1.00% difference in sweep accuracy between 0% delay and 250% trigger delay. Note that several iterations observing 0% delay compared to 250% trigger delay may be necessary.

Internal Horizontal Calibration

1. Set Cal Mode to Horiz from the SCD Utility menu (3rd level menu). For the SCD5000, connect the front panel calibrator output signal to the signal input using the 8" calibration cable, Tektronix part number 012-0118- 00.
2. Press the Cal button and wait about 5 minutes for the calibration to finish.

Sweep Accuracy and Linearity Check

1. Set the synthesizer frequency to 2000 MHz, amplitude to approx 2.5 V p-p (RF level approx 8 dBm).
2. Run the sweep linearity/accuracy program from the controller for the 5 ns window:

```
linacc 5ns /d250 /g<addr> [/f /c /l /a /b]
```

3. Check that the sweep accuracy is < ±2.5% and sweep linearity is <3.5% from 0% trigger delay to 500% trigger delay.
4. Repeat the above steps using the information given in the Table 5-9.

Table 5-9: Sweep Accuracy and Linearity

Acquisition Window	SG Frequency	SG Amplitude	Timing Accuracy	Timing Linearity
5 ns	2000 MHz	2.5 V p-p	±2%	±3.5%
10 ns	1000 MHz	2.5 V p-p	±2%	±3.5%
20 ns	500 MHz	2.5 V p-p	±1.5%	±3.5%
50 ns	200 MHz	2.5 V p-p	±1.5%	±3.5%
100 ns	100 MHz	2.5 V p-p	±1.5%	±3.5%
200 ns	50 MHz	2.5 V p-p	±1.5%	±3.5%
500 ns	20 MHz	2.5 V p-p	±1.5%	±3.5%
1 μs	10 MHz	2.5 V p-p	±1.5%	±3.5%
2 μs	5 MHz	2.5 V p-p	±1.5%	±3.5%
5 μs	2 MHz	2.5 V p-p	±1.5%	±3.5%
10 μs	1 MHz	2.5 V p-p	±1.5%	±3.5%
20 μs	500 kHz	2.5 V p-p	±1.5%	±3.5%
50 μs	200 kHz	2.5 V p-p	±1.5%	±3.5%
100 μs	100 kHz	2.5 V p-p	±1.5%	±3.5%

5. If any of the sweep speed do not meet the above adjustment limits, return to step 1 and repeat the rest of the procedure. Note that several iterations may be required to meet the above adjustment limits.

Vertical System Calibration (SCD1000 Only)

Check Vertical Deflection

1. Set the SCD for:

   Vertical range: 5 V
   Input coupling: AC
   Vertical mode: CHA
   Vertical offset: 0 V

2. Set the Leveled Sine Wave Generator (SG503) for 1 MHz signal, 2 V p-p amplitude. Connect the SG503 output to the CH A input.

3. Set the test oscilloscope for:

   V/division: 10 V/division
   Input coupling: DC
   Time/division: 500 ns
   Triggering: INT

4. Set the SCD on its left side and remove the bottom cover to allow access to the CRT vertical termination.

5. Connect the probe lead to one side of the CRT vertical termination, below the inductor leading to the vertical plates. Figure 5-21 shows the underside of the SCD. The probes must go on the left side of the inductor's lead on the terminal board.

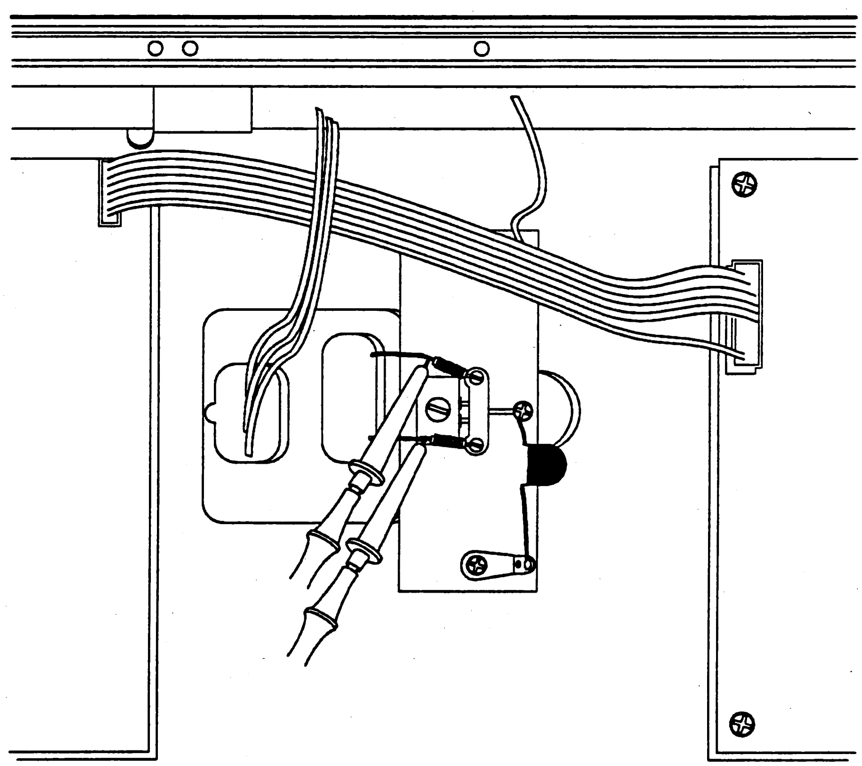


Figure 5-21: CRT Vertical Termination

6. Check the test oscilloscope for approximately 28 V deflection from the ground reference.
7. Move the probe to the other CRT termination lead. Check for a like amount of deflection (within 3 volts).
8. Set the test oscilloscope vertical coupling to AC, and range to 0.5 V/division.
9. Check for approximately 2.4 volts (4.8 divisions) deflection at the CRT termination.
10. Check the other CRT termination lead for a like amount of deflection (within 0.5 V).
11. Remove the test probes, install the bottom cover, and tip the SCD back down on the bench surface.

Input Calibration (SCD 1000 Only)

Channel A Input Adjust

NOTE

The input current and impedance adjustments are highly interactive. Exercise proper care when adjusting these parameters.

1. Connect equal-length BNC cables to both sides of a BNC "T" connector.
2. Connect one cable to the VOLTS/OHMS and the other cable to the OHMS SENSE using the BNC to banana jack adapters. Be sure that the GND plug is inserted into the LOW input of the DVM.
3. Set the DVM to enable Ohms Comp. (prog 1, TEK DM5120 only). Set the SCD channel A input range to 100 mV. Connect the BNC "T" to the channel A input.
4. Run the batch program FINDA from the GPIB controller. This batch file will iteratively adjust the input current and resistance, running each calibration three times.
5. While adjusting the SCD channel A input range from 100 mV to 10 V, check that the input current (measured as voltage across the 50 Ω input resistance) measures 0 V ±.50 mV (±10 μA) for channel A input current.
6. Check that the input resistance measures 50 ±0.25 Ω while adjusting the SCD channel A input range from 100 mV to 10 V.

Channel B Input Adjust

1. Repeat *Channel A Input Adjust* procedure for the channel B input. Connect the BNC "T" connector to channel B and run the batch file FINDB on the GPIB controller to calibrate the SCD channel B input current and resistance.

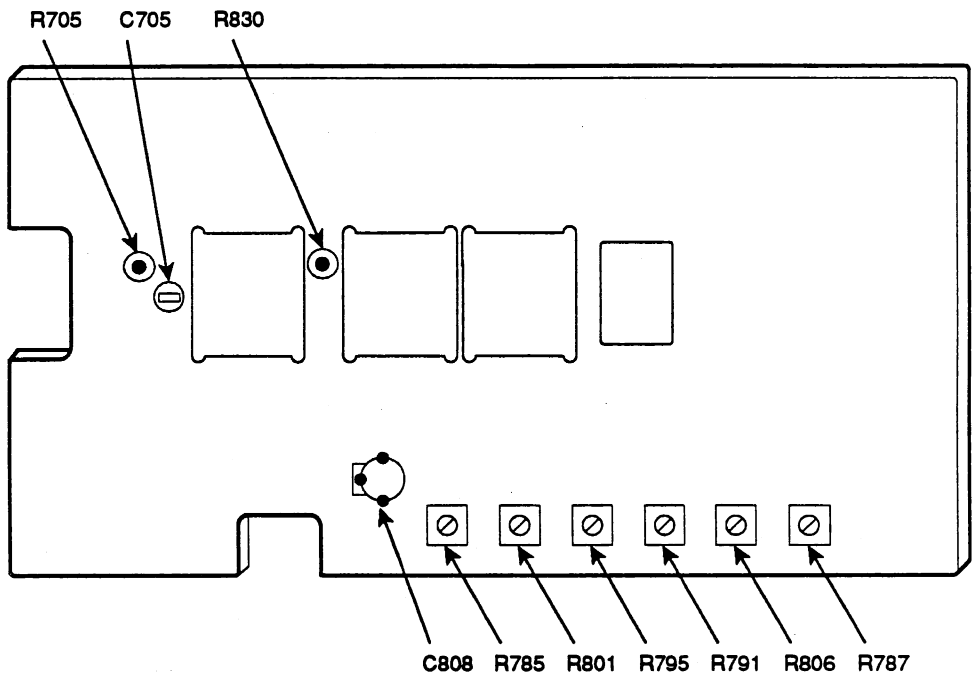


Figure 5-22: Output Amp Adjustment Points

CRT Termination Compensation (SCD1000 Only)

1. Set the SCD1000 for:

   CHAN: A
   Range: 100 mV
   vert. coupling: DC
   acq. window: 5 μs

2. Connect the PG506 Fast Rise output through a 10× attenuator to the channel A input.
3. Remove the instrument bottom cover and leave the instrument standing on its left side.
4. Set the PG506 amplitude for 1 μs period, approximately 1/2-screen amplitude on the SCD1000 (adjust the SCD1000 Offset control to center the square wave).
5. Set the SCD acquisition window to 20 ns and the trig delay to 0%.

6. Look at the first 4 to 5 ns of the step response on the SCD display. Adjust the pot (A22 CRT Termination) for the smallest aberrations and flattest top in the first 4 ns of the pulse as shown in Figure 5-23.

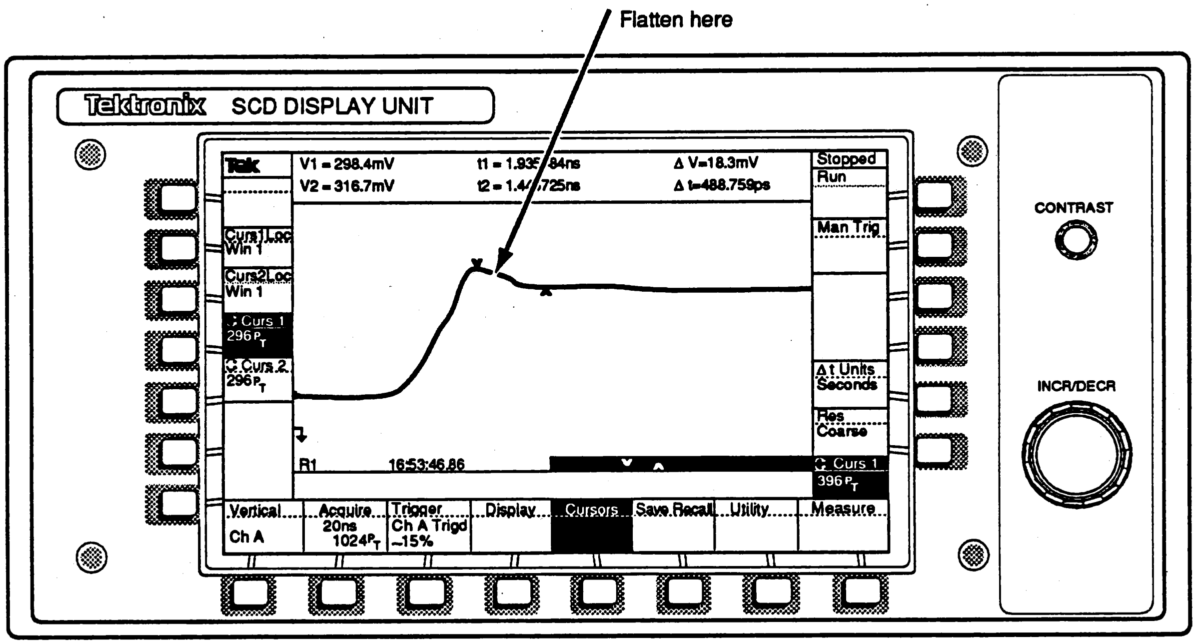


Figure 5-23: CRT Termination Compensation

Output Amp Gain and Feedbeside

NOTE

Adjusting the gain and transient response on the Output Amp is complicated and interactive. Use caution in adjusting this section of the amp.

1. Insert a 7A13 differential amplifier into the vertical compartment of the test oscilloscope.
2. Set the test oscilloscope for:

   7A13 vertical range: 1 V/division.
   Vertical offset: 0 V
   Coupling: DC on both inputs.
   time/division: 200 μs

3. Connect the PG506 to the channel A input and set it to STD AMPL, 100 mV.

4. Set cco156:127. This centers the channel A gain for the following adjustments. (Refer to *How to Change Cal Constants With CCO.*)

5. Connect properly compensated and calibrated probes for the 7A13 to the vertical deflector termination inductors as shown in Figure 5-21. You should see a 6 V (6 division) peak-to-peak square wave on the oscilloscope as shown in Figure 5-24. Establish a ground reference on the oscilloscope using the 7A13 Position control, then use the SCD Vertical Offset control to center the waveform on the test oscilloscope's screen.

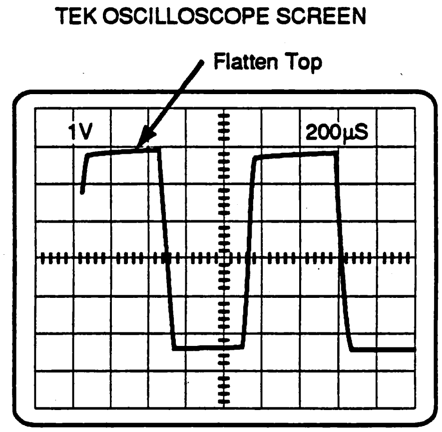


Figure 5-24: Output Amp Gain and Feedbeside Adjustments

6. Adjust R830 (GAIN) on the Output Amplifier board for exactly 6 V measured on the test scope.

NOTE

If R830 is ever readjusted, repeat the feedbeside adjustments described in the following steps.

7. Reconnect the PG506 Fast Rise output to the channel A input through a 10× attenuator.

NOTE

Check flatness with the test oscilloscope, not the SCD display, because the slow timing ranges necessary are not available in the SCD. Also, for this adjustment be sure you are looking at the TOP level of the PG waveform. (For the –1 V to 0 V pulse, the 0 V level is the good, flat top.)

8. Set the PG506 amplitude for six divisions on the test oscilloscope with the period from 1 μs to 100 ms. If necessary, make the following feedbeside adjustments to achieve the best flat top as shown in Figure 5-24:
   - adjust C808 and R785 at 1 MHz
   - adjust R801 at 100 kHz
   - adjust R795 at 10 kHz
   - adjust R791 at 1 kHz
   - adjust R806 at 100 Hz
   - adjust R787 at 10 Hz
9. If any adjustments were made in step 8, repeat the adjustments in the following order:
   - adjust R787 at 10 Hz
   - adjust R806 at 100 Hz
   - adjust R791 at 1 kHz
   - adjust R795 at 10 kHz
   - adjust R801 at 100 kHz
   - adjust C808 and R785 at 1 MHz
10. If any adjustments were necessary for steps 8 or 9, continue looping through steps 3 through 9 until no adjustments are necessary for step 6, Output Amp Gain. Several loops may be necessary to adjust the SCD properly.

Vertical Size (Read Gun Board Y-ramp Size) and Position

1. Connect the PG506 standard amplitude to the channel A input with Pulse Amplitude at 100 mV. Verify that the test oscilloscope shows a six-division waveform.
2. Set the SCD to a 100 μs acquisition window. Trigger on the rising edge of the signal, and adjust the SCD trigger delay to find the falling edge where both high and low levels for the signal are visible on the SCD display screen (approximately 450%) as shown in Figure 5-25.

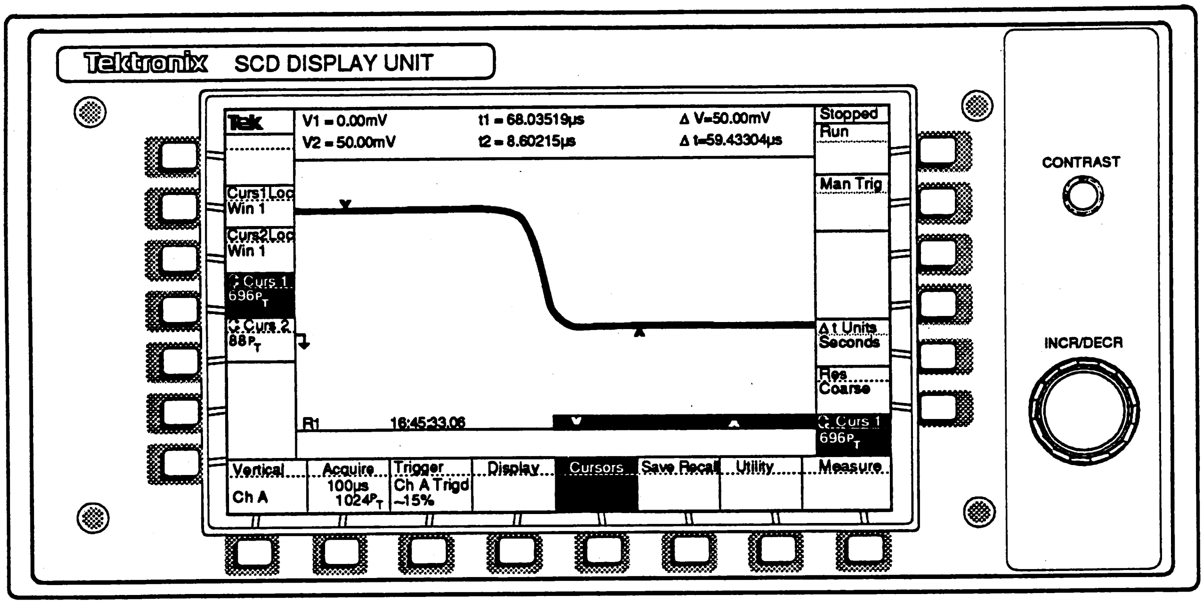


Figure 5-25: Vertical Size and Position Adjustment

3. Adjust cal constant 17 (Y-ramp size) for exactly 1/2 screen amplitude (50.0 mV) on the SCD display. Cal constant 17 is nominally 127 (refer to *How to Change Cal Constants With CCO*). Use the cursors or internal SCD measurements (BASE-TOP amplitude) to help make this measurement. Vary the vertical offset on the SCD, if necessary, to help make the measurements for adjusting cal constant 17.
4. Set the SCD channel A coupling to OFF.
5. Set cco0:2048. Then adjust cco10 to center the trace on the test oscilloscope (0 V on the SCD vertical deflector).
6. Adjust cal constant 10 (Y position) to center the displayed trace on the screen. Cal constant 10 is nominally 127. Use the cursors or internal SCD measurements (Mean) to help make this measurement as shown in Figure 5-26.

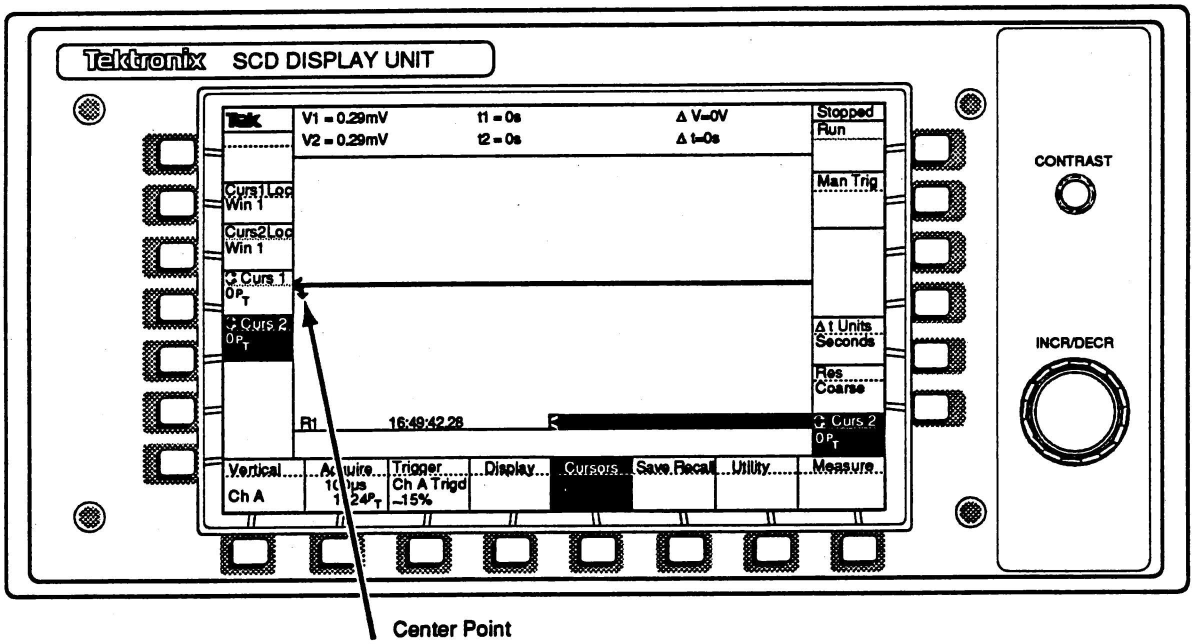


Figure 5-26: Vertical Centering Adjustment

Internal Vertical Calibration

1. Remove the signals from the channel A input. Remove the probes from the CRT termination and reinstall all instrument covers.
2. Select **Cal Mode**: Vertical, then press **Cal**:Stopped in the Utility menu to start calibration.
3. Wait for the internal vertical calibration routines to complete the offset and gain calibration (approximately 5 minutes for SCD1000)
4. Verify that calibration completes successfully with a GPIB query or by reading the front-panel status messages.

Fast Transient Response

The adjustments made in this procedure must be set for a compromise between system bandwidth and step response aberrations. Aberrations will typically be about +6–7% in the first ~400 ps, followed by about -3% in the next ~400 ps, followed by aberrations less than ±2% for the rest of the waveform.

The trigger delay must be calibrated so that the triggering event is visible before performing this procedure. If the trigger delay hasn't been calibrated, do so now by following the *Internal Horizontal Calibration* procedure.

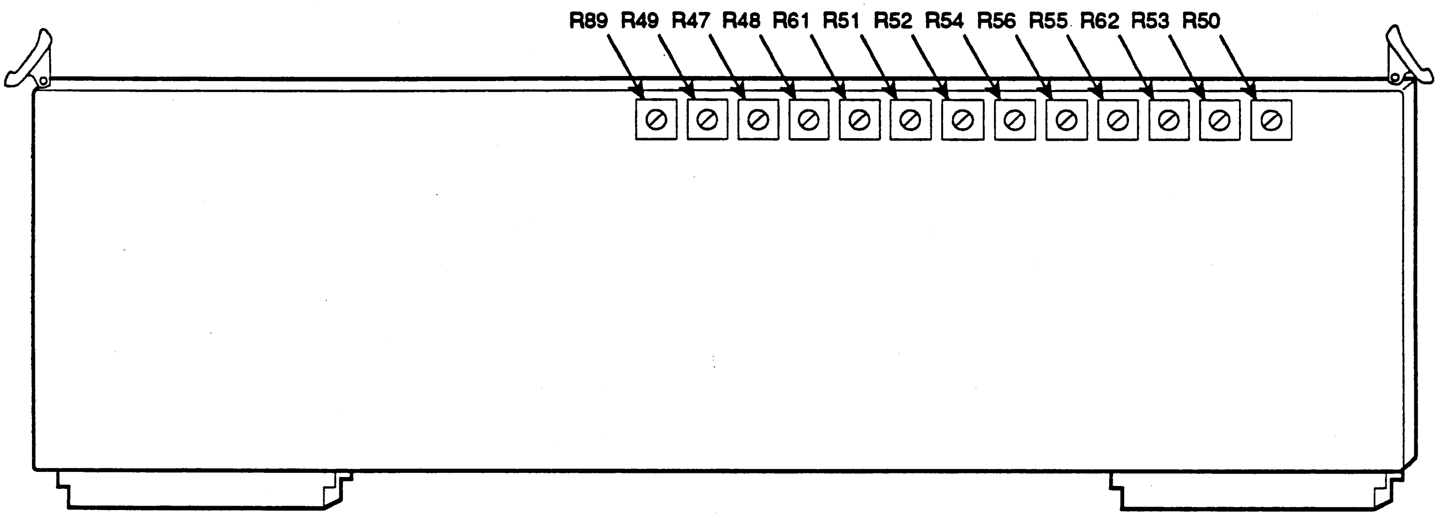


Figure 5-27: Analog Board Adjustment Points

1. Set the SCD for:

   Vert Mode: A
   Channel sel: A
   Range: 500 mV
   Offset: +100 mV (± about 50 mV)
   Coupling: DC
   Invert: Off
   Trig Mode: Normal
   Trig Level: 0%
   Time Window: 2 μs

2. Connect the TD Pulser output directly to the channel A input. Set the PG506 to High Amplitude, and turn the pulse amplitude to maximum. Set the PG506 period to 1 μs.

3. Set the CG frequency to 100 kHz. Adjust the TD triggered level control to the miniumum level which will provide a fast rise pulse output (approximately 250 mV).

4. Set the SCD Time Window to 10 ns.

5. Remove the instrument top cover.

6. Adjust R705 and C705 on the Output board for best rise time with aberrations less than +7%, -3%, and less than 12% peak-to-peak overall.
7. As before, adjust the following for square corner, flat top, aberrations less than +7%, -3%, and less than 12% peak-to-peak overall as shown in Figure 5-28. Do this by adjusting the following components on the Analog board:
   - R61 (A Thermal)
   - R47 (A HF 1)
   - R48 (A HF 2)
   - R49 (A HF 3)
   - R50 (A HF D)

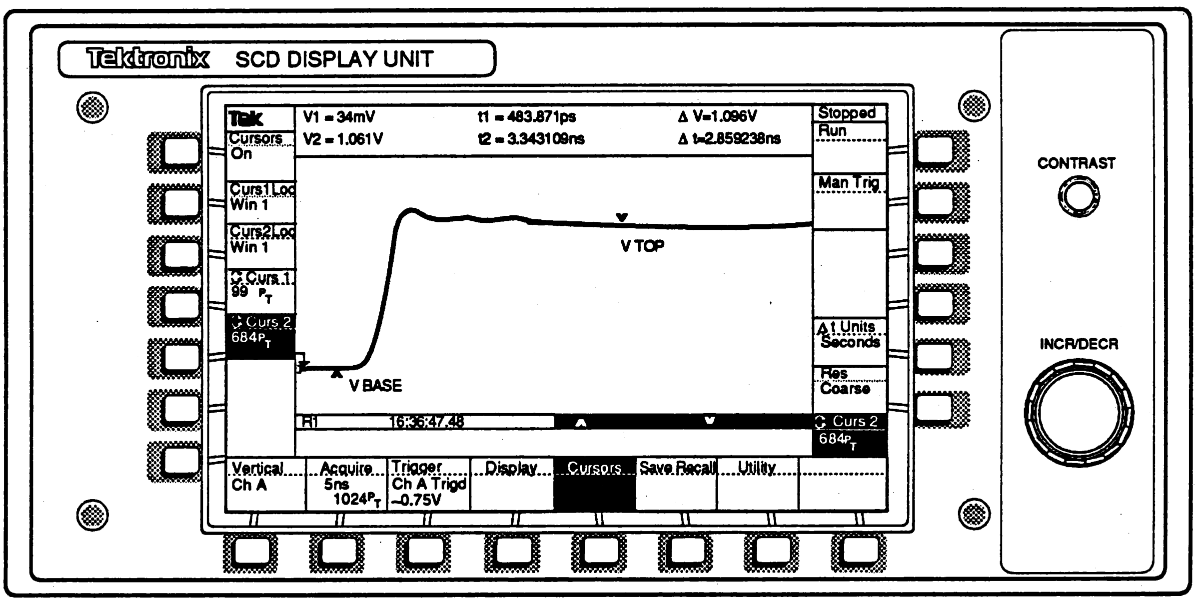


Figure 5-28: Output Adjustment

8. R50 may affect the channel A vertical gain adjustment. If you adjust R50, recheck the channel A vertical gain adjustment before proceeding further. Then repeat the above adjustments in step 6 as necessary for the best overall transient response.
9. Move the TD Pulser output to CH B input. Readjust the TRD triggered level to the minimum level required for fast-rise output.

10. Adjust for square corner, flat top, aberrations less than +7%, -3%, and less than 12% peak-to-peak overall by adjusting the following components on the Analog board:
    - R62 (B Thermal)
    - R56 (B HF 1)
    - R55 (B HF 2)
    - R54 (B HF 3)
    - R53 (B HF D)
11. R53 may affect the channel B vertical gain adjustment. If you adjust R53, recheck the channel B vertical gain adjustment, then repeat the above adjustments in step 10 as necessary for the best overall transient response.
12. Reinstall instrument covers.

Bandwidth Check (SCD1000 Only)

1. Set the SCD for:

   Vert Mode: CHA
   Range: 100 mV
   Offset: 0 mV
   Coupling: DC
   Invert: Off
   Trig Mode: Normal
   Trig Level: 0%
   Time Window: 1 μs

2. Connect the SG504 Output Head through a 10× and a 2× attenuator (or the Wiltron 6722A-20 output) to the channel A input. Set the output frequency to REF (6 MHz for SG, 10 MHz for Wiltron).
3. Adjust the output amplitude for a 70 mV p-p signal. Use the cursors or measurements (VBASE-TOP) to make this measurement.
4. Set the SG output frequency to 500 MHz.
5. Verify that the measured waveform is at least 51.8 mV in amplitude (74% of the reference signal) by using 100 MHz steps in frequency from 500 MHz through 1000 MHz.
6. Set the SCD channel A invert to ON. Set the SG frequency to REF.
7. Adjust the output amplitude for a 70 mV p-p signal. Use the cursors or measurements (VBASE-TOP) to make this measurement.
8. Set the SG output frequency to 1000 MHz.
9. Verify that the measured waveform is at least 51.8 mV in amplitude (74% of the reference signal). Set the SCD channel A invert to OFF.

10. With the SG frequency set to 1000 MHz, verify that the signal amplitude is at least 74% of the reference frequency amplitude set for each range, for the settings listed in Table 5-10.

11. Repeat the entire Bandwidth Check procedure for the channel B input.

Table 5-10: 1000 MHz Bandwidth

Volts/Window	SG Amplitude	Attenuators Needed	Min. Measured Amplitude
100 mV	70 mV	2X and 10X	51.8 mV
200 mV	140 mV	10X	103.6 mV
500 mV	350 mV	5X	259.0 mV
1 V	700 mV	2X	518.0 mV
2 V	1.40 V	2X	1.04 V
5 V	3.50 V	none	2.59 V
10 V	4.50 V	none	3.33 V

Vertical System Calibration (SCD5000 Only)

Internal Calibration

1. Remove the signals from the SCD input. Connect the SCD5000 calibrator output signal to the SCD input using the 50 Ω coaxial cable, Tektronix part number 012-0118-00.
2. Select Cal Mode: Vertical, then press Cal:Stopped in the Utility menu to start calibration.
3. Wait for vertical autocal to complete offset and gain calibration.
4. Verify that calibration completes successfully via GPIB query or front panel status messages.

Bandwidth Check (SCD5000 Standard)

1. Set the synthesizer output to –50 dBm.
2. Connect the frequency synthesizer output to the precision power splitter input. Connect one output of the splitter to a precision SMA-N adapter (if standard N connectors are present), then directly to the SCD input. Connect the power meter's RF power sensor through a 20 dB (10×) attenuator to the other output of the precision splitter.
3. Set the SCD for:

   Acquire Time:1 µs
   Acquire Length: 1024pt
   Hold Next: On
   Trigger Mode: Normal
   Trigger Source: EXT
   Trigger Level: 0%

4. Set the synthesizer for:

   Frequency: 0.01 GHz (CW)
   RF Level: -10 dBm

   Power Meter
   Mode: REL
   Frequency: 10 MHz

5. Adjust the signal generator to give 50% full-scale displayed output at the 10 MHz reference frequency. Use the display cursors or measurements (VBASE-TOP) to verify the displayed amplitude.
6. Set the power meter to relative measurement (press the **REL** button). The power meter readout should be 0.00 dB.
7. Adjust the signal generator to 500 MHz, set the SCD Acquire time window to 5 ns, adjust the synthesizer output level until the power meter reads 0 dB ±0.1 dB.

8. Acquire a waveform and measure the amplitude using measurements (VBASE-TOP) or compute the average peak-to-peak amplitude of the waveform by taking several cursor measurements across the cycles displayed on screen.

9. Verify that the measured amplitude is greater than the minimum displayed amplitude given in Table 5-11 for the following frequencies and relative amplitudes. Adjust the signal generator output level at each frequency so the power meter reads 0 dB ±0.1 dB.

Table 5-11: SCD5000 Standard Frequency Response Limits

Frequency	Low Limit	Display Amplitude (50% ref.)	Min. Measured Amplitude (2.5 V ref.)
1000 MHz	-1.0 dB	45%	2.25 V
2000 MHz	-1.5 dB	42%	2.1 V
3000 MHz	-2.5 d	38%	1.9 V
4000 MHz	-2.5 dB	38%	1.9 V
4500 MHz	-3.0 dB	35.5%	1.775 V

Bandwidth Check (SCD5000 Option 01)

1. Set the synthesizer output to -50 dBm, and power up the HF amplifier.

2. Connect the frequency synthesizer output to the precision power splitter input. Connect one output of the splitter to a precision SMA-N adapter (if std N connectors are present), then directly to the SCD input. Connect the power meter's RF power sensor through a 20 dB (10×) attenuator to the other output of the precision splitter.

3. Set the SCD for:

   Acquire Time: 20 ns
   Acquire Length: 1024pt
   Hold Next: On
   Trigger Mode: Normal
   Trigger Source: EXT
   Trigger Level: 0%

4. Set the synthesizer for:

   Frequency: 0.25 GHz (CW)
   RF Level: -10 dB

   Power Meter Setup
   Mode: REL
   Frequency 250 MHz

5. Adjust the signal generator to give 25% full-scale displayed output at the 250 MHz reference frequency. Use the display cursors or measurements (VBASE-TOP) to verify the displayed amplitude.

6. Set the power meter to relative measurement (press the **REL** button). The power meter readout should be 0.00 dB.

7. Adjust the signal generator to 500 MHz, set the SCD Acquire time window to 5 ns, adjust the synthesizer output level until the power meter reads 0 dB ±0.1 dB.

8. Acquire a waveform and measure the amplitude using measurements (VBASE-TOP) or compute the average peak-to-peak amplitude of the waveform by taking several cursor measurements across the cycles displayed on screen.

9. Verify that the measured amplitude is greater than the minimum displayed amplitude given in Table 5-12 for the following frequencies and relative amplitudes. Adjust the signal generator output level at each frequency so the power meter reads 0 dB ±0.1 dB.

Table 5-12: SCD5000 Standard Frequency Response Limits

Frequency	Low Limit	Display Amplitude (25% ref.)	Min. Measured Amplitude
500 MHz	-1.0 dB	22.5%	2.25 V
1000 MHz	-1.0 dB	22.5%	2.25 V
1500 MHz	-1.5 dB	21%	2.1 V
2000 MHz	-2.5 d	19%	1.9 V
2500 MHz	-2.5 dB	19%	1.9 V
3000 MHz	-3.0 dB	17.8%	1.78 V

Trigger Calibration

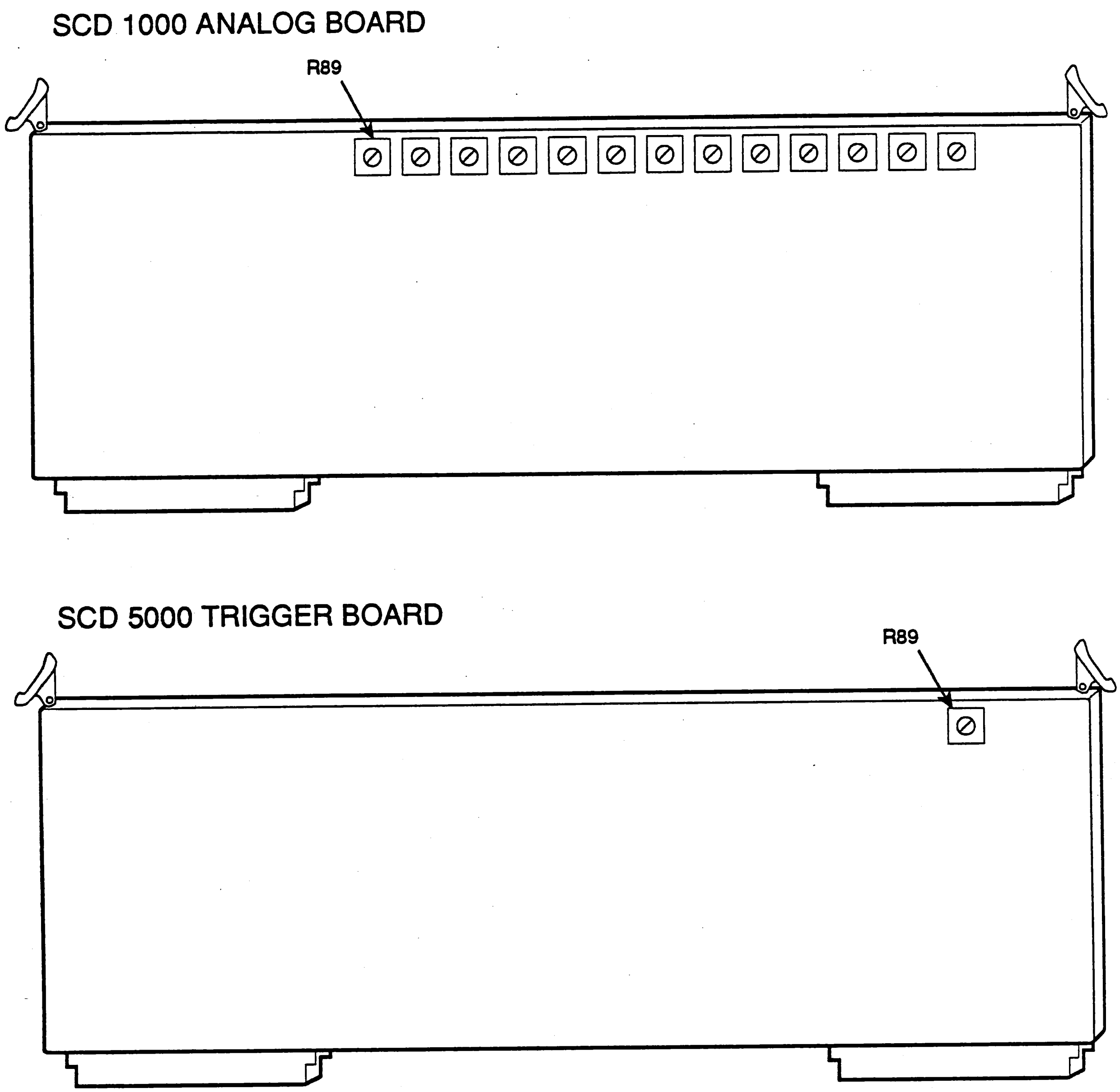


Figure 5-29: Trigger Board Adjustment Points

Internal Trigger Calibration

1. Run Trigger Cal from the Utility menu. Select **Cal Mode**: Trigger, then **Cal**: Stopped to start calibration. Wait for the calibration routine to complete (2 minutes for the SCD1000, 30 seconds for SCD5000). Verify that the calibration completed successfully by sending the GPIB command `CALIBRATE?` or by examining the Display Unit status messages.

2. Adjust R89 (TR), the Trigger Sensitivity adjustment (on the SCD1000 Analog board or the SCD5000 Trigger board) fully counterclockwise, then about 90° clockwise.

3. If you are calibrating the SCD1000, adjust R51 (AT) and R52 (BT), the A & B High Frequency trigger adjustments, fully counterclockwise, then about 45° clockwise.

External Trigger Calibration

1. Connect the FG to the GPIB bus at address 24. Connect the FG output to a signal splitter.

2. From the GPIB controller, run the program CALTRIG by entering the following command line as the DOS prompt:

   ```
   CALTRIG /g<addr>
   ```

   where <addr> is the GPIB address of the instrument.

3. Follow the signal connection instructions given by the program, then choose selection 1 – calibrate ALL. Wait for the calibration to complete, and verify that all sections pass the specification limits.

Internal Trigger Sensitivity (SCD1000 and SCD5000 with Option 01)

The internal trigger sensitivity calibration has two different parts: the Internal Sensitivity calibration, and the Internal High Frequency Jitter check. For the SCD5000 with Option 01, all input signal voltages given for the SCD1000 should be multiplied by 10.

Part I: Internal Sensitivity

1. Set the SCD for:

   time window: 20 ns
   trigger slope: positive
   trigger source: channel A
   vertical range: 100 mV
   Holdnext: off

2. Connect the SG503 to the channel A input. Set the SG503 frequency to 249 MHz, and adjust the output for a 40 mV p-p signal. (400 mV p-p for SCD5000 with Option 01).

3. Set the SCD vertical range to 1 V.

4. Set the SCD Acquire State to Running, then check for a stable-triggered waveform display (the TRIG'D indicator will appear) with the trigger coupling set to DC, then set to AC. Adjust the trigger level as necessary to achieve a stable displayed trace.

5. Set the triggering slope to negative and repeat step 4.

6. If after at least 20 acquisitions the SCD can not acquire with a stable trigger point, adjust R51 (AT) on the Analog board (SCD1000) or R89 (TRIG) on the Trigger board (SCD5000 with Option 01), 45° counterclockwise and repeat the channel A trigger tests above.
7. Connect the SG503 output to the channel B input.
8. Set the SCD1000 for:

   trigger source: CHB
   vert chan.: CHB
   vertical range: 1 V

9. Set the SCD Acquire State to Run, and check for a stable-triggered waveform on the display (the TRIG'D indicator will appear) with the trigger coupling set to DC, then set to AC. Adjust the trigger level as necessary to achieve a stable displayed trace.
10. Set the triggering slope to negative and repeat step 9.
11. If after at least 20 acquisitions the SCD can not acquire with a stable trigger point, adjust R52 (BT on Analog board) 45° counterclockwise and repeat the channel B trigger tests above.
12. Set the SCD for:

    acq. window: 5 ns
    trigger slope: positive
    trigger source: CHA (SCD1000)
    trigger source: INT (SCD5000 with Option 01)
    vertical range: 200 mV

13. For the SCD1000, connect the SG504 to the channel A input through a 10× attenuator. Set the SG504 frequency to 1000 MHz, and adjust the output for a 140 mV p-p signal.

    For the SCD5000 with Option 01, connect the SG504 to the channel A input. Set the SG504 frequency to 1000 MHz, and adjust the output for a 1.4 V p-p signal.

14. Set the SCD vertical range to 1 V.
15. Check for a stable-triggered display (the TRIG'D indicator appears) with the trigger coupling set to DC, then to AC. Adjust the trigger level as necessary to achieve a stable displayed trace.
16. Set the triggering slope to negative and repeat step 15.
17. If after at least 20 acquisitions the SCD can not acquire with a stable trigger point, adjust R51 (AT on the Analog board for SCD1000) or R89 (TRIG on Trigger board for SCD5000 with Option 01) 45° counterclockwise and repeat the channel A trigger tests immediately above.
18. Connect the SG504 output to channel B input.

19. Set the SCD1000 for:

    trigger source: CHB
    trigger slope: positive
    vert chan.: CHB
    vertical range: 2 V

20. Check for a stable-triggered display (the TRIG'D indicator appears) with the trigger coupling set to DC, then to AC. Adjust the trigger level as necessary to achieve a stable displayed trace.
21. Set the triggering slope to negative and repeat step 20.
22. If after at least 20 acquisitions the SCD cannot acquire with a stable trigger point, adjust R52 (BT on the Analog board) 45° counterclockwise and repeat the channel B trigger tests above.

Part II: Internal Trigger Jitter (SCD1000 and SCD5000 with Option 01)

1. Set the SCD for:

    acquire state: run
    hold next: off
    acquire: 1024 pt

2. Set the SG504 output connected to the SCD channel A input, set the SG504 output for a 500 mV p-p signal (5 V p-p for SCD5000 with Option 01). Set the SCD Acquire State to Run.
3. Watch at least 20 acquisitions and make sure the display is stable with less than 30 ps (3 pixels on Display Unit screen) of visible jitter.
4. If the SCD cannot acquire with a stable trigger point (watch a minimum of 20 acquisitions), adjust R51 (AT on the Analog board for the SCD10000) or R89 (TRIG on the Trigger board for the SCD5000 with Option 01) 45° counterclockwise and repeat step 3.
5. For the SCD1000, repeat steps 1 through 4 for the SCD channel B input.

External Trigger Sensitivity and Jitter

The external trigger sensitivity calibration has four different parts: the External Low Frequency Trigger Sensitivity calibration, External Mid Frequency Trigger Sensitivity, the External High Frequency Trigger Sensitivity, and the External Trigger Jitter calibration. The setups for each of these parts is shown in Figure 5-30.

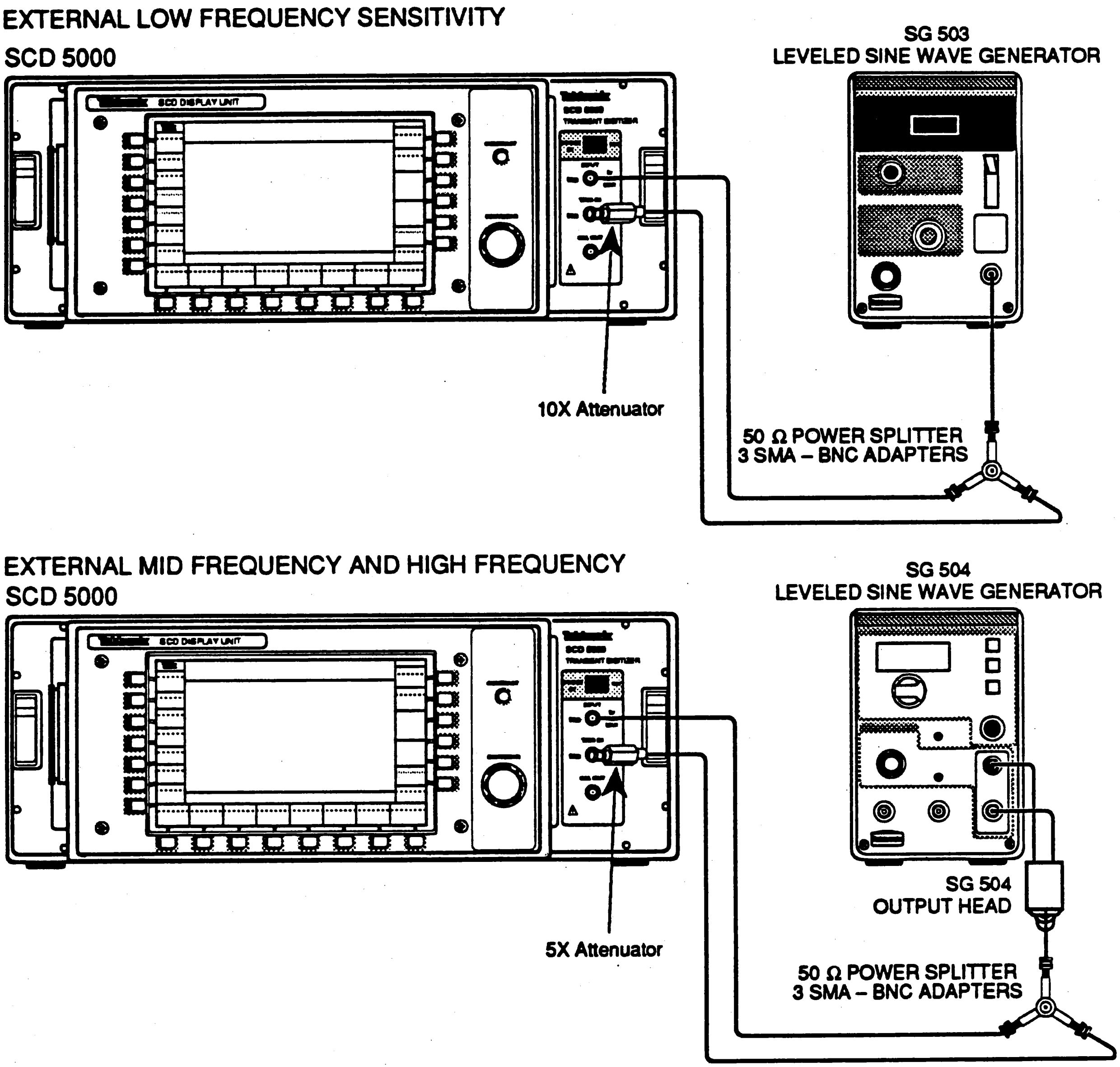


Figure 5-30: External Trigger Sensitivity and Jitter Calibration

External Low Frequency Trigger Sensitivity

1. Set the SCD1000 for:

   time window: 1 μs
   vertical range: 5 V
   vert chan: CHA
   trigger mode: NORM
   trigger coupling: DC
   trigger source: CHA
   trigger slope: positive
   trigger level: Stable display (TRIG'D indicator displayed)

If calibrating the SCD5000, use the same settings except for:

   vertical range: 5 V
   trigger source: EXT

2. Connect the FG5010 output through a power divider and a 10× attenuator to the SCD external trigger input as shown in Figure 5-30. Also connect the FG5010 output from the signal splitter to the channel A input.
3. Set the FG5010 frequency to 20 kHz. Adjust the FG5010 amplitude for a 400 mV p-p signal (40 mV at TRIG IN) measured using the SCD measurements (VBASE–TOP) or cursors.
4. Set the SCD trigger source to EXT.
5. Check for a stable-triggered display (TRIG'D indicator lit). Adjust the trigger level as necessary to achieve a stable displayed trace.
6. Set the trigger slope to negative and repeat step 5.
7. If after at least 20 acquisitions the SCD can not acquire with a stable trigger point, adjust R89 (TR) 30° counterclockwise and repeat the Low Frequency External Sensitivity trigger tests.

External Mid Frequency Trigger Sensitivity

1. Connect the SG504 output through a signal splitter and a 5x attenuator to the SCD external trigger input. Also connect the SG504 output from the signal splitter to the channel A input. Set the SG504 frequency to 500 MHz, and adjust the SG504 amplitude for a 700 mV p-p signal (140 mV at TRIG IN) as measured with SCD measurements (VBASE–TOP) or cursors.
2. Set the SCD trigger source to EXT and the time window to 5 ns.
3. Check for a stable-triggered display (the TRIG'D indicator on the Display Unit appears). Adjust the trigger level as necessary to achieve a stable displayed trace.
4. Set the trigger slope to negative and repeat step 3.
5. If after at least 20 acquisitions the SCD can not acquire with a stable trigger point, adjust R89 (TR) 30° counterclockwise and repeat the trigger tests immediately above.

External High Frequency Trigger Sensitivity

1. Set the SG504 frequency to 1000 MHz. Adjust the SG504 amplitude for a 1.5 V p-p signal (300 mV at EXT TRIG IN) measured using the SCD measurements (VBASE–TOP) or cursors.
2. Check for a stable-triggered display (TRIG'D indicator lit). Adjust the trigger level as necessary to achieve a stable displayed trace.
3. Set the trigger slope to negative and repeat step 2.
4. If after at least 20 acquisitions the SCD cannot acquire with a stable trigger point, adjust R89 (TR) 30° counterclockwise and repeat the *External Mid Frequency Trigger Sensitivity* test.

External Trigger Jitter

1. Remove the 10× attenuator from the TRIG IN input path and connect the output of the signal splitter directly to the TRIG IN input. Adjust the SG504 output for approximately 1.5 V p-p signal.
2. Set the SCD acquire length to 1024 points.
3. Watch at least 20 acquisitions, checking that the display is stable with less than 30 ps (three screen pixels width) of visible jitter. If too much jitter is observed, turn R89 30° counterclockwise and repeat this check.

NOTE

If either the AT and TR or the BT and TR pots are fully turned counterclockwise and still need adjustment, return the Analog board for repair.

4. Run Trigger Cal from the Utility menu. Select **Cal Mode**: Trigger, then **Cal:** Stopped to start calibration. Wait for the calibration routine to complete (2 minutes for the SCD1000, 30 seconds for SCD5000). Verify that the calibration completed successfully by sending the GPIB command CALIBRATE? or by examining the Display Unit status messages.

Post Calibration Procedure

Perform this procedure after completion of external calibration, or any subset of calibration.

1. Move jumper JP1 on the High Voltage Board onto pins 2-3 to re-enable the High Voltage Power Supply if it is still disabled.

2. Reinstall the card cage locking bracket, inspect the instrument for any missing or loose hardware, and reinstall the covers.

3. Save the SCD's new cal constants to disk in case the SCD's memory is ever corrupted. To read cal constants 0 through (M – 1) from the SCD at address N and store them in <file>, enter

   ```
   CONIO N <file> M
   ```

   It is suggested that you use the SCD serial number for the file name, with a .CCO extension (example: B020120.CCO) There are currently 352 cal constants, so use M=351.

4. Set a new calibration date using the following command:

   ```
   CAL DATE "yy-mm-dd"
   ```

   Include the double quotes and dashes in the command line.

5. Verify the time and date setting with the following queries:

   ```
   CLOCK? TIME
   ```

   ```
   CLOCK? DATE
   ```

   Change them if necessary with the following command syntax:

   ```
   CLOCK TIME "hh:mm:ss"
   ```

   ```
   CLOCK DATE "yy-mm-dd"
   ```

   Include the double quotes, dashes, and colons in the command lines.

6. Set the GPIB address switches on the rear panel as they were before the calibration. Set the rear panel power-up test switch to on. Close the MPU board DIP switch 1 to disable factory calibration commands.

   Make sure all instrument jumpers are set for correct instrument operation. Make sure all cables are securely connected in proper places. Make sure that card cage board hold-down clamp is securely installed. Make sure all instrument covers are securely installed with all screws.

Calibration Utilities

The following pages describe in detail the software and other utilities used during the Calibration Procedure.

How to Use the FIND Program

Several calibration routines use the FIND program to determine the best settings for certain calibration constants. To install FIND on the controller, copy the following files from the disk supplied with this manual into a directory on your hard disk drive, and add that directory to a path your system can find:

FIND.EXE

FINDA.BAT

FINDB.BAT

FINDCAL1.BAT

FINDCAL5.BAT

FINDA.SET

FINDB.SET

FINDCAL.SET

FINDHELP.DOC

The talker/listener program TALK (described on page 5-92) must also be loaded for the batch files to work.

Enter the following lines into the controller's AUTOEXEC.BAT file:

```
Set GPIBO=PC2A 0 0 0

Set MAN=ON

Set DM=(T for Tek DM5120 or FL for Fluke 8842A)
```

If your DMM is always used at the same GPIB address, then add the following line to the AUTOEXEC.BAT file:

```
SET AD=<gpib address of DMM>
```

Now, change to the directory that the FIND program is located in and enter FIND without any arguments. The program displays a help screen describing usage:

```
Usage: 'find pri:sec CCO Value
                |      |     |
                |      |     +--Ideal measured value
                |      +--Cal Const Location #
                +--GPIB address

For proper GPIB function
   SET GPIBO=PC2A 0 0 0
   Set MAN=(ON or OFF)
```

The FIND program uses a three step process to arrive at the correct cal constant value for the given function. First, the program measures the value of the function at the extremes of the cal constant range, and it does an interval bisection search to find the cal constant number which gives a measurement closest to the ideal value that was specified on the command line.

The second phase of the search consists of abandoning interval bisection, and doing a simple linear search, examining the measurements and picking the best value. This phase might be skipped, if the program finds exactly the right value.

The third (and optional) phase is a manual control situation, in which the + and – keys on the controller keyboard may be used to increment and decrement the cal constant number, while watching the readings on the DMM. This phase is entered only if MAN=ON is set as an environment variable in the AUTOEXEC.BAT file, or if the linear search is not able to find a satisfactory value. In this phase, cal constant numbers and function readings will not show up on the controller screen. When you are satisfied, type q to quit. Quitting gives an opportunity to view the result and correct it if necessary, and provides settling time for the adjustment.

How to Use Find Batch Files

FINDA.BAT, FINDB.BAT, FINDCAL1.BAT and FINDCAL5.BAT are batch files which call FIND for channel A functions, channel B functions, and calibrator functions. Each one takes the GPIB address of the SCD as a variable. For example, if the instrument is set at GPIB address 2, run FINDCAL5 by entering:

```
FINDCAL5 2
```

The batch files send the necessary setup instructions to the SCD over the GPIB bus, and connection instructions are displayed on screen for the operator, followed by a pause. Type any key to continue after the pause. Each individual step of the batch file ends by invoking the manual phase, which requires user interaction. Type +, –, or Q to continue after the pause.

FINDA.BAT and FINDB.BAT – are used for adjusting channel A and B input. The FINDA batch file assumes that a DMM is connected to the channel A input, using a "T" to connect to both the VOLTS/OHMS and the OHMS SENSE on the DMM.

FINDA.BAT uses TALK and FINDA.SET to set up the SCD as follows:

Coup: DC
Range: 100 mV
Offset: 0 V

FINDA.BAT adjusts the following cal constants:

- CHANNEL A IMPEDANCE (50 Ω), cal constant 2
- CHANNEL A CURRENT (0 volts), cal constant 4

FINDB.BAT makes similar adjustments for channel B and also adjusts the following cal constants:

- CH B IMPEDANCE (50 Ω), cal constant 3
- CH B CURRENT (0 volts), cal constant 5

FINDCAL1.BAT SCD1000 – is used in the Calibrator Amplitude calibration. The FINDCAL.BAT batch file assumes a DMM is connected with one cable to the Calibrator Output. FINDCAL.BAT uses TALK and FINDCAL.SET to set CALOUT EXTERNAL: AMPL.

FINDCAL1.BAT adjusts the following cal constants:

- CALIBRATOR –2.5 VOLTS, cal constant 170
- CALIBRATOR –2.0 VOLTS, cal constant 171
- CALIBRATOR –0.8 VOLTS, cal constant 172
- CALIBRATOR –0.4 VOLTS, cal constant 173
- CALIBRATOR –0.2 VOLTS, cal constant 174
- CALIBRATOR –.080 VOLTS, cal constant 175
- CALIBRATOR –.040 VOLTS, cal constant 176
- CALIBRATOR 0 VOLTS, cal constant 177
- CALIBRATOR +.040 VOLTS, cal constant 178
- CALIBRATOR +.080 VOLTS, cal constant 179
- CALIBRATOR +0.2 VOLTS, cal constant 180
- CALIBRATOR +0.4 VOLTS, cal constant 181
- CALIBRATOR +0.8 VOLTS, cal constant 182
- CALIBRATOR +2.0 VOLTS, cal constant 183
- CALIBRATOR +2.5 VOLTS, cal constant 184

FINDCAL5.BAT SCD5000

- CALIBRATOR –4.0 VOLTS, cal constant 205
- CALIBRATOR –3.0 VOLTS, cal constant 206
- CALIBRATOR –2.0 VOLTS, cal constant 207
- CALIBRATOR –1.0 VOLTS, cal constant 208
- CALIBRATOR –0.8 VOLTS, cal constant 209
- CALIBRATOR –0.4 VOLTS, cal constant 210
- CALIBRATOR –0.2 VOLTS, cal constant 211
- CALIBRATOR –0.1 VOLTS, cal constant 212
- CALIBRATOR 0.0 VOLTS, cal constant 213
- CALIBRATOR +0.1 VOLTS, cal constant 214
- CALIBRATOR +0.2 VOLTS, cal constant 215
- CALIBRATOR +0.4 VOLTS, cal constant 216
- CALIBRATOR +0.8 VOLTS, cal constant 217
- CALIBRATOR +1.0 VOLTS, cal constant 218
- CALIBRATOR +2.0 VOLTS, cal constant 219
- CALIBRATOR +3.0 VOLTS, cal constant 220
- CALIBRATOR +4.0 VOLTS, cal constant 221

Video Mode

The video mode operation provides the technician with a real time view of the CRT target through the use of a TV monitor. Input signals are thus displayed in a scope-like manner. This is accomplished by turning the Read Gun scan into a raster scan (similar to standard vidicon tubes), and triggering the Write Gun sweeps at a much faster rate. The Read Gun beam constantly scans the target compiling information into a composite video signal for an external TV monitor (TEK 634 type).

NOTE

Use video mode only as an aid in calibration or a tool in trouble-shooting. The instrument should not be run in video mode for any significant period of time. Internal firmware limits the time of video mode operation to approximately 5 minutes. For the last 15 seconds of video mode operation, the instrument will ring its bell (clicking sound) warning the user that video mode is about to time out. If the user wishes to continue in video mode operation, any front panel button will reset the timer allowing another 5 minutes. GPIB commands, except for the VIDEO ON command, will not reset the timer.

On the Read Gun Board, the Y-scan system (i.e., the "line" scan) has three scan sizes selected by jumper J804:

- 26 V scan for 1.77 mm deflection (normal SCD5000 Y-scan)
- 70 V scan for 4.75 mm deflection (normal SCD1000 Y-scan)
- 186 V scan for 12.7 mm deflection (video mode X-scan)

There are also two line scan durations, selected by jumper J801:

- 10.24 μs scan (normal Y-scan)
- 58 μs scan (video mode X-scan)

The X-scan system (i.e., the "field" scan) has two scan sizes selected by jumper J802:

- 186 V scan for 12.7 mm deflection (normal X-scan)
- 139 V scan for 9.5 mm deflection (video mode Y-scan)

Video Mode Instructions

Put the instrument into video mode as follows:

1. Remove the connectors J26 and J28.
2. Connect the cable from J26 (X-scan) to the pins for J28 (Y-scan), reversing pin 1 and pin 2 (solid color wire on the bottom). Pin 1 is always marked with a square in Figure 5-31.
3. Connect the Y-scan cable that was on J28 to J26, reversing pins 1 and 2 (solid color cable to the top).
4. Move J801 (the Y-scan duration selector jumper) from the N (normal) to V (video) position.
5. Move J804 from the 1.77 mm or 4.75 mm Y-scan selector pins to J802 (the 9.5 mm X-scan VIDEO size selector pins).
6. On the SCD5000 only, disconnect J803 (SAVER).
7. Connect a Peltola cable and a Peltola-cable-to-BNC adapter to J400 on the Control Board. Connect a 75 Ω BNC cable from the adapter to a video monitor.
8. Set the Acquire mode to 256 points.
9. Send the command VID ON from the controller to the SCD.
10. To restore normal operation, send the command VID OFF and reverse this procedure.
11. Replace the jumper on J804 on pins 1-2 (S) for the SCD5000 and on pins 2-3 (L) for the SCD1000.

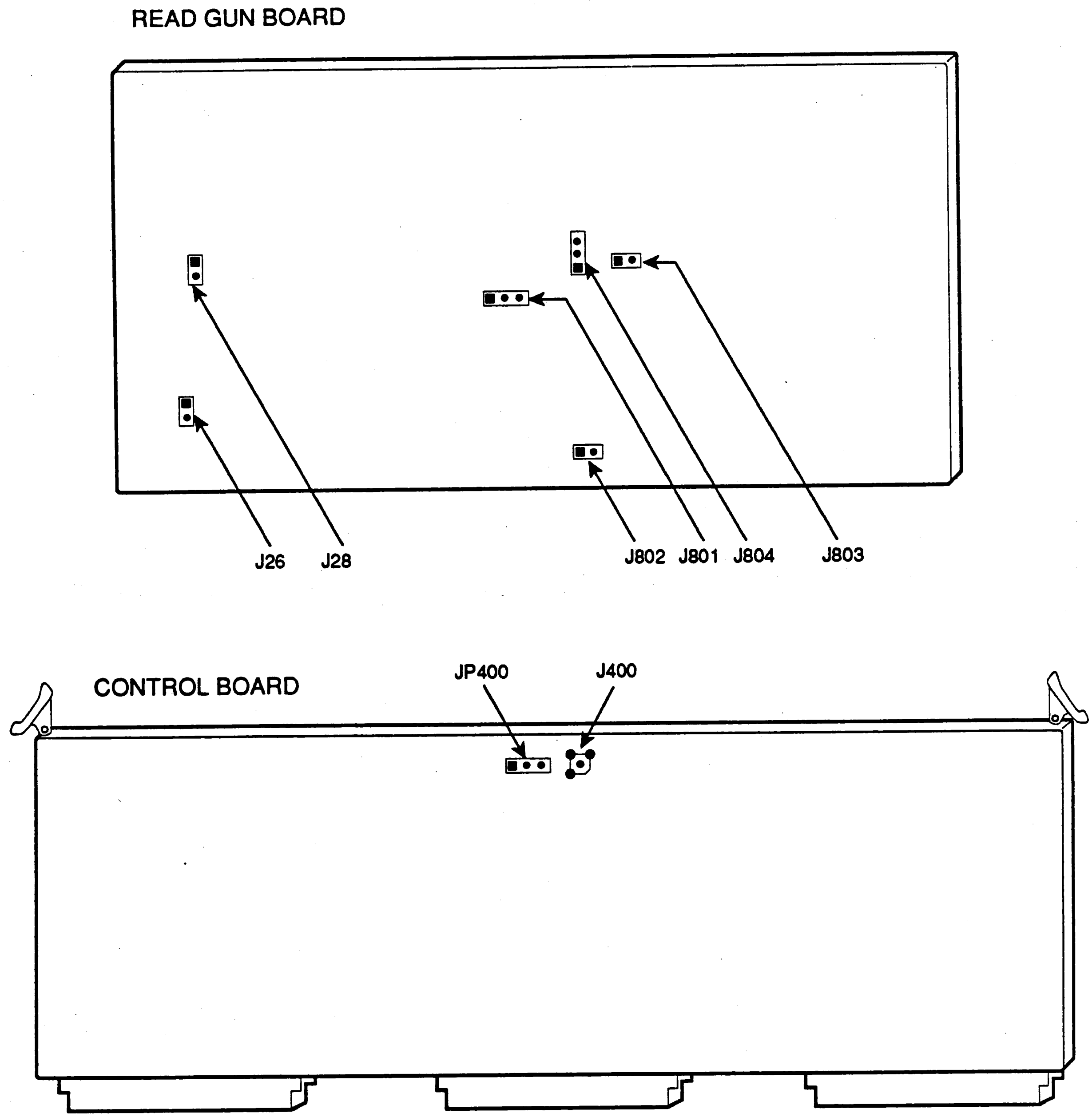


Figure 5-31: Read Gun Board Video Mode Adjustment Points

GPIB Talker/Listener Program

TALK is a GPIB talker/listener program that is useful in calibrating the SCD. To install this program on a controller, copy it into the BIN directory of the C: drive. Include the path C:\BIN in the controller's AUTOEXEC.BAT file to allow the program to execute from any directory.

TALK – version 2.01 is a simple talker/listener for sending GPIB commands across the bus to the instrument. The command line syntax used for this program may be found by typing TALK at the DOS prompt:

```
Usage: 'talk pri:sec x <query>
                 |   |    |
                 |   |    \_error query string
                 |   \_ do autopoll
                 \_ Primary:secondary GPIB address
```

To call the program to talk to an SCD at address 4 with autopolling and error query, the command line would look like:

```
talk 4 x error?
```

Once TALK is running, GPIB commands can be entered at the prompt message. To get information on other functions available within the program, type a '?'. To quit TALK, enter q.

How to Change Cal Constants with CCO

The SCD stores 352 calibration constants in memory. The instrument firmware uses these constants to adjust the hardware so that it operates with maximum accuracy. To adjust a cal constant, first set up the SCD with a controller and the talker/listener program so that you can send GPIB commands to the SCD.

First check the cal constant's old value by entering the following query:

```
CCO?<cal constant number>
```

Add or subtract (depending on the adjustment you are making) about 1% of the old value returned and enter the following command:

```
CCO<cal constant number>:<new value>
```

Check that your change to the cal constant has the desired effect. Refer to the *SCD1000/SCD5000 Instrument Interfacing Guide* for more instructions on using CCO.

CAUTION

Use extreme caution whenever calibration constants are directly altered. cco23 has direct control of the Write Gun intensity without the protection normally provided by the maximum intensity cal constants. Setting an inappropriate value to cco23 can damage the CRT.

Factory Command Enable Switch

The Factory command is only enabled when the Factory/Service Enable switch (switch 1 of the MPU Board DIP switches) is set to ON. This command enables you to run specific sections of the internal calibration routines, or to disable sections of the calibration routines that don't directly influence the section being worked on.

NOTE

The contents of the Factory register are NOT stored across a power cycle.

The Factory command disables the sections of the internal calibration routines shown in Table 5-13. To disable a section, first open MPU Board DIP switch 1, then from a controller run the TALK program. Enter Factory with either the decimal or hex number that corresponds with the section to disable as follows:

`FACtory <NN>` or

`FACtory #h<HH>`

where NN is the decimal number from Table 5-13, and HH is the hex number from Table 5-13.

Table 5-13: Calibration Enable Codes

Calibration Section	NN	HH	Register Contents
Horizontal Sweep	1	01	0000 0000 0000 0000 0001
Horizontal Min Trig Delay	2	02	0000 0000 0000 0000 0010
Horizontal Max Trig Delay	4	04	0000 0000 0000 0000 0100
Crt X-tilt	8	08	0000 0000 0000 0000 1000
Crt Y-tilt	16	10	0000 0000 0000 0001 0000
Crt Intensity (Horiz. Intensity Too)	32	20	0000 0000 0000 0010 0000
Disable Vertical CHA Cal	64	40	0000 0000 0000 0100 0000
Disable Vertical CHA Cal	128	80	0000 0000 0000 1000 0000
Disable Geometry Cal	256	100	0000 0000 0001 0000 0000
TLEV_Anyway	512	200	0000 0000 0010 0000 0000

Table 5-13: Calibration Enable Codes(Cont.)

Calibration Section	NN	HH	Register Contents
Disable Signal Smoothing	65,536	10,000	0001 0000 0000 0000 0000
Double Sweep Enable	262,144	40,000	0100 0000 0000 0000 0000
Disable Cal Prompts	524,288	80,000	1000 0000 0000 0000 0000
The following bits are effective during Intensity, Sweep, Minimum and Maximum Trigger Calibrations.			
DISABLE_100US		1000	0000 0001 0000 0000 0000
DISABLE_50US		2000	0000 0010 0000 0000 0000
DISABLE_20US		4000	0000 0100 0000 0000 0000
DISABLE_10US		8000	0000 1000 0000 0000 0000
DISABLE_5US		100000	
DISABLE_2US		200000	
DISABLE_1US		400000	
DISABLE_500NS		800000	
DISABLE_200NS		1000000	
DISABLE_100NS		2000000	
DISABLE_50NS		4000000	
DISABLE_20NS		8000000	
DISABLE_10NS		10000000	
DISABLE_5NS		20000000	
DISABLE_ALL		3FF0F000	

More than one section of calibration can be disabled by OR'ing their register bits together and sending the appropriate decimal or hexadecimal number.

For example, to run HORIZONTAL SWEEP calibration you can simply OR the register bits together since the internal horizontal cal runs the INTENSITY, SWEEP, MIN TRIGGER DELAY, and MAX TRIGGER DELAY sections.

Combine (logical OR) the register bits of the sections to disable:

Table 5-14: Calibration Disable Codes

Calibration Section	NN	HH	Register Contents
Horizontal Min Trig Delay	2	02	0000 0000 0000 0000 0010
Horizontal Max Trig Delay	4	04	0000 0000 0000 0000 0100
CRT Intensity (Horiz. Intensity Too)	32	20	0000 0000 0000 0010 0000
OR'd Result	38	26	0000 0000 0000 0010 0110

Therefore, the correct command line to send would be

`FAC 38` or `FAC #h26`

Calibration Utility Programs for the GPIB Controller

The following programs are available for calibration and performance verification of the SCD1000 and the SCD5000 instruments. All of these programs will set the computer's GPIB address at 30 and will use a default address of 7 for the SCD. As noted below, the address may be changed using program /g command line option. The programs were designed to run on PC–compatible 386 machines with an EGA color display system and a National Instruments PC2A GPIB controller card. A math coprocessor is preferred for most of the compute–intensive programs (like NOISE and LINACC) in order for the programs to run at reasonable speed.

These programs are specific in nature, and are have not been evaluated for use in a systems environment (ie more than one SCD and several other GPIB instruments on the bus at the same time. Error handling and SRQ handling is handled on an as–needed basis only, and the possibility does exist to confuse the programs enough that the controller may lock up and need to re–boot.

CONIO.EXE

CONIO is a program to allow the storage of instrument calibration constants to a file. This is useful when replacing MPU boards (NVRAM on the MPU board stores the calibration constants) or preserving calibration data for an instrument.

To transfer cal constants between SCD and PC, use the program conio.exe and the bat files ccwr and ccrd. The usage for conio is printed by typing conio with no arguments.

```
Usage: 'conio pri:sec file [num]
              |    |
              |    |     +--# of cal constants
              |    |        will 'get' if included
              |    +--File name
              +--GPIB address
```

ccwr N file
will write all the cal constants in 'file' to SCD at GPIB address N.

ccrd N file
will read cal constants 0 through M–1 from SCD at GPIB address N, and stuff them into 'file'.

"ccrd <addr> file" calls "conio <addr> file 352".

"ccwr <addr> file" calls "conio <addr> file".

that is, these are shorthand for a fixed number of cal constants (352), and instruments with GPIB address <addr> selected.

GRIDBIAS.EXE

The purpose of this program is to determine the CRT grid bias voltage setting – it may also be used to check whether the maximum intensity calibration constants have been properly set. GRIDBIAS will read the maximum intensity cal constant for the 5ns window, cco86. Based upon this value, the CRT grid bias voltage is computed by taking the inverse of the equation that created the maximum intensity cal constant in the first place (in the routine MAXINTE). The maximum intensity cal constants are calculated based upon the following equation:

5ns Maxinte = 255/10 * (2.32 * (5 – ((Vgk–10) +5)/21) + 0.7)

Note that this equation is formulated based upon the Z-axis amplifier circuit, and the 5ns MAXINTE cal constant value is computed so that the grid voltage will always be less than the Cathode voltage, thus preventing damage to the CRT.

The grid bias voltage is then computed from the inverse of the above equation, which is given below:

WG board 671–0637–02 and below:

Vgk (grid bias) = 21 * (5 – ((10 * cco86 / 255) – .7) / 2.32) + 5

WG board 671–0637–03 and above:

Vgk (grid bias) = 21 * (5 – ((8 * cco86 / 127) – .7) / 2.32) + 5

To invoke the program, type:

```
GRIDBIAS /g<addr>
```

<addr> – GPIB address of DUT (defaults to 7)

GRIDBIAS Version 2.XX,, MM/DD/YY

The program will then print the results to the screen, after querying the instrument UID (User IDentification) string:

<UID_string> calculated Grid Bias Voltage (Vgk) = NN.NN V

If CCO86 is not a valid number, or it is at the default value, the program will issue a warning indicating that the Maximum Intensity cal constants have not been set, and the operator should run the MAXINTE program after measuring the Grid Bias voltage on the SCD High Voltage Board.

LINACC.EXE

This program provides a graphical output of the timing accuracy and linearity of horizontal sweep. It is intended to be used during the horizontal calibration section, but may also be used for performance verification of timing accuracy and linearity. In this program, the acquired signal is displayed on the monitor along with a superimposed plot of the linearity function for that acquisition. Linearity is plotted as the percent deviation of the 5th zero crossing (two cycles) away from any arbitrary zero crossing. Typing LINACC with no command line options at the DOS command line will give the following results:

LINACC <window> [/g /d /a /f /c /o /b /p /n /l /5000]

where

<window> – time window for SCD (defaults to 5ns)
where <window> is expressed from 5ns to 100us

d<nnn> – time delay for the window, nnn is percent from 0 to 500 (defaults to 250%)

a<n> – Average n waveforms

f – superimpose ideal frequency sine wave over data

c – use CG5011 as signal source (default is Wiltron 4722A)

o – turn SCD display off to increase waveform throughput

g – GPIB address of instrument – 0 to 30 are on GPIB0, addresses 100 to 130 are on GPIB1 (default is 7)

b – Instrument debug messages on

p – Print GPIB messages to screen only

n – do not change instrument vertical & triggering settings

l – Signal Source limited to 1GHz frequency output (using SG504)

5000 – instrument is an SCD5000 (defaults to SCD1000)

LINACC Version X.xx, MM/DD/YY

Do you wish to continue? 1. Yes 2. No

If the user enters 2 (or moves the highlight to NO using the arrow keys), the program will abort. If the user enters 1, the program will continue, starting by setting up the program options (if command line options are included, this section is skipped). The program option menu will appear as follows:

LINEAR Default Settings:

Trig Delay: 250%.

SCD Display: ON

Signal Source: SG

Ideal Signal: TRUE

Wfm Avg'ing: OFF

SCD GPIB addr: 7

Do you wish to change any of the above settings? 1. Yes 2. No

Using the selection method described above, the user may continue with defaults, or be asked to change each of the above settings. Some special cases need to be mentioned here. If it is not desired to change the displayed default, enter CR (carriage return or ENTER) on the keyboard, and the value will not be altered. Trigger delay is limited between 0% and 500% – do not enter the % sign, just enter the percent delay desired. The signal source may either be selected as CG (for CG5011 at address 15) or SG (for the Wiltron 67XX synthesizer at address 5) for programmable operation, or if no signal source is detected, instructions for the source will be displayed. If you are using a non-programmable signal source, choose SG as the source. If the source is limited to 1GHz (like the TEK SG504), then choose YES when the program asks if the signal source is limited to 1GHz. If the source is chosen to be the CG, then the superimposition of an ideal sine signal will not be permitted (because the CG uses time marks, not a sine wave). Waveform averaging will significantly slow the operation of the program (unless the instrument has option 1P installed).

Once the default setting is compete, the program will proceed to the main menu, displaying the time windows that may be checked:

SCD Horizontal Linearity/Accuracy Menu

1) 5ns	(8) 1us
2) 10ns	(9) 2us
3) 20ns	(10) 5us
4) 50ns	(11) 10us
5) 100ns	(12) 20us
(6) 200ns	(13) 50us
(7) 500ns	(14) 100us

(15) Change Default Settings

(16) Sweep Accuracy vs Delay

(17)(q) Exit program

(m) Continue to next window

Selection> >

Enter the number for the desired time window, and the program will enter the acquisition loop mode. In the acquire loop mode, the program acquires waveforms, calculates the timing accuracy and linearity, and displays the results.

The way the program does this is described below:

Set window, coupling, offset, range.

For specified timing window

Do

Apply time marks to DUT

Find 0 x'ings

Determine absolute timing accuracy between 10% and 90% of time window

Determine timing linearity

If option is set, synthesize the ideal waveform based upon the center screen zero crossing

Plot the display

While the operator has not hit any key.

During the acquisition loop described above, repeated acquisitions are performed at the fastest possible rate. The intention is to update the display at a reasonable rate in order to allow for feedback when making linearity calibration adjustments on the write gun board. If any key is hit during the acquisition loop, the acquisition process will stop, and a selection menu will appear at the top of the display screen (leaving the waveform still displayed):

```
<c>-Cal constant <d>-Trigger delay <m>-Menu <q><ESC>-Exit
   <ENTER>-Continue
```

Program commands:

c Change the sweep timing cal constant for the current sweep time. The MPU factory switch (switch #1) must be set to the ON position for this to be successful.

d Change the delay time as a percent of the acquisition window.

m Return to the main program menu.

ESC or q Exit the program (sweep timing cal constant, if changed, is saved by the instrument).

<ENTER> Continue the acquisition loop at the current instrument settings

MAXINTE.EXE

This routine sets the SCD's internal maximum intensity calibration constants. These calibration constants control the maximum allowable Z-axis voltage that may be applied to unblank the CRT write gun. The proper setting of these values is critical to ensure correct operation of the instrument (maximum writing speed) and to prevent damage to the CRT (by prematurely aging the cathode). If the grid bias voltage is not set or measured properly, the instrument may not operate properly. The MAXINTE routine asks the user to input the measured CRT Grid Bias voltage (Vgk). Based upon this entered value, maximum intensity calibration constants are calculated based upon the following equation:

5ns Maxinte = ((255.0/10.0) * (2.32*(5.0 – ((Vgk – 5.0)/21.0)) + 0.7))

This equation is computed so that the grid voltage will always be less than the Cathode voltage, thus preventing damage to the CRT. The remainder of the sweep constants are based upon empirical data gathered from instruments on the manufacturing floor – useable intensities are calculated in relation to 5ns intensity value:

10ns = 5ns * 1.00	(100%)
20ns = 5ns * 0.90	(90%)
50ns = 5ns * 0.75	(75%)
100ns = 5ns * 0.65	(65%)
200ns = 5ns * 0.45	(45%)
500ns = 5ns * 0.35	(35%)
1us= 5ns * 0.30	(30%)
2us = 5ns * 0.30	(30%)
5us = 5ns * 0.25	(25%)
10us = 5ns * 0.25	(25%)
20us = 5ns * 0.22	(22%)
50us = 5ns * 0.20	(20%)
100us = 5ns * 0.18	(18%)

The program may be invoked by typing MAXINTE at the DOS prompt with no command line arguments. The following message will be displayed:

Usage: MAXINTE <Gridbias V> [/g<addr>]

g<add> – GPIB address of instrument – 0 to 30 are on GPIB0, addresses 100 to 130 are on GPIB1

MAXINTE Version 2.xx, MM/DD/YY

Do you wish to continue? 1. Yes 2. No

If the instrument is not at address 7, the program will display an error message and abort. The operator must enter the correct GPIB address for the SCD. Also, the MPU factory switch (switch #1) must be set to the ON position for this program to be successful. An example invocation would be:

MAXINTE 86.5 /g1

where 86.5 is the grid bias voltage measured from the instrument and /g indicates the GPIB address of the instrument.

NOISE.EXE

This program computes the RMS noise value for a set of signals. The maximum peak to peak disturbance found in that set of signals is also found and displayed. Prior to determining the RMS noise value, a set of waveforms are acquired and averaged in order to determine the reference value for the noise signals. This is necessary because of noticeable geometry distortion when the vertical is expanded. The acquired noise signals are then subtracted from the reference level after which the RMS noise value for each noise signal is computed and averaged into one RMS noise value for the entire set of noise signals. An amplitude histogram (logarithmic scaling in amplitude) is also provided as a graphical means of determining the peak to peak levels in the noise signals acquired. The program is invoked as follows:

```
NOISE <window> /d250 /f /m64 /n32 /g1
```

where

<window> indicates the time window on which to make the measurement

/d specifies the trigger delay in percent of the acquisition window.

/f informs the program to save the reference waveform in a file called ref.dat and the noisiest waveform acquired in a file called wav.dat.

/m specifies the number of waveforms to acquire in the construction of the reference waveform (average waveform).

/n specifies the number of noise waveforms to acquire.

/g specifies the GPIB address of the instrument.

/h provides information on the above parameters.

ESC exits the program

SCDCYCLE.EXE

Up to 10 instruments may be run at any one time on this program, which automatically runs repeated calibration and diagnostic cycles on all of the instruments. When the program prompts you to "Enter time delay between cycles [minutes]," type in the number 30. Now the program will run continuous calibration and diagnostic cycles, waiting 30 minutes for calibration to complete, and 10 minutes for diagnostics to complete. The program will store the information from the calibration runs (responses to CALIBRATE?, DIAG?, and ERRLOG?) in the calruns directory. Let the program run for at least 12 hours (overnight).

A:\> SCDCYCLE <addr1> [<addr2> ... <addr10>]

where <addr1> is the GPIB address of the first SCD, <addr2> (optional, only for running more than one instrument) is the address of the second SCD.

One thing that may a problem with this program is the UID stored in the digitizers. In the factory, the UIDis set to the serial number, such as "B030136." The SCDCYCLE program uses the UID string as the file name for storing the results of calibration. DOS limits filenames to 8 characters plus a 3 character extension. The UID strings will be truncated to 8 characters, and then the extension ".rsp" will be appended. In order to maintain the independence of each file, the UID should be changed to a unique, 8-character string for this program (suggest changing the UID to the serial number ex: UID "B030136", but switch #1 on the MPU board must be ON). The user must create a subdirectory called CALRUNS before starting the program, otherwise it will give an error message saying that it could not open a file.

to exit the program while the program is running, hit any keyboard key it will say:

```
**Keyboard hit detected -- ABORT ?? [y n]
```

if you enter yes, OR you enter a <ctrl>C, the program will exit. Otherwise it will continue.

SETGBCAL.EXE

This is a calibration program. It sets up the instrument's parameters to allow the technician to calibrate the grid bias voltage and to allow him to adjust the focus and other write gun beam parameters. If the grid bias is being adjusted, the the sweep mode should be selected. The DOT mode is provided for engineering use – do not attempt to use this mode because it is EXTREMELY easy to damage the CRT diode array target by doing this.

To initiate the program enter:

SETGBCAL /g1 [/p /b /DOT]

/g indicates the GPIB address of the instrument. (defaults to 7)
/b SCD GPIB debug messages turned on
/p GPIB commands printed to screen only
/DOT is used when sweeps have been (or will be) disabled in hardware.

If no command line options are given the following usage statement will appear:

Usage: SETGBCAL [/g<addr> /dot /b /p]

g<add> – GPIB address of instrument – 0 to 30 are on GPIB0; addresses 100 to 130 are on GPIB1 (defaults to 7)

dot – calibrate focus using dot mode on WG board

b – SCD GPIB debug messages on

p – Print GPIB commands printed to screen

SETGBCAL Version 2.xx, MM/DD/YY

Do you wish to continue? 1. Yes 2. No

NOTE

The SCD should be set up in video mode for all operations covered in this routine.

The operator will be given instructions by the program upon how to proceed. Once the grid bais and focus are correctly adjusted, this program will ask to calibrate the MAXINTE values. This routine is identical to that in the MAXINTE program, and should probably be run at this time.

WGZACAL.EXE

This program sets up the instrument in a mode that allows the high frequency circuitry on the write gun board and the z-axis transient response on the high voltage board to be calibrated. This program is invoked as follows:

The instrument is put into a fast repetition mode by invoking the video mode. For this reason, please disable the high voltage by moving the jumper on the high voltage board.

To initiate the program for an SCD enter:

WGZACAL /g<addr> /d<elay> /b /p

/g<addr> indicates the GPIB address of the instrument.
/d<elay> sets the trigger delay (in percent)
/b SCD GPIB debug messages turned on
/p GPIB commands printed to screen

NOTE

The DUT should does not need the read gun board to be set up in video mode for the operations covered in this routine

Maintenance Information

This section contains the information needed to do periodic and corrective maintenance on the SCD Series Waveform Recorders. It includes the following subsections:

Maintenance Information – It includes this introduction plus general information on preventing damage to internal modules when doing maintenance and rackmounting instructions.

Inspection and Cleaning – Information on the care of the waveform recorder.

Removal and Installation Procedures – Procedures for the removal of defective modules and the installation of new or repaired modules.

Troubleshooting – Information for isolating failed modules.

Diagnostics – Procedures for running diagnostic self-tests.

WARNING

The procedures described in this section should be done only by a qualified service technician.

Do not service alone. Do not adjust or perform internal service on this instrument unless another person capable of rendering first aid and cardio-pulmonary resuscitation is present.

Use extreme care when servicing with power on. Dangerous voltages exist at several points inside this instrument. To avoid injury, do not touch exposed connections or components while the power is on. Disconnect power before removing protective panels or replacing components.

WARNING

Wear safety glasses and use care when inserting and removing cables on the Scan Converter CRT pins. Lateral movement of the pins could crack the CRT glass, causing the tube to lose its vacuum or implode.

CAUTION

Static discharge can damage semiconductor components in this instrument. Read the precautionary measures described later in this section.

CAUTION

The Scan Converter CRT is fragile and requires special handling. Do not use magnetized tools near the Scan Converter CRT. Magnetic fields can significantly degrade the CRT performance, and special tools are required to demagnetize the CRT shield.

Preventing ESD

CAUTION

Static discharge can damage semiconductor components in this instrument.

Precautions

To avoid damage from electrostatic discharge (ESD), observe the following precautions while servicing static-sensitive components or assemblies:

- *Wear a grounding wrist strap at all times while handling components and modules*. Components should only be serviced by qualified personnel at a static-free work station.
- Handle components and modules no more than absolutely necessary.
- Transport and store components in their original containers, on a metal rail, or on conductive foam. Label all packages that contain static-sensitive components.
- Wear clothing made from materials that do not accumulate static charges. Wool and some artificial fibers build up static charges readily. Cotton, in contrast, conducts electricity and resists static accumulation.
- Avoid handling components in areas that have a floor or work surface covering that can generate a static charge. Use a grounded, conductive static safe mat on work surfaces where components and modules are handled.
- Spray carpeted work areas with a solution of equal parts water and fabric softener. This will reduce static accumulation and provide a discharge path to ground.
- Allow nothing capable of generating or holding a static charge on the work station surface.
- Keep component leads shorted together whenever possible.
- Pick up components by the body, and never by the leads.
- Do not slide components over any surface.
- Connect all soldering irons to earth ground. Use only special anti-static, suction-type or wick-type desoldering tools.

Susceptibility to ESD

The SCD contains components that are susceptible to damage from static discharge. Static voltages of 1 to 30 kV are common in unprotected environments. For comparison, Table 6-1 shows the maximum voltage various components can sustain without damage. If you suspect damage from static discharge, check the most sensitive components first.

Table 6-1: Relative Susceptibility to Damage from Static Discharge

Semiconductor Class	Critical Voltage
MOS or CMOS microcircuits, and discrete or linear microcircuits with MOS inputs (most sensitive)	30-500 V
ECL	200-500 V
Schottky signal diodes	250 V
Schottky TTL	500 V
High-frequency bipolar transistors	400-600 V
JFETs	600-800 V
Linear Microcircuits	400-1000 V (est.)
Low-power Schottky TTL	900 V
TTL (least sensitive)	1200 V

Inspection and Cleaning

This subsection describes how to inspect and clean the SCD Series Waveform Recorders. Such inspection and cleaning are performed as preventive maintenance. Preventive maintenance, when performed regularly, may prevent instrument malfunction and enhance reliability.

Preventive maintenance consists of visually inspecting and cleaning the instrument and using general care when operating it.

Inspection and Cleaning Procedures

The waveform recorder should be visually inspected and cleaned as often as operating conditions require. Accumulation of dirt in the instrument can cause overheating and component breakdown. Dirt on the components acts as an insulating blanket, preventing efficient heat dissipation. It also provides an electrical conduction path that could result in instrument failure, especially under high-humidity conditions.

CAUTION

Clean the digitizer only with water soluble detergents or isopropyl alcohol. Do not use cleaning agents that can damage the plastic parts of the instrument. Do not clean with organic solvents such as benzene, toluene, xylene, acetone, or similar compounds.

Inspection

Occasionally inspect the instrument for loosely seated or heat-damaged components. Heat damage usually indicates circuits that need adjustment. It is important to correct the cause of overheating rather than simply replacing the damaged component, or damage may reoccur.

Cleaning

Clean the interior of the instrument with low-velocity compressed air. Remove any hardened dirt with a soft, dry brush or a cloth dampened with a mild solution of detergent and water.

CAUTION

To prevent damage from electrical arcing, ensure that circuit boards and components are dry before applying power to the instrument.

Removal and Installation Procedures

This subsection contains procedures for removal of all electrical and mechanical modules. Reinstall the modules by following the procedures in reverse order. Before beginning a procedure, read through the *Performance Verification* section to make sure you have the equipment needed to calibrate the newly-installed modules.

Preparation – Please Read

The SCD Series of instruments is designed to be modular in nature in order to facilitate board exchange. In instances where a defective board is replaced, refer to this table to determine which sections of the calibration procedure are necessary to return the instrument to a calibrated state. In cases where no calibration is necessary, but other actions may be necessary (such as exchanging NVRAM integrated circuits), these are listed in the table. Also actions to determine the functionality of the board are included as well.

List of Modules

Refer to Figure 6-3 for an overview of all module locations. Table 6-2 lists the modules along with their part numbers and the calibration procedures necessary for the replacement procedure. In the calibration column, "internal" refers to calibration routines run using the SCD's internal firmware.

Table 6-2: Module Part Numbers

Part Number	Module Description	Functional Checkout	Calibration Required
SCDFO19	SCD Display Unit	Front Panel Test Button Test Instrument Test	N/A
119-3353-xx	SCD1000 Delay Line	N/A	Input Calibration Vertical Calibration Internal Horizontal Calibration
119-5018-xx	SCD5000 Delay Line	N/A	Input Calibration Vertical Calibration Internal Horizontal Calibration
020-1940-xx	Component Kit; SCD EPROMS; Firmware	Instrument Test	Rerun SETREF Restore old cal constants (CONIO) Internal System Calibration
154-0945-xx	SCD1000 Scan Converter CRT	N/A	Internal Calibration Procedure External Calibration Procedure

Table 6-2: Module Part Numbers (Cont.)

Part Number	Module Description	Functional Checkout	Calibration Required
154-0949-xx	SCD5000 Scan Converter CRT	N/A	Internal Calibration Procedure External Calibration Procedure
620-0054-xx	Power Supply Assembly	N/A	Power Supply Calibration Internal System Calibration
670-4377-xx	Target Amplifier (Video Preampl) board	N/A	Target Amplifier Calibration Internal CRT Calibration (Intensity) Video Pulse Response Check
670-9655-xx	Regulator board	N/A	Internal System Calibration Power Supply Calibration
671-0580-xx	Output Amplifier board	N/A	Vertical System Calibration
671-0580-xx	Front Panel Display board	Front Panel Test Button Test Instrument Test	N/A
671-0636-xx	LED board	Front Panel Test Instrument Test	N/A
671-0637-xx	Write Gun board	Acquisition Test	CRT Bias Adjustment: ■ CRT Focus Adjust ■ CRT Grid Bias Adjust ■ Writing Speed Check/Adjust ■ Geometry Adjust Horizontal System Calibration
671-0638-xx	Read Gun board	Acquisition Test	Read Gun Adjustment CRT Bias Adjustment Vertical System Calibration ■ Vertical Size and Position ■ Internal Vertical Calibration Internal System Calibration
671-0639-xx	High Voltage board	Acquisition Test	High Voltage and Z-Axis Adjust Internal System Calibration CRT Bias Adjustment: ■ CRT Focus Adjust ■ CRT Grid Bias Adjust ■ Writing Speed Check/Adjust

Table 6-2: Module Part Numbers (Cont.)

Part Number	Module Description	Functional Checkout	Calibration Required
671-0640-xx	SCD1000 Analog board	Acquisition Test	Internal Calibrator Signal Calibration Vertical System Calibration Trigger System Calibration
671-0641-xx	MPU board	NVRAM exchange Instrument Test GPIB Communication Check	Internal System Calibration
671-0642-xx	Control board	Acquisition Test	CRT Bias Adjustment ■ Video Clamp Level Adjust
671-0643-xx	Data Memory board	Acquisition Test	N/A
671-0644-xx	Backplane board	Instrument Test	N/A
671-0645-xx	Power Converter board	N/A	Power Supply Calibration ■ Power Supply Tolerance Check
671-1601-xx	SCD5000 Trigger board	Acquisition Test	Internal Calibrator Signal Calibration CRT Bias Adjustment Vertical System Calibration Trigger System Calibration
671-1620-xx	Address Select board	Power-up Self-Test	N/A
671-1718-xx	Option 1E board	Tekprobe Verification Test Instrument Test	N/A
671-1762-xx	Option 1P board	Acquisition Test Option Test	Internal Geometry Calibration
671-1808-xx	Option 2F board	Acquisition Test Option Test HSDO NVRAM Test	N/A

Connector Orientation – Most of the SCD connectors can only be inserted in the proper position. Some of the harmonica connectors, however, must be aligned with markings on the circuit board as follows (see Figure 6-1):

- Line up the arrow on the cable connector with the arrow on the circuit board, or
- line up the arrow on the cable connector with the circuit board pin with the square base.
- Be sure to note the cabling connections and connector orientations before removing any module. This will allow you to correctly install the replacement module.

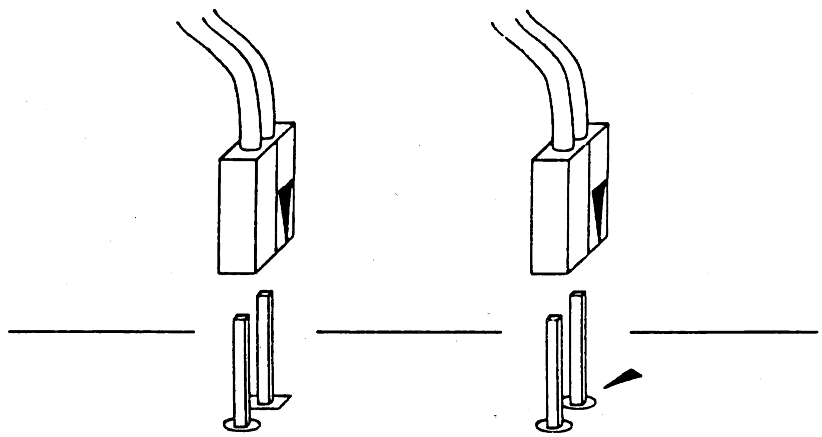


Figure 6-1: Cable Orientation

Jumper Settings

The jumpers on the various boards of the SCD must be set properly for the SCD to operate correctly. Figure 6-2 list the jumper settings.

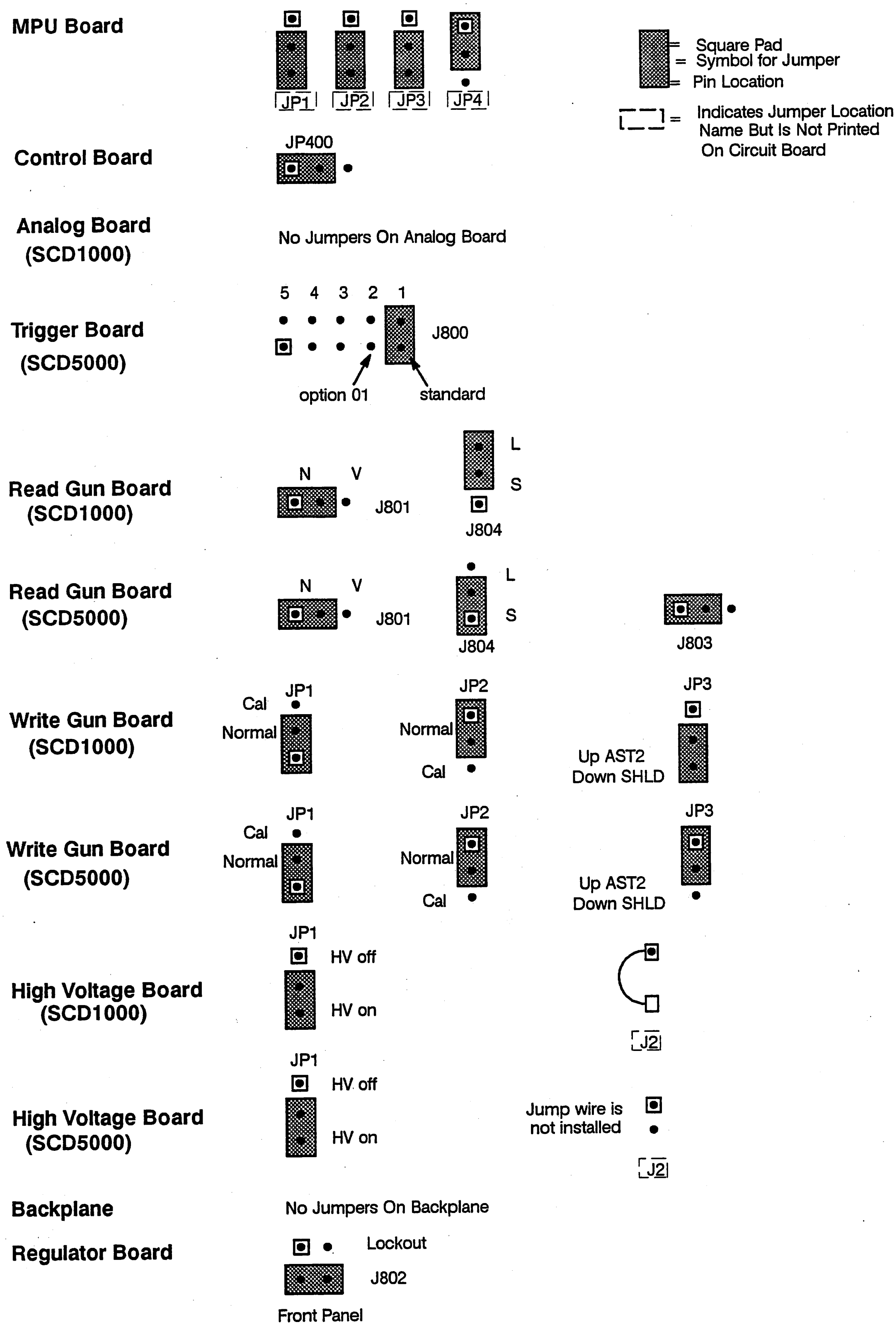


Figure 6-2: Jumper Settings

Access Procedure

Begin with this procedure when you have identified a module to be removed for service.

1. *Locate module to be removed:* Find the module to be removed in the module locator diagram, Figure 6-3.
2. Turn off the power to the instrument and remove the power cord plug from the outlet.
3. Remove the instrument from the rack and place it on a static-free workbench.
4. Find and perform the procedure whose title matches the name of the module to be removed under *Procedures for Modules*.
5. *Reinstall all modules removed:* Follow the removal procedure in reverse to reinstall a module.

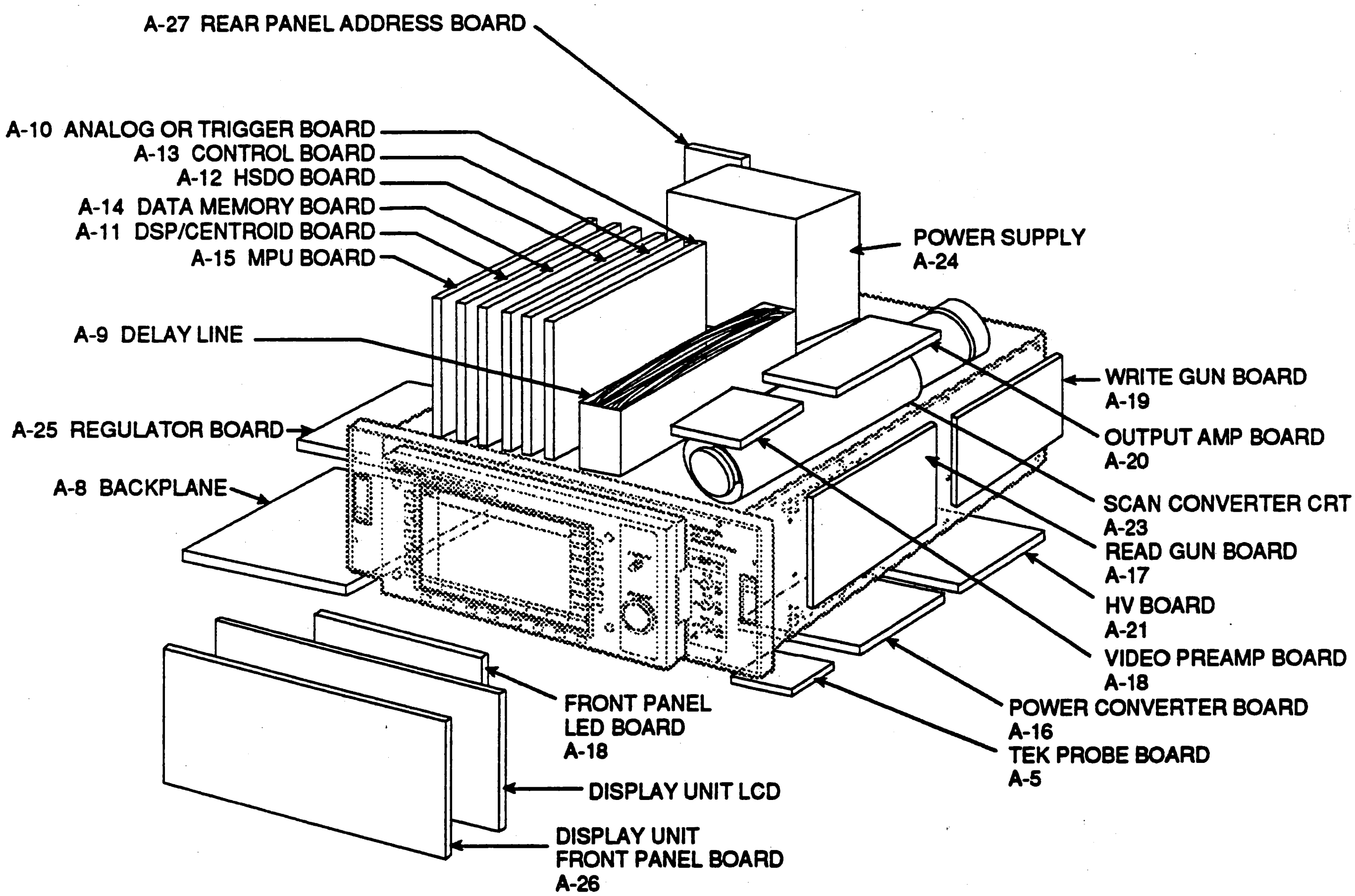


Figure 6-3: Module Locations

Procedures for Modules

Scan Converter CRT

CAUTION

The Scan Converter CRT is fragile and requires special handling.

Do not use magnetized tools near the Scan Converter CRT. Magnetic fields can significantly degrade the CRT performance, and special tools are required to demagnetize the CRT shield.

WARNING

Wear safety glasses and use care when inserting and removing cables on the CRT pins. Lateral movement of the pins could crack the CRT glass, causing the tube to lose its vacuum or implode.

The CRT in the SCD1000 and the SCD5000 are slightly different. These differences are noted in the following instructions.

Before replacing an SCD5000 CRT because of a target burn or defect, check if the CRT can still be made useable with the *Target-Saver Adjustment* procedure. The Target-Saver procedure is used for moving the write and read gun scanning areas to a defect-free portion of the target. It is available only for the SCD5000.

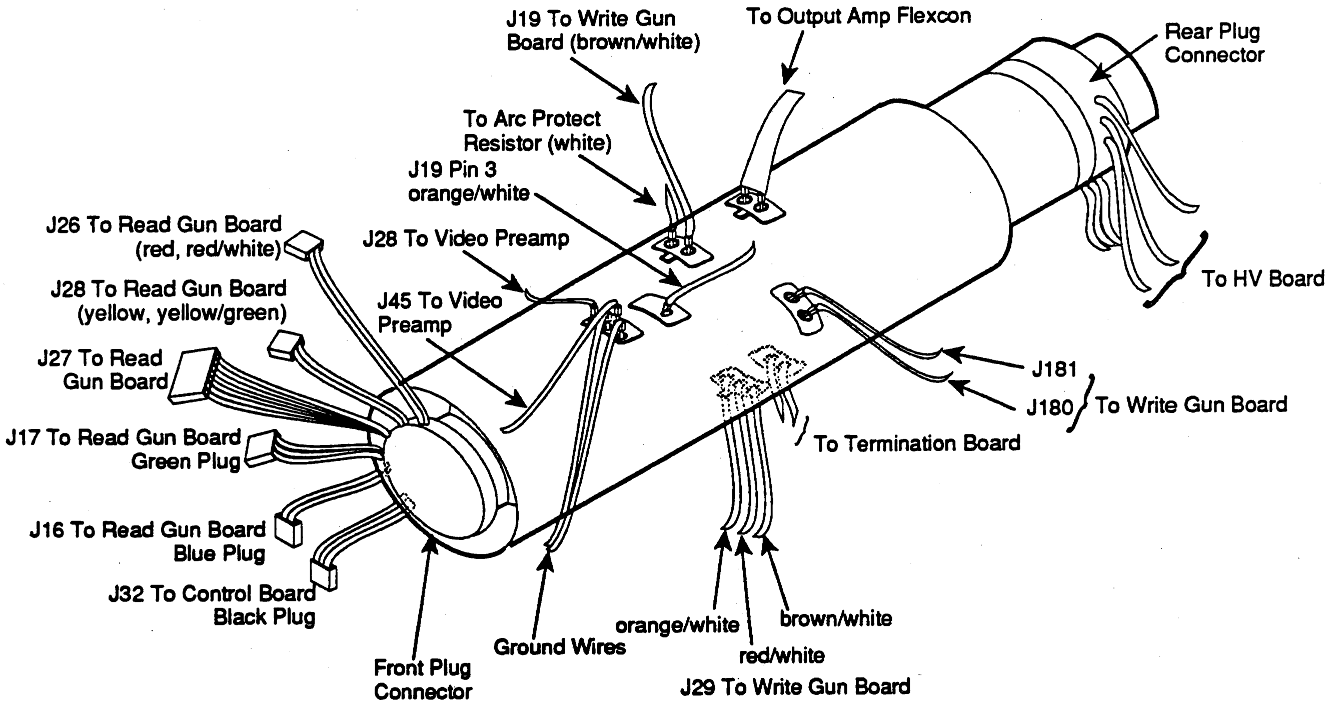


Figure 6-4: SCD1000 Scan Converter Pin Diagram

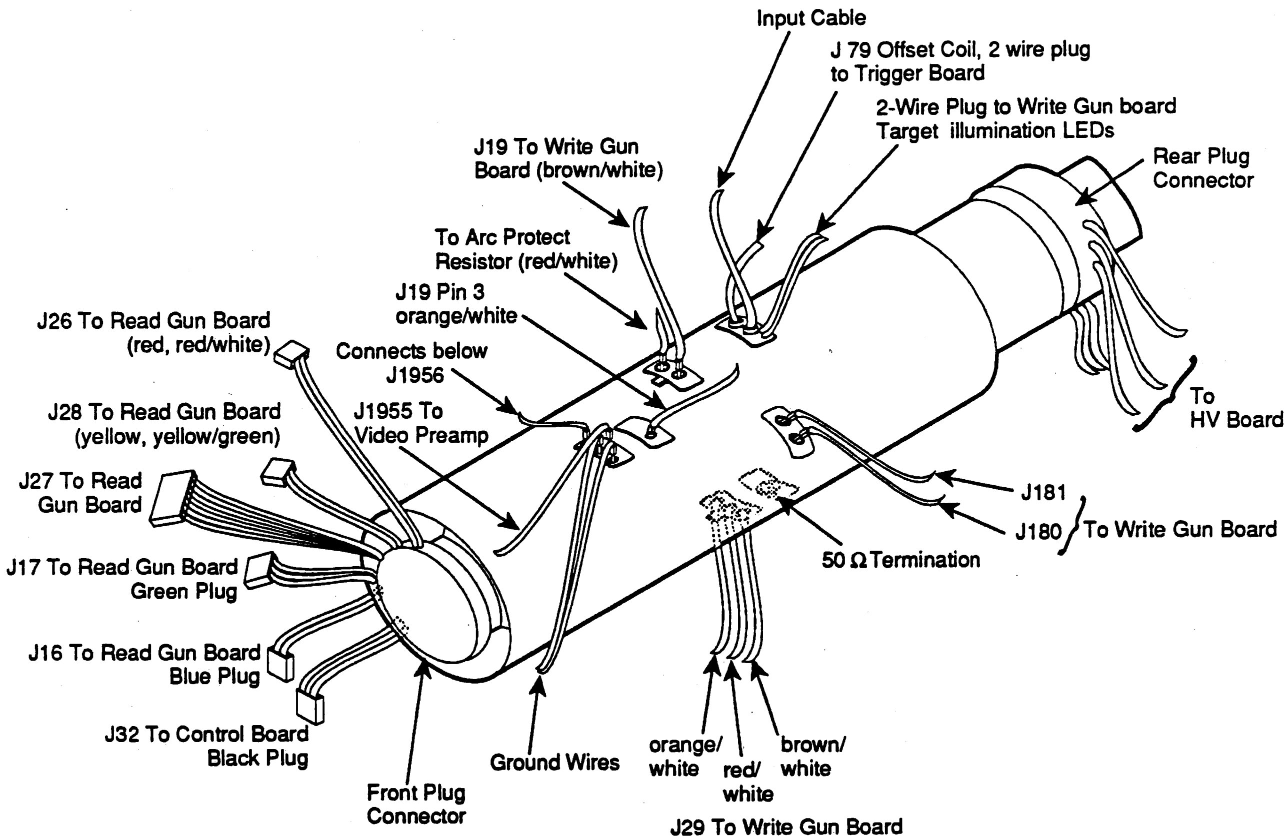


Figure 6-5: SCD5000 Scan Converter Pin Diagram

To replace either the SCD1000 or SCD5000 Scan Converter CRT, refer to Figure 6-4 or 6-5 and perform the following steps:

1. Turn the eight screws that hold down the SCD top cover one quarter turn counterclockwise and remove the cover. (The screws are locked when the slots are lined up with the dot.) Similarly remove the bottom cover and the right cover (as seen from the front).
2. Use a non-magnetic screwdriver to loosen the two screws on the right side (as seen from the front) of the rear section of the CRT shield. Slide the small section of the shield to align the holes with the screw heads, and remove the small shield.
3. Use a non-magnetic screwdriver to remove the three rear panel shield screws. Do not loosen the three dome nuts. Pull out the shield from the rear panel opening, taking care not to snag the high voltage wires on the CRT Write Gun socket.

4. Remove the four screws for the Video Preamplifier board shield. (The Video Preamplifier board is the front circuit board mounted over the CRT.) Remove the following cables to the Video Preamplifier:
   - the 5-wire power cable (J1997)
   - the single-wire mesh cable to the Read Gun board (J1945)
   - the Peltola cable to the CRT mesh (J1955)
   - the Peltola cable to the Control board (J1994)
5. Remove the four Video Preamplifier board 3/16″ posts. Slide the Video Preamplifier board towards the front of the SCD to expose the target pin connection under the board (J1956). Using tweezers, carefully remove the cable from the CRT pin by pulling the pin connector and wire straight up.
6. Set the Video Preamplifier board aside on a static free surface.
7. Remove the two CRT grounding wire screws and push the grounding wires and mesh Peltola cable through the CRT cover plate.
8. Perform part a if your instrument is a SCD1000 or part b if your instrument is a SCD5000.
   a. **(SCD1000 Only):** Remove the following cables from the Output Amplifier board:
      - the 7-wire Read Gun board cable (P789)
      - the Peltola cables to the Delay Line (J702 and J704)
      - the Termination board cable (J783)

      Using tweezers, carefully remove the Output Amplifier board flexcon connector from the CRT pins. Grasp the connector by the pin sockets, not by the flexible plastic part. Use a flashlight to help see the pin sockets (see Figure 6-6).

      Using tweezers, remove the following wires at the CRT pins (refer to Figure 6-6):
      - the two Write Gun board control wires on top of the CRT from J19
      - the two Write Gun board wires on the side of the CRT from J180 and J181
      - the three Write Gun board wires on the bottom of the CRT from J29
      - the two Termination board wires on the bottom of the CRT

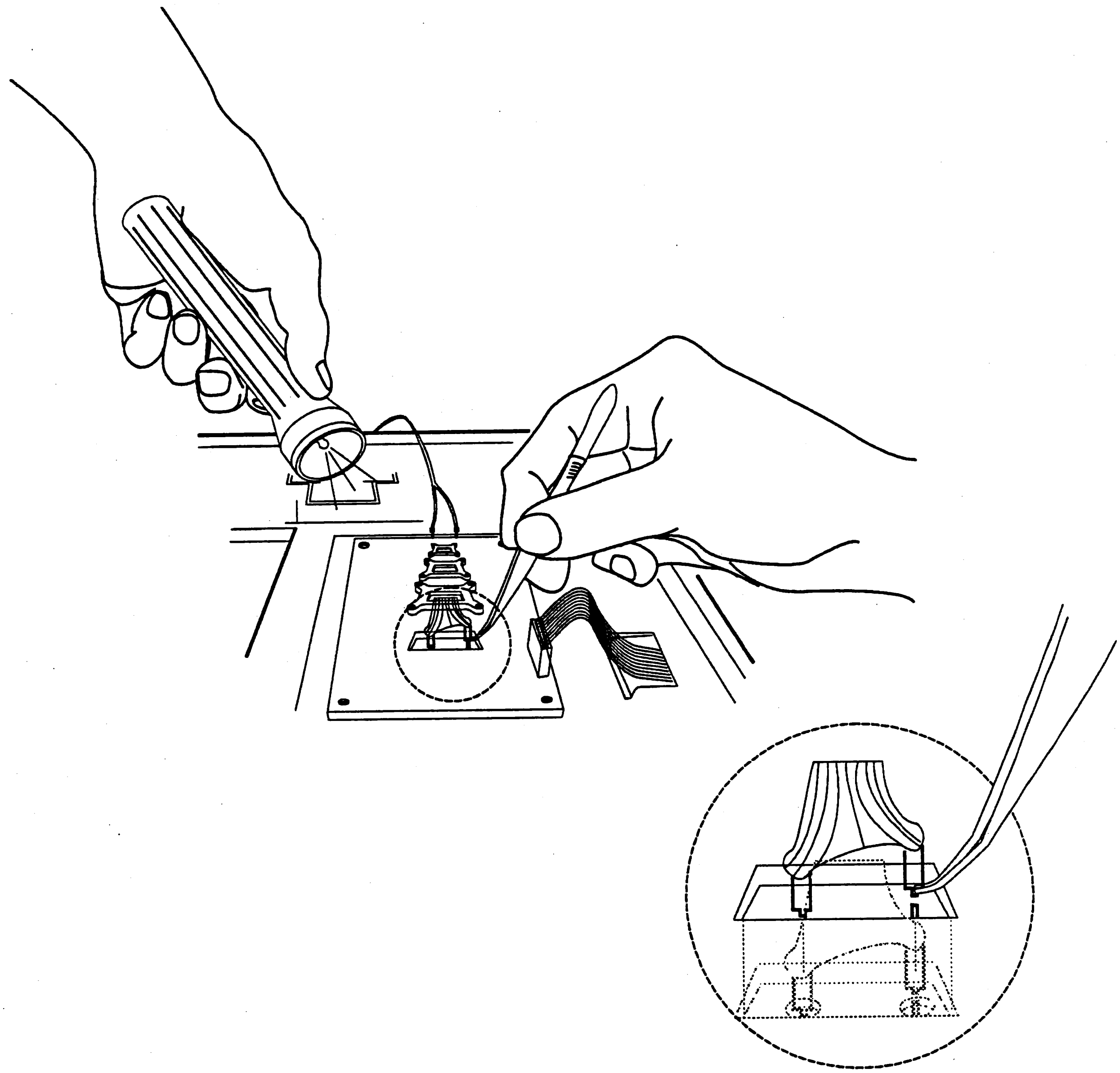


Figure 6-6: Using Tweezers to Remove the Flexcon Connector

b. **(SCD5000 Only):** Remove the following CRT cable connections:

CAUTION

Be careful not to overtighten the CRT cable connections. Use a torque wrench to ensure that this connection is not over-tightened by more than 6 inch-pounds of torque. Do not apply any lateral torque to the CRT SMA connector. The tensile strength of the glass SMA joint is much less than the shear strength.

- Remove the input signal to deflection plate cable on top of the CRT using a 5/16" torque wrench set to 6 in-lbs. as shown in Figure 6-7.
- Remove the two Write Gun board control wires on top of the CRT from J19.
- Remove the Write Gun board wires on the side of the CRT from J180 and J181.
- Remove the Write Gun board wire on the bottom of the CRT from J29.
- Remove the Trigger board two-wire harmonica cable from J79.

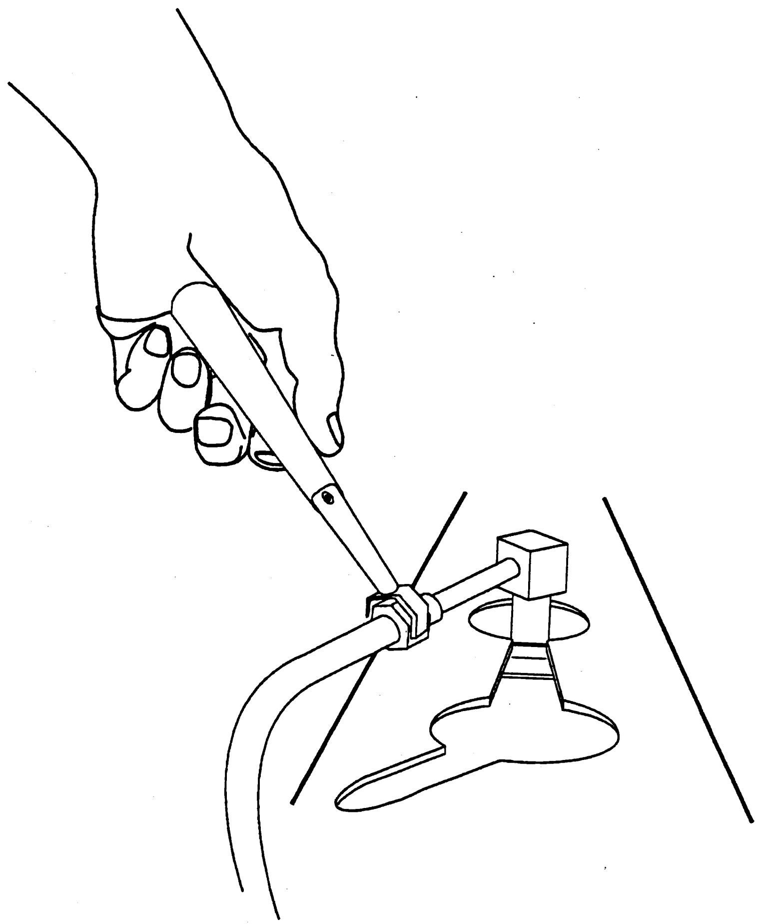


Figure 6-7: Removing the CRT Input Cable

9. Firmly grasp the plastic handle of the CRT rear end (write gun) socket, and pull the socket straight off.
10. Remove the Display Unit (if installed). Remove the eight front-panel screws and lean the front panel back so that the CRT front end (read gun) socket can be reached. Carefully pull the socket straight off being careful no to twist or rock the socket. Remove the other CRT read gun cables:
    - the black 3-wire harmonica connector to the Control board (J32)
    - the green 3-wire harmonica connector to the Read Gun board (J17)
    - the blue 2-wire harmonica connector to the Read Gun board (J16)

11. Perform part a if your instrument is a SCD1000 or part b if your instrument is a SCD5000.

    a. **(SCD1000 only):** Remove the CRT cover plate by removing the four 5/16" bolts on the top. Remove the wire from the upper terminal board to the Write Gun board and clear the wires away from the cover plate. Pull the cover plate straight up, exposing the CRT.

    b. **(SCD5000 only):** Remove four 5/16" bolts on the top and two bolts from the bottom. Pull the cover plate straight up, exposing the CRT.

12. Remove the CRT cradle brackets (the brackets are held on with double-sided tape). Carefully lift the CRT from the instrument chassis.

13. Use a 5/16" torque wrench to remove the 50 Ω terminator and attenuator on the bottom of the CRT. Save the terminator assembly to install on the replacement CRT.

14. Pack the CRT within its metal shield in a Tektronix CRT shipping box. If you have a replacement CRT on hand, use the box that the replacement came in. If you don't have the proper shipping box, order one from Tektronix (part number 004-0924-00).

15. To replace the CRT, follow the preceding directions in reverse order, keeping in mind the following points:

    - The CRT cradle brackets fit onto pegs in the CRT chassis and the CRT shield. The brackets must be properly aligned for the cover plate to fit.
    - Be sure to put in the CRT with the correct side up.
    - Make sure the cables are connected properly.
    - Do not over-tighten the cover plate screws or you may bend the cover plate.

WARNING

Wear safety glasses and use care when inserting and removing cables on the Scan Converter CRT pins. Lateral movement of the pins could crack the CRT glass, causing the tube to lose its vacuum or implode.

    - Use tweezers to replace the CRT pin connections. Be very careful not to move the pin sideways, or the CRT glass could crack.
    - On the SCD5000, use a torque wrench to tighten the input-signal-to-deflector connection and the 50 Ω terminator to 6 inch-pounds.
    - Connect the SCD5000 termination assembly before reinstalling the CRT into the chassis. use caution to assure proper alignment with clearance holes when placing the CRT in the chassis.

- Note that the Video Preamplifier board shield has notches that fit over the wires that pass underneath. Do not to pinch these wires when replacing the shield.

16. Perform the complete *External Calibration Procedure*.

SCD1000 Analog Board

Only the SCD1000 has an Analog board. To replace the Analog board, perform the following steps:

1. Turn the eight screws that hold down the top cover one quarter turn counterclockwise and remove the cover. (The screws are locked when the slots are lined up with the dot.)
2. Using tweezers remove the channel A and B input Peltola cables (AT1J1 and AT2J1).
3. Remove the card cage locking bracket.
4. Remove the Analog board by pulling up the white tabs on the corners of the board as shown in Figure 6-9, and sliding the board out of its slot. Be careful not to snag the attenuators (the small vertical cards on the board) on the chassis.
5. Remove the rest of the cables:

NOTE

Note the location of these cables for later reassembly.

- the orange on blue calibrator output Peltola cable (J8)
- the red on blue external trigger input Peltola cable (J7)
- the black on blue trigger Peltola cables to the Read and Write Gun boards (J5 and J6)
- the black on blue and blue Peltola cables to the Delay Line (J3 and J4)

6. Replace the Analog board by performing the above steps in reverse order. Be sure to correctly relocate any cables that were disconnected.
7. Refer to Table 6-2 for functional checkout and calibration sections that are required for this replacement board.

Analog Board Attenuator

To replace an Analog board attenuator, perform the following steps:

1. Remove the Analog board as described above.
2. Remove the short Peltola cable from the attenuator output.
3. Remove the two attenuator mounting screws from the backside of the Analog board.
4. Pull the ceramic attenuator board with its plastic alignment clamps straight out from the circuit board.
5. Install a replacement attenuator onto the circuit board, making sure not to bend the pins by carefully inserting the pins into the sockets and gently pressing down.
6. Replace the screws and cables.

NOTE

It is easy to bend the center pin of the Peltola cable if it isn't inserted properly.

7. Refer to Table 6-2 for functional checkout and calibration sections that are required for this replacement board.

SCD1000 Output Amplifier Board

Only the SCD1000 has an Output Amplifier board. To replace the board, perform the following steps:

1. Turn the eight screws that hold down the top cover one quarter turn counterclockwise and remove the cover. (The screws are locked when the slots are lined up with the dot.)
2. Using tweezers, carefully remove the Output Amplifier board's flexcon connector from the CRT pins. Grasp the connector by the pin sockets, not by the flexible plastic part. A flashlight may help with this operation (see Figure 6-6).
3. Remove the other cables to the Output Amplifier board:
   - the 7-wire Read Gun board cable (P789)
   - the Delay Line Peltola cables (J702 and J704, black on blue and solid blue)
   - the Termination board cable (J783, white)

WARNING

Handle the hybrids on this board carefully. The hybrids' substrate material contains beryllium oxide, which can be harmful if the substrate is scraped, chipped, or broken. Don't touch the surface of the hybrid and avoid breathing dust from a broken chip.

CAUTION

There are exposed bond wires on hybrid U762. Do not touch the top surface of this hybrid.

4. Remove the two brass-colored screws from hybrid U862. Remove the four mounting screws and lift out the Output Amplifier board.
5. Install a replacement board following the above instructions in reverse order. Use a torque screwdriver to screw the mounting screws for U862 to 2 inch-pounds of torque.
6. Refer to Table 6-2 for functional checkout and calibration sections that are required for this replacement board.

SCD1000 Delay Line

To replace the Delay Line on the SCD1000, perform the following steps:

1. Turn the eight screws that hold down the top cover one quarter turn counterclockwise and remove the cover. (The screws are locked when the slots are lined up with the dot.)
2. Remove the five Delay Line mounting screws and the front bracket.
3. Remove the Analog board as described previously and remove the Delay Line input cables at J3 and J4 (black on blue and solid blue). Remove the Delay Line output cables at the Output Amplifier board (J702 and J704, black on blue and blue). Return these four Peltola cables with the Delay Line. These cables are specific lengths for each delay line, and should be replaced as a unit.
4. Install the replacement Delay Line and new Peltola cables. Be careful not to bend the center pin when installing the Peltola cables. Connect the cables as follows:
   - the black on blue lower rear cable goes to J702 on the Output Amplifier board
   - the solid blue upper rear cable goes to J704 on the Output Amplifier board
   - the solid blue lower front cable goes to J4 on the Analog board
   - the black on blue upper front cable goes to J3 on the Analog board
5. Refer to Table 6-2 for functional checkout and calibration sections that are required for this replacement module.

SCD5000 Delay Line (Option 01)

To replace the Delay Line on the SCD5000 with Option 01, perform the following steps:

1. Turn the eight screws that hold down the top cover one quarter turn counterclockwise and remove the cover. (The screws are locked when the slots are lined up with the dot.)
2. Remove the Delay Line mounting screws.
3. Remove the input cable at the front panel, the Delay Line output cable at the CRT, and the trigger pickoff.
4. Install the replacement Delay Line. Use a 5/16" torque wrench to secure the Delay Line output cable to the CRT at 6 inch-pounds.

CAUTION

Be careful not to overtighten the CRT cable connections. Use a torque wrench to ensure that this connection is not over-tightened by more than 6 inch-pounds of torque. Do not apply any lateral torque to the CRT SMA connector. The tensile strength of the glass SMA joint is much less than the shear strength.

5. Refer to Table 6-2 for functional checkout and calibration sections that are required for this replacement module.

SCD5000 Trigger Board

Only the SCD5000 has a Trigger board. To replace the board, perform the following steps:

1. Turn the eight screws that hold down the top cover one quarter turn counterclockwise and remove the cover. (The screws are locked when the slots are lined up with the dot.)
2. Remove the card cage locking bracket by removing the two screws securing it to the card cage chassis.
3. Remove the Trigger board by pulling up the white tabs on the corners of the board as shown in Figure 6-9, and sliding the board partially out of its slot.
4. Remove the Trigger board cables:
   - the red on blue calibrator output Peltola cable (J8)
   - the black on blue external trigger input Peltola cable (J7)
   - the black or brown on blue internal trigger cable (J66 or J67) coiled on top of the CRT
   - the black on blue trigger Peltola cables to the Read and Write Gun boards (J5 and J6)
   - the red harmonica connector to the CRT offset coil (J79)
5. Install a replacement Trigger board by following the above directions in reverse order.
6. Refer to Table 6-2 for functional checkout and calibration sections that are required for this replacement module.

Write Gun Board

To replace the Write Gun board, perform the following steps:

1. Remove the eight right panel screws (as seen from the front) and remove the right panel.
2. Remove the cables to the Write Gun board:
   - the 8-wire power cable (J11)
   - the 20-wire control ribbon cable (J14)
   - the 10-wire High Voltage board ribbon cable (J30)
   - the black on blue trigger Peltola cable from the Analog board (labeled J5 on the Analog board and J6 on the Write Gun board)
   - the 3-wire shield cable (J29) (all wires are the same length on this cable)
   - the 3-wire CRT control cables (J19) (the wires have different lengths on this cable)

WARNING

Wear safety glasses and use care when inserting and removing cables on the CRT pins. Lateral movement of the pins could crack the CRT glass, causing the tube to lose its vacuum or implode.

3. Using tweezers, remove the two horizontal deflector wires on the side of the CRT (J180 and J181).
4. Remove the six Write Gun board mounting screws and install a replacement board by following the above directions in reverse order.
5. Refer to Table 6-2 for functional checkout and calibration sections that are required for this replacement module.

High Voltage Board

To replace the High Voltage board, perform the following steps:

1. Remove the top and bottom covers. (The screws are locked when the slots are lined up with the dot.)
2. Remove the cables to the High Voltage board:
   - the 10-wire Write Gun board ribbon cable (J30)
   - the 8-wire power converter cable (J20)
   - the power converter wire (J21)
   - the 4-wire power supply cable (J621)

CAUTION

Do not use magnetized tools near the Scan Converter CRT. Magnetic fields can significantly degrade the CRT performance, and special tools are required to demagnetize the CRT shield.

3. Using a non-magnetic screwdriver, loosen the two screws on the right side (as seen from the front) of the rear section of the CRT shield. Remove the shield by sliding it over the screws.
4. Using a non-magnetic screwdriver, remove the three rear panel shield screws (not the three dome-nuts) and pull out the rear CRT shield and back cover plate, taking care not to snag the CRT socket wires.
5. Firmly grasp the plastic handle of the CRT rear end write gun socket, and slowly pull the socket straight off.
6. Remove the five High Voltage board mounting screws and remove the board. Follow the above instructions in reverse order to install a new board.
7. Refer to Table 6-2 for functional checkout and calibration sections that are required for this replacement module.

Read Gun Board

To replace the Read Gun board, perform the following steps:

1. Remove the right cover (as seen facing the front of the instrument).
2. Remove the cables to the Read Gun board:
   - the 20-wire Write Gun board cable (J14)
   - the 50-wire control cable (J13)
   - the 8-wire Power Converter cable (J12)
   - the 5-wire Video Preamplifier board power cable (J15)
   - on the SCD1000 only, the 7-wire Output Amplifier board cable (J789)
   - the 3-wire 6-pin Power Converter cable (J34)
   - on instruments with the optional Tekprobe board, the 4-wire Tekprobe board cable (J602)
   - the black on blue trigger Peltola cable from the Analog board (J6)
   - the single-wire mesh cable to the Video Preamplifier board (J80)
   - the 2-wire red and red on white CRT cable (J26)
   - the 2-wire yellow and green on yellow CRT cable (J28)
   - the 7-wire CRT cable (J27)
   - the 2-wire blue harmonica connector CRT cable (J16)
   - the 3-wire green harmonica connector CRT cable (J17)
3. Remove the six Read Gun board mounting screws and remove the board. Follow the above instructions in reverse order to install a new board.
4. Refer to Table 6-2 for functional checkout and calibration sections that are required for this replacement module.

Video Preamplifier Board

To replace the Video Preamplifier board, perform the following steps:

1. Turn the eight screws that hold down the top cover one quarter turn counterclockwise and remove the cover. (The screws are locked when the slots are lined up with the dot.)
2. Remove the four screws to the Video Preamplifier board shield and set the shield aside.
3. Remove the cables to the Video Preamplifier board:
   - the 5-wire power cable (J1997)
   - the single-wire mesh cable to the Read Gun board (J1945)
   - the Peltola mesh cable to the CRT (J1955)
   - the video output cable to the Control board (J1944)
4. Remove the four Video Preamplifier board 3/16" posts. Slide the Video Preamplifier board to the front of the instrument to expose the target pin connection under the board (J1956). Using tweezers, carefully remove the cable from the CRT pin by pulling the cable straight up.
5. Install a replacement board by following the above directions in reverse order.

NOTE

The Video Preamplifier board shield has notches that fit over the wires that pass underneath: do not pinch these wires when replacing the shield.

6. Refer to Table 6-2 for functional checkout and calibration sections that are required for this replacement module.

MPU Board NVRAM IC Swap

1. Turn the eight screws that hold down the top cover one quarter turn counterclockwise and remove the cover. (The screws are locked when the slots are lined up with the dot.)
2. Remove the MPU board as described earlier in this section under Removing the Card Cage boards.

CAUTION

When installing the new IC microcircuits, make sure that pin 1 is correctly positioned in the EPROM socket and all component pins are correctly seated.

If steps 3 through 5 are not performed correctly the 350 cal constants that are stored in NVRAM will be lost. The instrument will require a complete calibration to recover this information.

3. Using an IC puller, carefully remove U701 from the MPU board, mark it with a unique mark, and set it aside. Remove U701 from the replacement MPU board, and install this IC into the old MPU board.
4. Install the U701 that you removed in step 3 into socket U701 on the MPU replacement board.
5. Repeat steps 3 and 4 for U800.
6. Install the replacement MPU board into its former location in the card cage by aligning the edge of the board with the card guides. Firmly seat the board onto the backplane connector.

CAUTION

The 96 pin connector requires a significant amount of insertion force to seat properly, however the pins may be damaged if the board is not first properly aligned.

7. Reconnect the 40-pin ribbon cable to the socket on the MPU board making sure that pin 1 (marked with red on the cable) is oriented towards the rear of the instrument. Reconnect the 9-pin harmonica cable to the 9 square pins towards the rear of the MPU board.
8. Verify that all of the DIP switches are set to the open position.
9. Reconnect the power cable to the rear of the SCD. Apply power to the SCD and wait for the power-up sequence to complete.

10. Connect the GPIB controller to the SCD. Using the talker/listener program, run diagnostics by sending the command sequence:

```
TEST SYS: MPU

DIAG?
```

11. Verify that the instrument successfully completes diagnostics by looking at the query response.
12. Initialize the instrument by pressing INIT in the Recall Status menu or by using the GPIB INIT command.
13. Turn off the instrument power.
14. Reinstall the center board hold-down clamp across the center of the instrument card cage. Replace the two flat-head screws retaining the board hold-clamp.
15. Reinstall the instrument top cover.
16. Using the GPIB talker/listener program, query the value of the cal constant cco86 by sending the command:

    ```
    CCO?86
    ```

    If zero is returned, this indicates that the contents of NVRAM have been lost, and you must perform the entire adjustment procedure.

    If a non-zero value is returned, refer to Table 6-2 for functional checkout and calibration sections that are required for this replacement module.

MPU Board ROMs

To replace the MPU board ROMS, perform the following steps:

1. Turn the eight screws that hold down the top cover one quarter turn counterclockwise and remove the cover. (The screws are locked when the slots are lined up with the dot.)
2. Remove the MPU board as described in Removing the Card Cage boards.

CAUTION

When installing the new IC microcircuits, make sure that pin 1 is correctly positioned in the EPROM socket and all component pins are correctly seated.

Avoid touching the IC's or their socket contacts. Finger oils can degrade component reliability.

3. Using an IC puller, remove the defective ROMs. The ROM locations are shown in Figure 6-8.

4. Insert new ROMS in the correct sockets, taking care not to bend their pins.

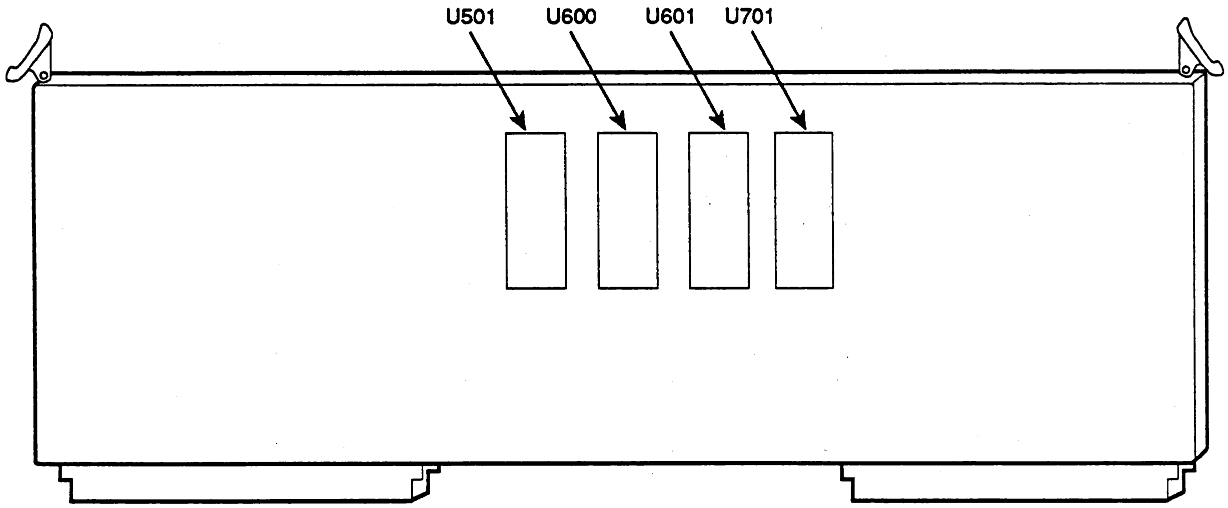


Figure 6-8: MPU Board ROM Locations

5. Reinstall the MPU board into its former location in the card cage by aligning the edge of the board with the card guides. Firmly seat the board onto the backplane connector.

CAUTION

The 96 pin connector requires a significant amount of insertion force to seat properly, however the pins may be damaged if the board is not first properly aligned.

6. Reconnect the 40-pin ribbon cable to the socket on the MPU board making sure that pin 1 (marked with red on the cable) is oriented towards the rear of the instrument. Reconnect the 9-pin harmonica cable to the 9 square pins towards the rear of the MPU board.
7. Verify that all of the DIP switches are set to the open position.
8. Reconnect the power cable to the rear of the SCD. Apply power to the SCD and wait for the power-up sequence to complete.
9. Connect the GPIB controller to the SCD. Using the talker/listener program, run diagnostics by sending the command sequence:

```
TEST SYS: MPU

DIAG?
```

10. Verify that the instrument successfully completes diagnostics by looking at the query response.
11. Initialize the instrument by pressing INIT in the Recall Status menu or by using the GPIB INIT command.
12. Refer to Table 6-2 for functional checkout and calibration sections that are required for this replacement module.

Card Cage Boards

The card cage boards are (left to right, facing front) the MPU board, Option 1P, Data Memory board, Option 2F, Control board, and the Analog or Trigger board. (Replacement procedures for the Analog and Trigger boards are given earlier in this section.) See Figure 6-3.

To replace the boards, follow these instructions:

1. Turn off the power and remove the power cord plug from the outlet. Remove the instrument from the rack and place it on a static-free workbench.
2. Turn the eight screws that hold down the top cover one quarter turn counterclockwise and remove the cover. (The screws are locked when the slots are lined up with the dot.)
3. Remove the accessible cables on the board, which are as follows, depending on the board you are replacing:
   - The Control board has a Peltola cable to the Video Preamplifier (J24) and a 3- wire cable to the CRT (J32). Make sure J32 is inserted orange to orange, red to red, brown to brown.
   - The Data Memory board doesn't have any cable connections.
   - The MPU board has a cable to the Rear Panel Address board (J38) and a 40-wire cable to the LED board (J22).
   - The Option 1P board doesn't have any cable connections.
4. Remove the card cage locking bracket.
5. Remove the card cage board by pulling up the white tabs on the corners of the board as shown in Figure 6-9, and sliding the board out of its slot.
6. Remove any remaining cables.
7. Replace the board and re-install the cables.

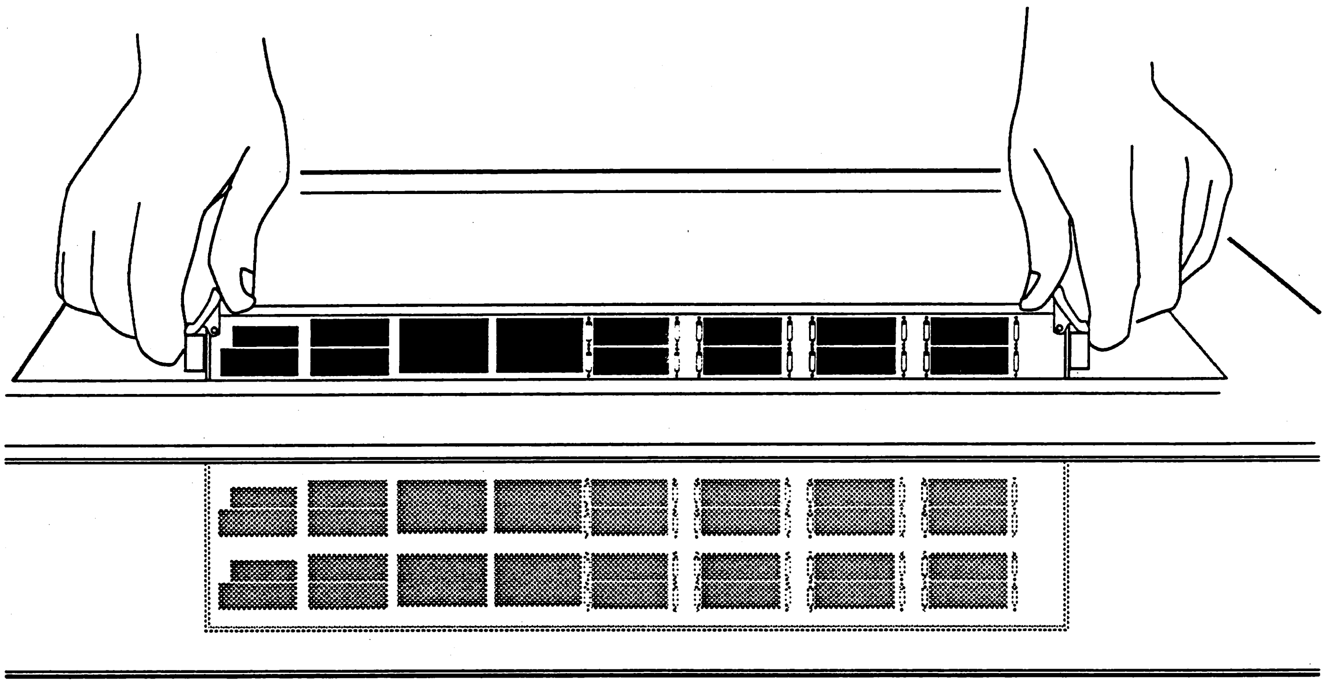


Figure 6-9: Removing a Card Cage Board

8. Calibrate the new board as described in Table 6-2. The procedures are as follows, depending on the board you are replacing:
   - Control board: Internal System calibration and diagnostic tests
   - Data Memory board: Internal System calibration and diagnostic tests
   - MPU board: Internal System and Geometry calibration, diagnostic tests, and run SETREF
   - Option 2F: run diagnostic tests
   - Option 1P: run diagnostic tests

Tekprobe Board

To replace the Tekprobe board, perform the following steps:

1. Turn the eight screws that hold down the bottom cover one quarter turn counterclockwise and remove the cover. (The screws are locked when the slots are lined up with the dot.)
2. Remove the cables to the Tekprobe board:
   - the 7-wire flexcon cables to the input connectors (J603 and J604)
   - the 4-wire Read Gun board connector (J602)
   - the Control board cable (J14)
   - the 5-wire power cable (J601)
3. Remove the four Tekprobe board screws and install a replacement.
4. Refer to Table 6-2 for functional checkout and calibration sections that are required for this replacement module.

Tekprobe Board Fuses

To replace fuses on the Tekprobe board, perform the following steps:

1. Turn the eight screws that hold down the bottom cover one quarter turn counterclockwise and remove the cover. (The screws are locked when the slots are lined up with the dot.)
2. Remove each defective fuse.
3. Install replacement fuse with the correct ratings. These are marked on the board.
4. Determine the cause for blowing the fuse and repair it before applying power to the instrument.

Front Panel LED Board

To replace the Front Panel LED board, perform the following steps:

1. Remove the Display Unit if it's attached.
2. Remove the eight front panel screws.
3. Open the front panel and tilt it down. Remove the ten nuts on the cable shield and board cover.
4. Remove the 40-wire cable to the MPU board (J22).
5. Remove the four screws securing the LED board to the Front Panel.
6. Install a replacement, making sure that the LEDs align with the front panel holes.

Backplane or Regulator Board

The Backplane and Regulator board must be removed from the instrument as a unit (although they are separate modules). To replace either of these boards, perform the following steps:

1. Turn the eight screws that hold down the top cover one quarter turn counterclockwise and remove the cover. (The screws are locked when the slots are lined up with the dot.)
2. Remove all of the card cage boards as described earlier.
3. Remove the cables to the Backplane and the Regulator board:
   - the cables to the Rear Panel (10-wire J35, 24-wire J36, 2-wire J37, and coax J39)
   - the cables to the Power Supply (6-wire J63, 5-wire J66-Backplane, 6-wire J66- Regulator, 11-wire J62, and 7-wire J65)
   - the front panel power switch (J60)
4. Remove the eleven screws along the Backplane perimeter.
5. Remove the Power Supply as described below and unscrew the two Regulator board screws.
6. Pull out the backplane and Regulator board as a unit.
7. Separate the Backplane and Regulator board and replace the defective board. Reassemble the instrument following the above instructions in reverse order. Be careful not to pinch the 3-wire cable to the front panel power switch (J60).

Power Supply

To replace the Power Supply, perform the following steps:

1. Turn the eight screws that hold down the top cover one quarter turn counterclockwise and remove the cover. (The screws are locked when the slots are lined up with the dot.)
2. Remove the five rear panel screws to the Power Supply.
3. Slide the Power Supply part way out. From the top of the instrument, remove the 5/16" nut to the chassis ground wire (as shown in Figure 6-10).
4. Remove the cables to the Power Supply inside the instrument:
   - the cables to the Regulator board (11-wire J62, 7-wire J65, and 5-wire J66)
   - the cables to the Backplane (4-wire J63 and 5-wire J66)
5. Slide the power supply completely out of the chassis.
6. Install a replacement Power Supply by following these instructions in reverse. Be careful not to pinch the cables when sliding in the replacement.

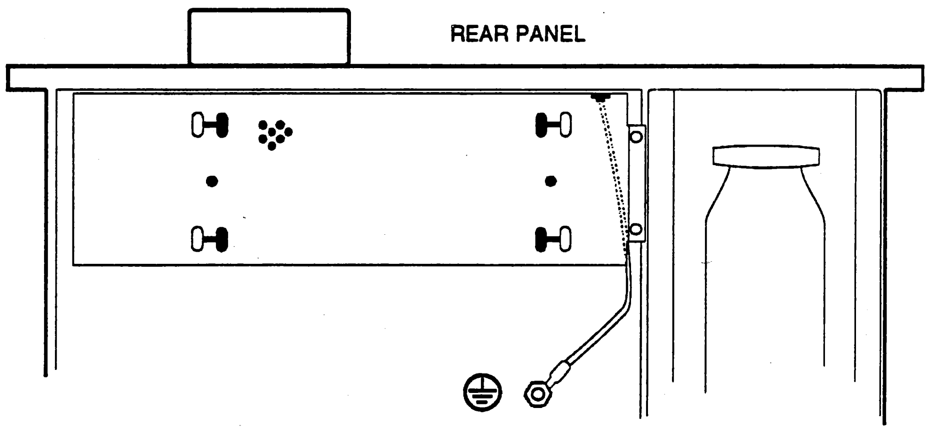


Figure 6-10: Chassis Ground Wire

Power Converter Board

To replace the Power Converter board, perform the following steps:

1. Set the instrument upside down. Turn the eight screws that hold down the bottom cover one quarter turn counterclockwise and remove the cover. (The screws are locked when the slots are lined up with the dot.)
2. Remove the 40-wire cable to the Read Gun board to allow access to the Converter board.
3. Remove the cables to the board:
   - the 10-wire power cable to the Backplane (J10)
   - the 8-wire Write Gun power cable (J11)
   - the Read Gun power cables (J34 and J12)
   - the High Voltage board power cables (J20 and J21)
   - the Tekprobe board power cable (J601) if Option 2E is installed
4. Remove the six screws to the board and remove the board. Install a replacement by following the above instructions in reverse order.

Display Unit Front Panel Board

To replace the Display Unit Front Panel board, perform the following steps:

1. Remove the Display Unit by pulling out the handle on the left side, and set the unit on a static-free workbench.
2. Remove the two knobs with a 1/16" hex wrench.
3. Remove the four screw plugs on the Display Unit. Use a fiberglass screw-driver to avoid marring the surface. Remove the the four screws and lift off the top.
4. Remove the cables to the Front Panel board:
   - the 40-wire main cable
   - the 3-wire cable
   - the ribbon cable to the LCD. To remove this cable, lift up the white cable housing. Likewise, lift up the housing first before reinserting the cable.
5. Remove the seven screws securing the Front Panel board and lift out the board.
6. Install a replacement by following the above instructions in reverse order. Before tightening the Front Panel screws, make sure the buttons line up by operating the buttons with the cover in place. This process may take some trial and error to ensure that the buttons don't stick.

Display Unit LCD

To replace the Display Unit LCD, perform the following steps:

1. Remove the Display Unit by pulling out the handle on the left side, and set the unit on a static- free workbench.
2. Remove the Front Panel board as described above.
3. Remove the four screws that secure the LCD. Save the Plexiglass cover to install with the replacement LCD.
4. Install the replacement LCD and reassemble the Display Unit.

Troubleshooting

The following section contains general troubleshooting information.

Using the Extender Board

For troubleshooting, the card cage boards in the SCD (the Control board, Analog board, Trigger board, MPU board, Data Memory board, and DSP/Centroid board) can be plugged into the Backplane through an Extender board (Tektronix part number 671-0692-xx). In this position the board is accessible for probing and testing, and the instrument can still be operated. The Extender board works in all of the card cage slots.

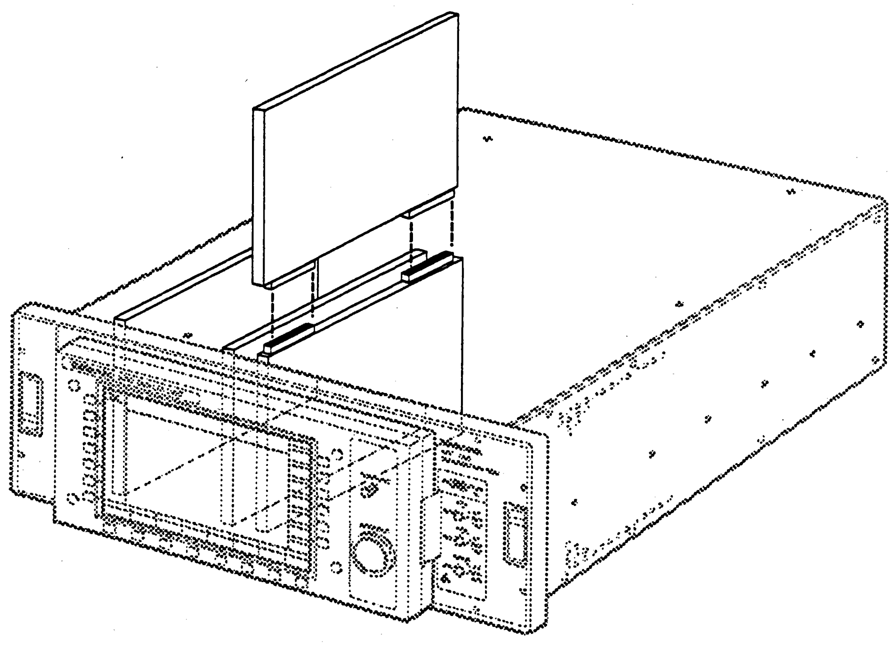


Figure 6-11: Using the Extender Board

To use the extender board, perform the following steps:

1. Turn off the power and take the power plug out of the outlet.
2. Remove the instrument from the rack and place it on a static-free workbench.

WARNING

Any operation that requires removing the cover should only be done by a qualified service technician. Removing the cover exposes dangerous voltages.

3. Turn the eight screws that hold down the top cover one quarter turn counterclockwise and remove the cover. (The screws are locked when the slots are lined up with the dot.)
4. Remove the card cage locking bracket.
5. Remove the card cage board to be probed by pulling up the white tabs on the corners of the board as shown in Figure 6-9, and sliding the board out of its slot. (If you are testing the Analog or Trigger board, disconnect the input cables from the front of the the board before removing the board. Reattach the cables after the Extender board is installed. For the other boards, leave the cables attached.)
6. Press the Extender board into the card cage slot until it is fully engaged with the backplane connectors.
7. Press the board to be probed onto the Extender board. Make sure all cables are attached before applying power.

Video Mode

The SCD can be placed in video mode so that the unprocessed write trace can be seen on a standard video monitor in real time. The SCD scans the full target area, and the scan is rotated 90° so that the aspect ratio matches a TV monitor. This mode allows you to check the target scanning for gross errors and to make adjustments easier. In video mode, you can verify that the read and write guns (and all analog hardware) are working even if portions of the digital sections of the instrument are disabled.

To put the SCD into video mode it is necessary to open the instrument and move some jumpers on the Read Gun board. Put the SCD into video mode following the procedure described in *Video Mode Instructions* on page 5-90.

Troubleshooting Procedure

Use this procedure to eliminate simple problems that may not require replacing an entire board:

1. Run the diagnostic tests described in Section 2. If the instrument does not start up, remove the top cover and run the power-up tests. The Diagnostic LEDs on the MPU board may indicate the trouble.
2. If the problem seems to be related to firmware, replace the SCD's processor ROMs with those from a working instrument (make sure the ROMs have the same version number). Refer to page 6-32.
3. Check that the MPU DIP switches (see Figure 6-8) and the rear panel DIP switches are set properly.
4. Check the instrument's control settings as described in the *SCD1000/SCD5000 Operator Manual*. Incorrect settings can falsely indicate a problem. Calibrate the instrument as described in *Internal Calibration*. The calibration error messages may help find the problem. Error messages are listed at the end of the *Internal Calibration* section.
5. If a controller is being used, check that it is operating correctly. Check that the interconnecting cables are not defective. Use the debug mode (as described in the Operator manual) to view bus traffic on the Display Unit. The error event codes described in the *SCD1000/SCD5000 Instrument Interfacing Guide* may also help solve the problem.
6. If the fan does not run, check the line-voltage source and the power supply fuse. If you suspect the Power Supply, check the Power Supply Fault LEDs located inside the Power Supply housing. You can use the 11K Power Supply Diagnostic Fixture (Tektronix part number 067-1264-00) to assist in troubleshooting.

NOTE

Operating the instrument from a 230 V (rms) power source while set for 115 V (rms) operation can blow the instrument's power supply fuse.

7. Inspect any suspected part of the instrument. Many problems can be found by such indications as desoldered connections, broken wires, or burned or broken circuits or components. Check that all cables are properly installed and that all jumper settings are correct.
8. Check circuit supply voltages (typical supply voltages are given in the calibration procedures).
9. Trace a suspect signal to check for broken wires. Data and address lines can be traced with an oscilloscope by setting the appropriate Diagnostic Test to looping mode (refer to *Diagnostics*).

10. If the problem is intermittent, set the appropriate Diagnostic Test to loop until it detects an error (refer to *Diagnostics*). Try heating, cooling, and re-seating suspected components to find if changing environmental conditions or a loose connection are causing the component to fail.

11. Check that the values of test points, resistors, and capacitors agree with those specified on the circuit diagrams. Check transistors and diodes for open or shorted conditions. Test integrated circuits with a logic probe or oscilloscope.

CAUTION

Do not attempt to desolder integrated circuits. The IC and circuit board can be damaged by the heat required to reflow the connections. Use care when probing around ICs so that adjacent leads are not shorted together.

12. If you locate a defective part, replace the module that contains the part following the procedures in *Removal and Installation Procedures.*

Diagnostics

This subsection describes the diagnostic self-tests built into the SCD1000 and SCD5000.

Overview

The SCD normally performs diagnostic self-tests every time the instrument is powered up. These tests are a subset of the internal diagnostic routines. The tests can also be run manually with either the GPIB interface or the Display Unit. The tests consist of two parts: the *Kernel Tests* and the *Essential Diagnostics Tests*.

Kernel Tests test the microprocessor, processor RAM and ROM, and the GPIB communication system. These tests verify that all operating system resources are working.

Once the instrument passes the Kernel Tests, the operating system is activated. The first task of the operating system is to execute the Essential Diagnostics Tests, which ensures that the instrument's basic subsystems are functioning properly.

If the instrument fails any of the Kernel Tests or Essential Diagnostic Tests, the following events occur:

- the instrument attempts to run while reporting an Internal Error event code over the GPIB (see Section 6D of the *SCD1000/SCD5000 Operator Manual* for an explanation of event codes)
- the front panel FAULT indicator (behind the Display Unit) lights
- the Display Unit displays a descriptive message in the message/measurements zone

If the system cannot display an error message, read the failure from the Diagnostic LEDs located on the MPU board inside the instrument. (These LEDs also report operating system software errors.) For more information, see Interpreting the Diagnostic LEDs on page 6-46.

Other methods of checking proper SCD operation:

- running the internal calibration routines and noting any error messages
- using the Debug Mode to monitor traffic on the GPIB bus
- using the `EVENT?` query to check for error event codes
- setting the diagnostic tests in looping mode to troubleshoot the instrument
- checking Power Supply Fault LEDs
- using power supply diagnostic fixture (Tektronix part number 067-1264-00)

Interpreting the Diagnostic LED's

The SCD digitizer uses a set of eight LEDs on the MPU board to indicate test failures and operating system software failures. Consult these LEDs if:

- the system locks up during power-up tests and cannot display error messages
- the system locks up during normal operation and displays FATAL ERROR
- the system doesn't respond to GPIB commands after power-up

To view these LEDs, remove the top cover. The MPU board is the leftmost board in the card cage, and the LEDs are located at the top edge of the board. The LEDs are read facing the component side of the board (the left side of the instrument).

CAUTION

Any procedure that requires opening the instrument should be performed by a qualified service technician.

The patterns are shown as they would appear when viewed from the left side of the instrument. During normal operation a single lit LED cycles from end to end of the display. The leftmost LED indicates that a test failed. The LED second from the left indicates that a test is in progress or that the instrument locked up while the test was running. The other six LEDs identify individual tests.

The SCD also has a set of four Fault LEDs located inside the Power Supply housing.

Operating System Failure

The Diagnostic LEDs also report any software problems that could cause the operating system to lock up, such as:

- a bus/address error
- a stray exception
- dividing by zero in the software
- a fatal error in the software

If the operating system reports errors, check for a loose chip or a faulty bus. Make sure ROMs are seated firmly in their sockets. If the operating system still fails, replace the set of four MPU ROMs following the instructions in *Removal and Installation Procedures*.

Kernel Tests

The LEDs located on the Microprocessor board provide the only user feedback during kernel tests. These tests check only the portion of the instrument necessary to support basic processor functions required to run the software operating system.

Interpreting LED Fields – The LED code for each test is generated by combining the test status LEDs and the test code LEDs. The first two LEDs are the status LEDs. The second one indicates test started or running and the first one indicates test error. The status LED configuration for "test start" (01XXXXXX) is displayed when a test begins. If a fault is detected, the test status LED configuration will change to "test error" (10XXXXXX) and testing will halt.

ROM 0,1,2,3 Location Tests

These tests check each ROM is inserted in the correct socket by reading a location code from the ROM trailer.

LED Codes	ROM
SS00 0010	U501
SS00 0011	U600
SS00 0100	U601
SS00 0101	U700

Recommended Action – If any of these tests fail, turn off the instrument and check the ROMs for proper location, orientation and correct insertion.

ROM 0,1,2,3 Checksum Tests

These tests check if the ROMs programming is correct. This is done by summing each ROMs content and comparing the results with a value stored in that ROM's header.

LED Codes	ROM
SS00 0110	U501
SS00 0111	U600
SS00 1000	U601
SS00 1001	U700

Recommended Action – If any of these tests fail, turn off the instrument and check the ROMs for proper location, orientation and correct insertion.

RAM Data Test

Checks Data Line integrity to the RAM chips with a walking ones test.

1. Write 0001H data pattern to base address of RAM.
2. Read the data pattern back from RAM.
3. Check that write and read patterns are the same.
4. Repeat test moving pattern one bit to the left until all bits have been tested.

LED Codes
SS00 1010

Recommended Action – If this test fails, the offending data pattern is placed on the address bus for you to check with an oscilloscope. Look for bent pins, broken traces, etc. This test only exercises the first byte and word of the memory devices.

System RAM Address Test

Checks Address Line integrity to the RAM chips by writing and reading several patterns into the entire RAM memory range.

1. Fill RAM with the AAAAH pattern.
2. At each memory location, check for the AAAAH pattern and write a CCCCH pattern. Repeat this for all RAM locations.
3. Repeat step 2 while checking for CCCCH and writing OFOFH.
4. Repeat step 2 while checking for OFOFH and writing 5555H.
5. Repeat step 2 while checking for 5555H and writing AAAAH.
6. Check all memory locations for the AAAAH pattern.

LED Codes
SS00 1011

Recommended Action – If this test fails, the offending data patterns are repeatedly read and written to the memory location at which the fault was detected. This test locates address line shorts and opens as well as defective memory cells.

Option 1P Tests

There are LED's on the Option 1P board. On power-up they should cycle through a binary sequence from 1 to 9. The rear LED is the LSB. In Table 6-3 the rear LED is shown first and the front LED is shown last. X indicates that the LED is lite, and O indicates that the LED is off.

Table 6-3: Option 1P Diagnostic LED Codes

LED	Description
XOOO	Low ROM checksum
OXOO	Mid ROM checksum
XXOO	High ROM checksum
OOXO	External X data RAM Test
XOXO	Internal X data RAM Test
OXXO	External Y data RAM Test
XXXO	Internal Y data RAM Test
OOOX	Internal program RAM Test
XOOX	Waiting for signals to go from the MPU
XXXX	All LEDs lite, indicates all tests have passed

Turning Off Power-Up Diagnostics

The power-up tests generally run quickly, and should be run every time the instrument is turned on. However, it may be desirable to disable them in environments subject to power glitches so the instrument can reach a ready state as soon as possible. Turn the power-up tests off with the GPIB command `SAFEGUARD PUPTST:OFF`, or by switching off rear panel DIP switch 1 (see the *D1000/SCD5000 Operator Manual* for more information). The PUPTST must be set to on for the digitizer to perform the power-up tests.

If the power-up tests are bypassed, the instrument generates an SRQ (Service Request). The Display Unit or an `EVENT?` query returns the following message on power-up:

```
Self test has been bypassed
```

Running Tests With GPIB Commands

The following is a summary of the GPIB commands used to run the diagnostic tests (refer to the *SCD1000/SCD5000 Operator Manual* for a complete description of GPIB commands and their use):

- **TEST SYS: [ALL]** runs all Essential Diagnostic tests
- **TEST SYS: MPU** runs tests of the MPU board
- **TEST SYS: FP** runs tests of the Front Panel board in the Display Unit
- **TEST SYS: DIG** runs tests of the acquisition system
- **TEST NUM: <NRx>** runs test number <NRx>
- **TEST LOOP:[ON/OFF]** sets the looping mode (see page 6-51)
- **TEST VERBOSE:[ON/OFF]** sets the verbose mode (see page 6-53)
- **TEST?** queries the test settings. For example, entering `TEST?` might get a response such as

  ```
  TEST LOOP: OFF, NUM: 1, SYS: MPU, VERBOSE, OFF
  ```

- **DIAG?** displays the results of the first test that failed, or the last test executed if there were no failures. The form of the output depends on the state of the `TEST VERBOSE` command.

The GPIB commands entered while the tests are running are not executed until the tests are done. If a group of tests are run, only one error message is displayed at a time. To view other error messages, individual tests must be run.

When a test completes, it sends either an error SRQ or the message

```
Self test completed successfully
```

This message can be used in a program to automate testing and querying the instrument for the results.

Running Tests From the Display Unit

Diagnostic tests can be run from the Display Unit's Utility menu as described in the *SCD1000/SCD5000 Operator Manual*. This menu has the following keys:

- the **InstTest** key runs all diagnostic tests
- the **MPU Test** key runs tests of the processor board
- the **Acq Test** key runs tests of the acquisition subsystem.
- the **FP Test** key runs tests of the Display Unit
- the **Opt Test** key runs tests of the Option 2F or Option 1P if installed

NOTE

Individual diagnostic tests cannot be run from the Display Unit.

The results of diagnostic tests are displayed in the message/measurements area of the Display Unit. The last 20 messages sent are saved, and can be reviewed using the **Rcl Stat** function key of the SaveRecall menu.

The Display Unit cannot be used to set the LOOP or VERBOSE test settings. These settings can be turned on and off only by using the GPIB commands `TEST LOOP[ON/OFF]` and `TEST VERBOSE[ON/OFF]`.

Looping Mode

Diagnostic tests normally run only once per command. However as a trouble-shooting aid, all diagnostic tests can be set to loop continuously or to loop until detection of an error.

Continuous looping aids testing with an oscilloscope. For example, if a data line is suspected of being shorted, a looping test can exercise the subsystem that the line belongs to while an oscilloscope verifies that the test signal is being received at various checkpoints in the circuit.

Looping until an error is detected can help catch intermittent problems. For example, a looping test can exercise the subsystem that a suspected component belongs to until the error occurs. The component can then be heated, cooled, or physically adjusted to determine if changing environmental conditions or a loose connection are causing the component to fail.

Make a test or group of tests loop continuously as follows:

1. Send the GPIB command `TEST LOOP:ON`. This puts the instrument in looping mode, and any tests run from this point will loop continuously.
2. Enter the GPIB command for the test to be looped.

For example, sending `TEST LOOP:ON TEST NUM: 15` would cause test number 15 to loop continuously. Tests set to loop continuously run until interrupted by any GPIB command. If more than one test is run in looping mode, the tests cycle one after the other. After a looping test has been stopped, the looping mode remains on, and any subsequent tests run will also loop. Turn off looping mode by sending the GPIB command `TEST LOOP:OFF`.

To set a test or group of tests so that they loop until an error is detected, send the command `ERRSTP:ON`. When this mode is on, any tests run will repeat until they detect an error, or until a GPIB command is issued. Turn off this mode by sending the command `ERRSTP:OFF`.

The LOOP command cannot be used with the Kernel ROM and RAM tests (which must be run before the operating system is activated) or the GPIB test (since the GPIB itself may not be operational). To make the kernel ROM and RAM tests or the GPIB tests loop, use the DIP switch located on the MPU board (see Figure 6-12). (The digitizer cabinet must be open to access this switch.)

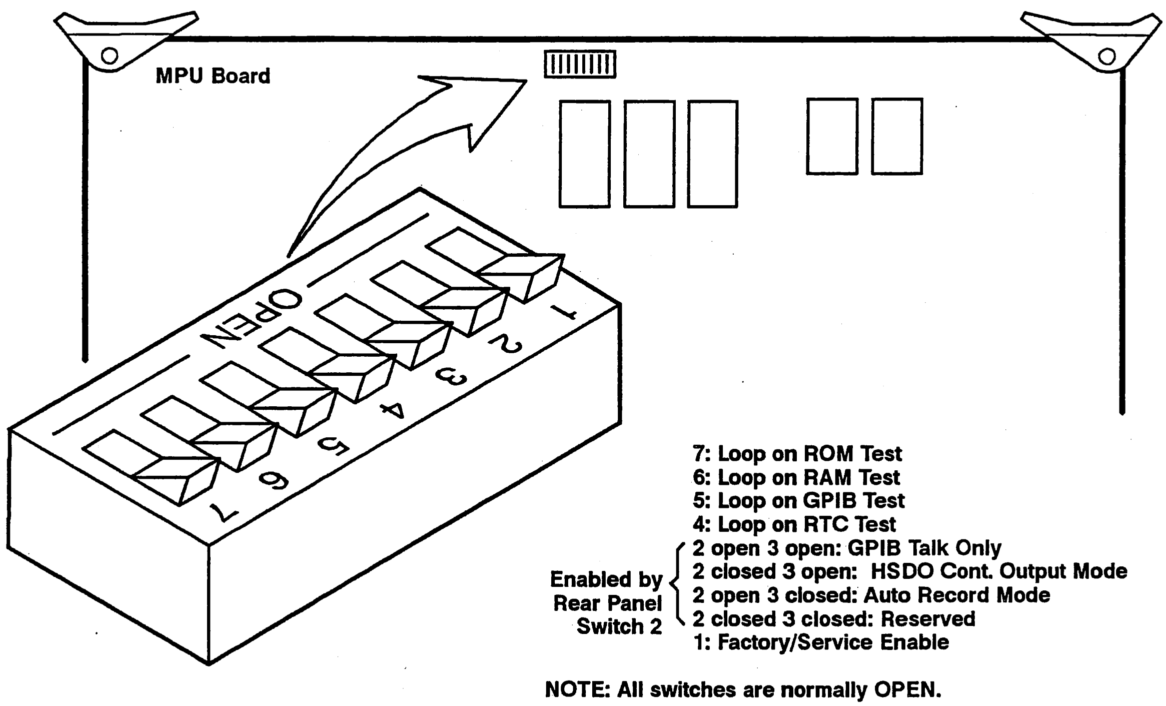


Figure 6-12: MPU Board DIP Switch

Verbose Mode

The diagnostic tests output an error message describing the results of the first test that failed, or the last test executed if there were no failures. These messages are formatted in one of two ways, depending on whether verbose mode is on or off:

- If verbose mode is off, the test will return `PASSED`, `FAILED`, or `BYPASSED`. (`BYPASSED` indicates that power-up diagnostics were turned off.)
- If verbose is on, a two phrase message is returned. The first phrase tells which test was executed and whether it passed or failed (for example `FAILED GPIB System Test`). The second phrase gives details about what specifically was tested. For example, the message might indicate that Data Input/Output (DIO) lines were tested, and give the address of the location being tested, the actual contents at that address, and the expected contents. A complete response might read:

```
FAILED RTC Test.
RTC count minimum TTTT maximum UUUU actual AAAA
```

If a series of tests discovers more than one failure, the first failure alone is reported, and the string `-MORE-` is added to the end of the first phrase of the error message. Individual tests can then be run to pinpoint the failure.

The Display Unit saves the first 20 error messages output by the diagnostic tests. These messages can be displayed one at a time using the **Rcl Stat** function key of the SaveRecall menu. (There is no GPIB equivalent for this function.)

Essential Diagnostic Tests

This section describes the 19 diagnostic tests contained in the SCD firmware. Each test description includes a line giving the test number (TEST NUM) and the subsystem test group that the test belongs to (MPU, FP, or DIG). Each test description is followed by a list of possible error messages, pertinent notes, and the recommended repair action if the test should fail.

The diagnostic tests detect gross errors. Before going to the expense of replacing a complete board, conduct further investigations to ensure that the problem is not simple. The troubleshooting procedure (see *Troubleshooting*) gives a few suggestions. Table 6-4 lists the diagnostic tests.

Table 6-4: Diagnostics Tests

Test	Num.	Sys.	Description
Real Time Clock	1	MPU	Assures the tick interrupts run at the correct rate
GPIB	2	MPU	Checks the GPIB interface
Bus Error	3	MPU	Checks the bus error-detect logic
Timer	4	MPU	Verifies that the timer interrupts at the correct rate
ROM0 Part Number	5	MPU	Checks the part number in the ROM header and performs a checksum on power-up
ROM1 Part Number	6	MPU	Checks the part number in the ROM header and performs a checksum on power-up
ROM2 Part Number	7	MPU	Checks the part number in the ROM header and performs a checksum on power-up
Display Unit ROM	9	MPU	Checks the part number in the ROM header and performs a checksum on power-up
NVRAM	10	MPU	Checks the NVRAM
Video	11	FP	Checks the video/LCD RAM
Button	12	FP	Exercises knobs and buttons
Front Panel Communication	13	FP	Checks communication between the Display Unit and the processor
Digital Acquisition/Memory	14	DIG	Checks digital acquisition hardware and memory
Digital Acquisition Only	15	DIG	Checks digital acquisition hardware only

Table 6-4: Diagnostics Tests

Test	Num.	Sys.	Description
Serial Bus	16	DIG	Checks communication over the serial bus to the Analog, Read, and Write boards
Options	17	OPT	Checks DSP and HSDO if installed
DSP Communication Option	18	OPT	Check DSP host port communication
HSDO Battery Backup	19	OPT	Checks HSDO nonvolatility

Real Time Clock Test

(GPIB NUM: 1, TEST SYS: MPU)

This test checks the period of the Real Time Clock against the period of the microprocessor clock on the MPU board. The clock period (15.625 ms) is vital to the operating system for timing, task swapping, etc. The accuracy of this clock period assures that the tick interrupts generated on the MPU board occur at a reasonable rate.

Error Messages

A. `RTC count minimum TTTT maximum UUUU actual AAAA`

Indicates the real time clock is not interrupting the 68010 processor at the correct rate. TTTT is the minimum allowed count, UUUU is the maximum allowed count, and AAAA is the actual count measured by the test.

LED Codes
SS00 1101

Recommended Action

Check circuitry supporting the Real Time Clock (RTC) chip (U721, U421) and it's interrupt decoding to the processor. If the RTC is completely inoperative, this test may be made to loop indefinitely at power up by setting the RTC Loop dip switch located on the processor board. The High level Error message will be inoperative during this time but the diagnostic LEDs will indicate test status.

If this test fails, replace the MPU board following the instructions in *Removal and Installation Procedures.*

GPIB Test

(GPIB NUM: 2, TEST SYS: MPU)

This test checks the GPIB hardware by disconnecting the TMS9914A chip from the external GPIB bus (that is, the controller is disconnected), and using the MC68B21 PIA to simulate bus activity. The test verifies state changes. The test checks that the following are true:

1. The TMS9914A correctly interrupts the processor upon receiving an IFC (Interface Clear) signal. [Error: A,B]
2. The TMS9914A responds correctly to the REN (Remote enable) line. [Error: C]
3. The TMS9914A responds correctly to a DCL (Device Clear) message. [Error: D,B]
4. The TMS9914A operates correctly when configured as a listener. This includes testing the Byte In interrupt and exercising the DIO lines with a walking-1's pattern. [Error: D,B,E,F,G]
5. The TMS9914A operates correctly when configured as a talker. This includes testing the Byte Out Interrupt and exercising the DIO lines with a walking-0's pattern.
6. The TMS9914A responds correctly to a Serial Poll operation. [Error: K,D,I,C,B]

Error Messages

A. `GPIB IFC expected EEEE actual AAAA`

   Indicates the controller did not send the interface clear signal.

B. `dg ISP expected EEEE actual AAAA`

   Indicates the 9914 GPIB controller chip did not interrupt the 68010 processor.

C. `GPIB Poll expected EEEE actual AAAA`

   Indicates the GPIB controller did not return the proper return status for a poll function.

D. `dg Add expected EEEE actual AAAA`

   Indicates the controller could not address the SCD.

E. `dg Put expected EEEE actual AAAA`

   Indicates the handshake during a data transfer from the controller to the SCD failed (NRFD and NDAC did not function properly).

F. `GPIB data expected EEEE actual AAAA`

   Indicates a bit error occurred during a data transfer.

G. `dg EOI expected EEEE actual AAAA`

Indicates the SCD did not receive the EOI signal when the controller addressed the SCD as a talker.

H. `GPIB Put expected EEEE actual AAAA`

Indicates the handshake during a data transfer from the SCD to the controller failed NRFD and NDAC did not function properly.

I. `dg Get expected EEEE actual AAAA`

Indicates that handshake during a data transfer from the controller to the SCD failed (DAC did not function properly).

J. `GPIB EOI expected EEEE actual AAAA`

Indicates the SCD did not send the EOI signal when the controller addressed the SCD as a talker.

K. `GPIB status expected EEEE actual AAAA`

Indicates the 9914 GPIB controller chip did not have the proper status bits set.

NOTE

"dg" implies fault on PIA communication. "GPIB" implies fault on GPIB communication.

LED Codes
SS00 1100

Recommended Action

Check the circuitry around the TMS9914 and 6821 (U211, U311) for loose or broken connections, bad solder joints, shorted pins or traces, etc. This test may be made to loop indefinitely at power up by setting the GPIB Loop dip switch located on the processor board. The High Level Error message will be inoperative during this time but the diagnostic LEDs will indicate test status. If failure is not correctable, replace the MPU board following the instructions in *Removal and Installation Procedures*.

Bus Error Test

(GPIB NUM: 3, TEST SYS: MPU)

This test checks the MPU bus error-detect logic by attempting to generate a bus error. The test writes to an address that should result in a bus error, then checks to see if the bus error occurred. The bus error timer and interrupt logic on the MPU board are tested for proper operation during this test.

Error Messages

A. `Bus Error Logic Failed`

Indicates the bus error-detect logic failed to detect an error purposely generated by the test.

LED Codes
SS01 0100

Recommended Action

Check the Bus Error timer and interrupt circuitry (U621, U522, U711) by looping on this test and using an oscilloscope to check for normal operation. If the failure is uncorrectable, replace the MPU board following the instructions in *Removal and Installation Procedures*.

Timer Test

(GPIB NUM: 4, TEST SYS: MPU)

The Timer Test checks the timer circuitry located in the UART IC on the MPU board. The test is performed by loading the timer with a known count and waiting in a microprocessor loop for the timer to count to completion. By counting the number of processor loops performed, the elapsed time can be calculated. If this time is within tolerance, the test passes.

Error Messages

A. `Timer count minimum TTTT maximum UUUU actual AAAA`

Indicates the timer is not interrupting the 68010 processor at the correct rate. TTTT is the minimum allowed count, UUUU is the maximum allowed count, and AAAA is the actual count measured by the test.

LED Codes
SS00 1110

Recommended Action

Check the UART IC and supporting circuitry (U320, Y320, C321, C320) by looping on this test and using an oscilloscope to check for normal operation. The terminal count of the timer is announced to the processor via interrupt, so check the interrupt logic (U421) also. If this test is uncorrectable, replace the MPU board following the instructions in *Removal and Installation Procedures*.

ROM Part Number Tests

(GPIB NUM: 5, 6, 7, 8)

The ROM Part Number tests display the part number located in each ROMs trailer. No pass or fail condition is tested, although the response will indicate pass.

Test number to circuit grid correlation:

Test Number	Circuit Grid
5	U501
6	U600
7	U601
8	U700

LED Codes
Not Used

Error Messages

The lack of a displayed response indicates an error. A successful test is indicated by displaying the message:

```
Passed Rom UXXXX: Part number 160-XXXX-XX
```

These messages indicate the following part numbers read by the test:

```
Part number 160-5800-nn
Part number 160-5801-nn
Part number 160-5802-nn
Part number 160-5803-nn
```

Recommended Action

If a ROM fails the test but is in the proper socket, try reseating it. If it still fails, replace the ROM as described in *Removal and Installation Procedures*.

Front Panel ROM Part Number Tests

(GPIB NUM: 9)

This test first checks if the front panel is connected and communicating correctly. If everything is OK, a part number request is sent to the Front Panel to retrieve it's part number. On a periodic basis, the instrument checks the Front Panel connect status and updates a global variable used by the rest of the system. A connected Front Panel is detected by a TTL high on U500 pin 9 on the MPU board. The SCD processor will try to establish communication with the Front Panel processor as soon as a connection is indicated. If all is well during initial communication, the main processor sets the Front Panel status variable to OK.

Possible settings are:

- Connected and Functioning (OK)
- Not Connected (MISSING)
- Connected But Not Responding (BROKE)

Check the global variable in system RAM that holds Front Panel status. This status is loaded at power up or when Front Panel status changes. The possible conditions are:

- If Front Panel MISSING
  Return Message: "Front Panel not Connected"
- If Front Panel BROKEN
  Return Message: "Front Panel not communicating"
- If Front Panel OK, get the part number from the Front Panel.
  Return Message: "Part number 160-XXXX-XX"

LED Codes
Not Used

Recommended Action

If this test does not return the Part number message, run the Front Panel Communication Exerciser Test on page 6-64.

NVRAM (Nonvolatile RAM) Test

(GPIB NUM: 10)

WARNING

DO NOT switch off instrument power while this test is executing. Powering down during this test results in a loss of all calibration constants, stored settings, and waveforms stored in nonvolatile memory.

This test checks the NVRAM. The NVRAM test copies NVRAM contents to system RAM prior to testing and then returns this data after completing the test. NVRAM test uses the System RAM Address Test algorithm from the Kernel Tests. This algorithm checks the RAM chips' address line integrity by writing and reading several patterns into the entire RAM memory range.

This test will:

- verify that the system RAM temporary buffer is OK [Error: A]
- check nonvolatile memory [Error: B]

Error Messages

A. `Temp memory Address XXXX expected EEEE actual AAAA`

Indicates the memory used to store the contents of NVRAM during the test is bad and the test was aborted.

B. `Nvram memory Address XXXX expected EEEE actual AAAA`

Indicates that there is a bad memory location in NVRAM.

LED Codes
SS00 1111

Recommended Action

If this test fails with the "Temp memory ... " error message, system RAM has been found at fault. Testing is aborted and nonvolatile RAM is not affected. System memory is tested at power up if `SAFEGUARD PUPTEST: ON` is set. Ensure power up test is enabled and then power up the instrument again. Observe LED codes on MPU board and troubleshoot using system RAM test.

If this test fails with the "Nvram memory ... " error message, nonvolatile memory is at fault. All stored settings and calibration constants may have been lost and need to be restored once the fault has been corrected. Check control, data and address lines to the nonvolatile RAMs for proper operation. Looping on this test is useful when checking these connections. If the fault is uncorrectable, replace the NVRAM as described in *Removal and Installation Procedures*.

Display Video and LCD Test

(GPIB NUM: 11, TEST SYS: FP)

This test checks video RAM and provides display exercisers for viewing by a technician. The System RAM Address Test algorithm from the Kernel Tests is used to check the video RAM [Error: A].

Error Messages

A. `Video Memory Address XXXX expected EEEE actual AAAA`

Indicates a bad location in the video RAM. XXXX is the address of the failure, EEEE is the test pattern expected, and AAAA is the actual test pattern read.

LED Codes
SS01 0000

Recommended Action

Check address, data, and control lines between the MPU and the video RAMs (U100, U110, U101, U200, U201, U300) located on the MPU board. If the video RAM test functions correctly but screen displays are incorrect, connect a VGA monitor to the video output on the rear apron and rerun the test observing test patterns on the monitor. If the VGA monitor test patterns are OK, troubleshoot the LCD Front Panel circuitry. If the VGA monitor patterns are not OK, the video circuitry on the MPU board is suspect. Replace either the Front Panel board or the MPU board according to most likely suspect.

Touch and Knob Exerciser (Button Test)

(GPIB NUM: 12)

This test displays simple graphic feedback to indicate that a button has been pressed or a knob has been rotated. To exit this test, select the upper left button and the lower right button along the sides of the LCD panel simultaneously.

LED Codes
Not Used

Error Messages

There are no error messages for this test.

Recommended Action

If the Front Panel board is not aligned properly, the buttons may stick. Refer to *Removal and Installation Procedures* for instructions aligning and replacing the Front Panel board.

Front Panel Communication Exerciser

(GPIB NUM: 13, TEST SYS: FP)

This test exercises and checks the communication between the Display Unit's 68705 MPU and the instrument's 68010 MPU. The Front Panel Communication Exerciser test sends a fixed set of test patterns to the Front Panel processor and then receives them back. The test patterns are: (01, 02, 04, 08, 10, 20, 40, 80, fe, fd, fb, f7, ef, df, bf, 7f). All test data patterns are transmitted and received before any error checking of the patterns is done.

NOTE

This exercise will not run if Front Panel communication is functioning normally.

Error Messages

A. `Front Panel Communications Test not allowed`

Indicates that the power-up communications test passed but further communications testing is not allowed.

B. `Data Path expected EE actual AA`

Indicates that there is a bad communication bus between the display unit and the 68010 processor.

LED Codes
SS01 0010

Recommended Action

If front panel communication fails, this test may be used to drive the communication port for troubleshooting.

- Set looping mode to on and run this test. Then use an oscilloscope to check the control and data lines to the front panel interface as the test patterns are repeatedly sent.
- Test the Display Unit on another SCD.

If the Display Unit is faulty, replace the Front Panel board, otherwise replace the MPU board. Refer to *Removal and Installation Procedures* for instructions on replacing these boards.

Digital Acquisition/Memory Test (Long)

(GPIB NUM: 14, TEST SYS: DIG)

This test checks the digital acquisition hardware along with the reference and linear array memories on the Controller board. The acquisition hardware is stepped through the following test sequence which is designed to verify operations of the acquisition state machine:

1. Reset the acquire state machine. [Error: A]
2. Generate an acquisition abort and then clear it. [Error: B, C]
3. Using the System RAM Address Test algorithm:
   a. test the Reference Array memory. [Error: D, E]
   b. test the Linear Array memory. [Error: F, G]
4. Verify byte access to the Linear Array. [Error: H, I]
5. Load walking ones test pattern in Reference Array. [Error: G]
6. Set acquisition state machine for 1024 point acquire.
7. Single-step state machine up to within one clock period of completing the pre- acquisition 2 k erase cycle. Check if the acquire STOP bit is low. [Error: J]
8. Step state machine one more clock period and check if the acquire STOP bit is high. [Error: K]
9. Single-step state machine up to within one clock period of completing the 1 k reference erase cycle. Check if the acquire STOP bit is low. [Error: G, L]
10. Step state machine one more clock period and check if the acquire STOP bit is high. [Error: M]
11. Generate a simulated trigger to the state machine.
12. Single-step the state machine to within one clock period of completing the acquisition cycle. Generate a walking ones pattern for the subtracter circuitry. Generate a FIFO Overflow Interrupt. Check if the acquire STOP bit is low. [Error: N]
13. Step state machine one more clock period and check if the acquire STOP bit is high. [Error: O]
14. Check Acquire DONE toggles correctly. [Error: P, Q]
15. Check FIFO Overflow Interrupt toggles correctly. [Error: R, S]
16. Check Linear Array data for the Horizontal and Vertical data expected. [Error: T, U, V, W]
17. Check Acquire DAV Interrupt toggles correctly. [Error: X, Y]
18. Check Linear Array length counter is correct. [Error: Z]

LED Codes
SS01 0011

Error Messages

A. `Acquisition State (CLK25, CLK12) does not change`

Indicates that the internal clocks of the digital acquisition state machine are not working.

B. `Acquisition State Machine did not abort`

Indicates an access error between the MPU board and the Data Memory board.

C. `Acquisition State Machine Abort did not clear`

Indicates that the acquisition acquire abort function did not clear.

D. `Reference Array Memory Address XXXX expected EEEE actual AAAA`

Indicates a bad memory location in the reference array memory.

E. `Bus error while accessing Memory board at address XXXX`

Indicates an access error between the MPU board and the Data Memory board.

F. `Linear Array Memory Address XXXX expected EEEE actual AAAA`

Indicates a bad memory location in the linear array memory.

G. `Bus error while accessing Control board at address XXXX`

Indicates an access error between the MPU board and the Control board.

H. `Low Byte of Linear Array will not Read Expected EEEE actual AAAA`

Indicates access error.

I. `High Byte of Linear Array will not Read Expected EEEE actual AAAA`

Indicates access error.

J. `Stop Stopped before end of scan (erase)`

Indicates that the end of scan signal interrupted the scan too early during erase cycles.

K. `Stop Did not Stop at end of scan (erase)`

Indicates that the end of scan signal did not occur during erase cycles.

L. `Stop Stopped before end of scan (reference)`

Indicates the end of scan signal interrupted the scan too early during reference cycles.

M. `Stop Did not Stop at end of scan (reference)`

Indicates the end of scan signal did not occur during reference cycles.

N. `Stop Stopped before end of scan (linear)`

Indicates that the end of scan signal interrupted the scan too early during read cycles.

O. `Stop Did not Stop at end of scan (linear)`

Indicates that the end of scan signal did not occur during read cycles.

P. `Acquisition Stop before End of Acquisition`

Indicates that the internal acquisition stop bit occurred too early.

Q. `Acquisition did not Stop at End of Acquisition`

Indicates that the internal acquisition stop bit did not occur.

R. `Ovfl Set before Overflow`

Indicates that the overflow interrupt occurred too early.

S. `Ovfl Did not Set at Overflow`

Indicates that the overflow interrupt did not occur.

T. `Hpoint was not found expecting EEEE found AAAA Add XXXX`

Indicates that the horizontal location bits in the linear array are incorrect.

U. `Vpoint was not found expecting EEEE found AAAA Add XXXX`

Indicates that the vertical location bits in the linear array are incorrect.

V. `Gpoint was not found expecting EEEE found AAAA Add XXXX`

Indicates that the gray-scale bits in the linear array are incorrect.

W. `Hpoint was not found expecting EEEE`

Indicates that the horizontal location bits in the linear array are incorrect.

X. `Dav Set before end of acquisition`

Indicates the data available interrupt occurred too early.

Y. `Dav Did not Set at end of acquisition`

Indicates the data available interrupt did not occur.

Z. `Linear Counter expected EEEE actual AAAA`

Indicates the linear array counter is not counting correctly.

Recommended Action

If this test fails, set the test to loop continuously and trace the signals that aren't getting through

These error messages could indicate a faulty Control board, Data Memory board, MPU board, or Backplane.

Digital Acquisition Test (Short)

(GPIB NUM: 15, TEST SYS: DIG)

This test checks the digital acquisition hardware without performing the memory test. Use this test to ensure that any waveform information stored in memory is not corrupted.

Error Messages

This test can return all error messages given above except the first two.

Instrument Serial Bus Test

(GPIB NUM: 16, TEST SYS: DIG)

This test checks the serial bus by reading the test nodes from all three analog-to-digital converters (ADCs) in the instrument. The ADCs are located on the Analog (Trigger in SCD5000), Read Gun, and Write Gun boards. This test checks communications to these boards coming from the Control board.

The components of this test are:

1. read the Analog board's analog-to-digital test node and check for the proper response [Error: A]
2. read the Read Gun board's analog-to-digital test node and check for the proper response [Error: B]
3. read the Write Gun board's analog-to-digital test node and check for the proper response [Error: C]

LED Codes
SS01 0110

Error Messages

A. `ADC readback minimum TT maximum UU actual AA (analog)`

Indicates the test failed to read the test location on the Analog (or Trigger) board correctly over the serial bus.

B. `ADC readback minimum TT maximum UU actual AA (read)`

Indicates the test failed to read the test location on the Read Gun board correctly over the serial bus.

C. `ADC readback minimum TT maximum UU actual AA (write)`

Indicates the test failed to read the test location on the Write Gun board correctly over the serial bus.

Recommended Action

Check all affected cabling. Set the test to loop continuously and use an oscilloscope to determine if the serial bus to the indicated ADC is properly accessing the ADC, and that the ADC is responding.

HSDO and DSP Options Test

(GPIB NUM: 17, TEST SYS: OPT)

This test checks both the memory and the acquisition interface of the HSDO and DSP options. Memory testing uses the algorithm that is used for testing the microprocessor RAM and acquisition interface testing uses the algorithm that is used for testing the SCD's acquisition hardware.

The following test sequence is used:

1. Checks if either the HSDO or the DSP option is installed. If neither option is installed, a passed status with an error is returned. [Error: A]
2. If the DSP option is installed, request the DSP external memory bus from the DSP processor. [Error: B]
   a. If the main processor is granted the DSP's external memory, test the DSP's external memory using the same test described for the *System Ram Address Test*. [Error: C, D]
3. If the HSDO option is installed, place the HSDO in an inactive state. [Error: E]
   a. If the HSDO controls appear normal, test the HSDO's memory using the same test described for the *System Ram Address Test*. [Error: F]
4. If the DSP option is installed, send commands to the DSP using the DSP host port to setup fro a 1024 point acquisition and then arm for an acquisition. [Error: H, I]
5. Run the SCD's acquisition test. [Error: G]
6. If the DSP option is installed,
   a. Send the command to the DSP requesting the centroided waveform buffer. [Error: H, I]
   b. Check the three raw waveform data arrays contained in the DSP external memories for the expected waveform data. One array contains vertical "Vpoint" position data. A second array contains the gray scale "Gpoint" data for each "Vpoint" data item. The third array contains "Npoint" data which shows how many Vpoints and Gpoints are in each acquired scan line. [Error: J, K, L, M]
7. If the HSDO option is installed, check if the SCD's linear array and the HSDO memory contain identical acquisition data. [Error: N]

Error Messages

A. `No DSP or HSDO option installed`

B. `DSP external memory bus request failed`

C. `DSP X memory Address <number> expected <number> actual <number>`

D. `DSP Y memory Address <number> expected <number> actual <number>`

E. `HSDO control register did not read verify`

F. `HSDO memory Address <number> expected <number> actual <number>`

G. `Fault in base instruments Acquisition System`

H. `DSP communication timed out`

I. `DSP response <number> (<string>) expected <number.`

J. `DSP Vpoint expected <number> found <number> Address <number>`

K. `DSP Gpoint expected <number> found <number> Address <number>`

L. `DSP Npoint expected <number> found <number> Address <number>`

M. `Bus error while accessing DSP board at address <number>`

N. `HSDO acq data expected <number> found <number> Address <number>`

LED Codes
SS01 0111

Recommended Action

If this test fails with a DSP error:

- troubleshoot the host communications fault by running the *DSP Communication Loop-back Exerciser* with `TEST LOOP:ON` and use an oscilloscope to diagnose the problem.

If this test fails with an HSDO error:

- use an oscilloscope to troubleshoot the circuit area indicated.

DSP Communication Loop-back Exerciser Test

(GPIB NUM: 18, TEST SYS: OPT)

This test will send and receive many test patterns over the Options Communication Interface. It should be used to troubleshoot a suspected DSP host port problem.

The following test sequence is used:

1. Check if the DSP option is installed. [Error: A]
2. Send the host message loop-back command to the DSP processor. The message sent contains the loop-back command name (04H) and an argument (000eH). These are combined in a three byte 24-bit message (04000eH).
3. Wait to receive the DSP loop-back response. [Error: B]
4. When the DSP has responded, evaluate the response for the expected acknowledgement name (ffH) and argument. [Error: C]

   The acknowledgement argument is the one's compliment of the argument sent (fff2H).These values are returned in the same three byte 24-bit message format (fffffeH).
5. Repeat the above steps, incrementing the argument field of the message by 81H each time. The loop-back message will have been sent and received 509 times for each invocation of this test.

Error Messages

A. `DSP option is not installed`

B. `Host communication timed out`

C. `Host port response <number> expected <number> from DSP`

LED Codes
SS01 1000

Recommended Action

If this test fails, set TEST LOOP:ON to run the test continuously. Then use an oscilloscope to troubleshoot the host port control and data lines.

HSDO Battery Backup Test

(GPIB NUM: 19, TEST SYS: OPT)

This test verifies that the nonvolatile RAM on the HSDO saves waveform data across power cycles. This test requires that a technician perform some of the tasks.

1. Run the test, and a checksum will be generated on the entire HSDO nonvolatile memory. This checksum is then compared with the value in the last word of the HSDO nonvolatile memory, and should fail. [Error: C]

   The new checksum will be loaded into top HSDO memory. Other error codes indicate a more serious problem that needs to be fixed prior to testing the battery backup feature.

2. Turn the instrument power off and let it remain powered-off for at least 10 seconds. This will ensure that the residual charge from the power supply has had time to bleed off and that the RAMs are truly being sustained by their internal batteries.
3. Turn the instrument power on. Rerun this test. [Error: A, B, C]

NOTE

DO NOT acquire any new waveform data prior to running this test because it will invalidate the previously calculated checksum.

Error Messages

A. `HSDO option is not installed`

B. `HSDO control register did not read verify`

C. `Data memory checksum expected <number> found <number>`

LED Codes
SS01 1001

Recommended Action

If this test fails with error A, the expected value (00d0H) was not returned at power-on or a bus error occurred while reading the HSDO register. Trouble-shoot the system processor interface with this register.

If this test fails with error B, the HSDO control registers did not return the value written. Troubleshoot the HSDO control registers.

If this test fails with error C, the HSDO Battery Backup is defective. Replace the affected nonvolatile RAM chip and rerun this test.

Options

This section describes the various options that are available for the SCD Series Waveform Recorders. Some of these options can be installed in the field using a Tektronix Field Upgrade Kit available from Tektronix.

Options A1–A5: International Power Cords

The SCD Series Waveform Recorders are shipped with a detachable power cord as ordered by the customer.

Table 7-1: Power Cords

Option Name	Description	Tektronix Part Number
A1	Universal European Power Cord (2.5 m) 220 V, 16 A, 50 Hz	161-0066-09
A2	United Kingdom Power Cord (2.5 m) 240 V, 13 A, 50 Hz	161-0066-10
A3	Australian Power Cord (2.5 m) 240 V, 15 A, 60 Hz	161-0066-11
A4	North American Power Cord (2.5 m) 240 V, 15A, 60 Hz	161-0066-12
A5	Switzerland Power Cord (2.5 m) 220 V, 10 A, 50 Hz	161-0154-00

Option 01: Delay Line (SCD5000 Only)

This option provides delay line and internal trigger pickoff.

Option 1E: Probe Interface (SCD1000 Only)

This option provides a TEKPROBE interface for level I and level II probes. This interface allows connection of active and other specialized probes with the proper scaling of the input range and control of probe offset. The ID button feature is not supported.

The scale (attenuation) factor and units of the TEKPROBE attached to the input are incorporated into the vertical offset and vertical range menus and the GPIB commands. In addition to being scaled by the probe factor, the vertical offset range may be limited according to an active probe's offset range rather than the SCD's offset range. AC coupling may not be available with certain probes.

Changes is probe status (attachment or removal of a probe, or change of the probe attenuation factor) are noticed by the SCD at all times except when an acquisition sequence is occurring. Unlike front-panel button presses or GPIB commands, which interrupt and terminate an acquisition sequence, changes in probe status will not be noticed until the acquisition sequence has ended.

Active probes receive operating power from the SCD1000 through contacts on the TEKPROBE connector. These power connections are fused. If a probe, which is known to be in good working order, does not function, it may be that one or more probe power fuses are blown. Refer servicing to qualified service personnel.

Option 1P: Fast Waveform Capture

This option increases the acquisition rate from about one to ten 512 point waveforms per second.

Option 2E: SMA Input Connectors

This option provides SMA-type input connectors on the front panel (N connectors are standard).

Option 2F: High Speed Data Output

This option provides high speed 16-bit data output and battery backed-up linear array.

Option 20: LCD Display Unit

With this option the instrument is supplied without the LCD display unit that allows manual operator control. Control with Option 20 is possible only over the GPIB interface.