

***TB 9-4931-538-40**

DEPARTMENT OF THE ARMY TECHNICAL BULLETIN

CALIBRATION PROCEDURE FOR DIGITIZING OSCILLOSCOPE HEWLETT PACKARD, MODEL 54121T CONSISTING OF DIGITIZING OSCILLOSCOPE MAINFRAME HEWLETT PACKARD, MODEL 54120B, AND FOUR-CHANNEL TEST SET HEWLETT PACKARD, MODEL 54121A

Headquarters, Department of the Army, Washington, DC
9 April 2008

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REPORTING OF ERRORS AND RECOMMENDING IMPROVEMENTS

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		Paragraph	Page
SECTION	I.	IDENTIFICATION AND DESCRIPTION	
		Test instrument identification.....	1 2
		Forms, records, and reports	2 2
		Calibration description.....	3 2
	II.	EQUIPMENT REQUIREMENTS	
		Equipment required	4 3
		Accessories required	5 3
	III.	CALIBRATION PROCESS	
		Preliminary instructions	6 4
		Equipment setup	7 5
		Bandwidth.....	8 5
		Dc voltage measurement and rms noise	9 9
		Time interval accuracy short delta t and long delta t	10 12
		Trigger sensitivity and jitter test	11 15
		TDR system.....	12 19
		Input reflection	13 22
		Final procedure.....	14 24

*This bulletin supersedes TB 9-4931-538-50, dated 17 August 1992.

SECTION	IV.	ADJUSTMENT PROCEDURES	Paragraph	Page
		Power supply adjustment.....	15	25
		Timebase data adjustment.....	16	25
		+10 volt reference adjustment	17	27
		Range adjustment.....	18	27
		Step recovery diode adjustment.....	19	28
		Frequency adjustment.....	20	30
		End and 4 ns cal adjustment	21	31
		Sampler bias adjustment	22	33
		Offset gain adjustment.....	23	36
		TDR step adjustment	24	37
		Feedthrough compensation adjustment.....	25	42
		Trigger adjustment.....	26	44
		Final procedure.....	27	45

SECTION I IDENTIFICATION AND DESCRIPTION

1. Test Instrument Identification. This bulletin provides instructions for the calibration of Digitizing Oscilloscope, Hewlett Packard, Model 54121T consisting of Digitizing Oscilloscope Mainframe, Hewlett Packard, Model 54120B and Four-Channel Test Set, Hewlett Packard, Model 54121A. The manufacturers' manuals were used as the prime data sources in compiling these instructions. The equipment being calibrated will be referred to as the TI (test instrument) throughout this bulletin.

a. Model Variations. None.

b. Time and Technique. The time required for this calibration is approximately 8 hours, using the dc and low frequency and microwave techniques.

2. Forms, Records, and Reports. Forms, records, and reports required for calibration personnel at all levels are prescribed by TB 750-25.

3. Calibration Description. TI parameters and performance specifications which pertain to this calibration are listed in table 1.

Table 1. Calibration Description

Test instrument parameters	Performance specifications
Bandwidth	Range: DC to 20 GHz ¹ Channel 1 dc to 18 GHz Channels 2, 3, and 4 dc to 20 GHz ¹ Channels 1 through 4 dc to 12.4 GHz Accuracy:-3 dB (channel 1 -3.5 dB at 20 GHz ¹)

See footnote at end of table.

Table 1. Calibration Description - Continued

Test instrument parameters	Performance specifications
DC voltage measurement and rms noise	DC voltage accuracy: (50 Ω source) Single voltage marker Average mode: $\pm 0.4\%$ of FS or marker reading (whichever is greater) ± 2 mV 20 GHz persistence mode: $\pm 0.4\%$ of FS or marker reading (whichever is greater) 12.4 GHz persistence mode: $\pm 0.4\%$ of FS or marker reading (whichever is greater) ± 2 mV $\pm 1.5\%$ of (reading - channel offset) Dual voltage markers (on same channel) Average mode $\pm 0.8\%$ of FS or delta reading (whichever is greater) 20 GHz persistence mode: $\pm 0.8\%$ of FS or delta reading (whichever is greater) $\pm 3\%$ of delta marker reading 12.4 GHz persistence mode: 0.8% of FS or delta reading (whichever is greater) 1.5% of delta marker reading RMS noise in persistence mode (1 sigma) 20 GHz bandwidth mode ≤ 2 mV (applies to Hewlett-Packard, Models 54120B firmware dated June 14, 1989 and later) 12.4 GHz bandwidth mode ≤ 1 mV
Time interval	Accuracy: 10 ps $\pm 0.1\%$ of reading
Trigger Sensitivity	Dc to 100 MHz Sensitivity: 40 mV p/p, increasing linearity to 200 mV p/p at 2.5 GHz
Jitter	Trigger and timebase combined (one standard deviation) < 2.5 ps $+5$ E-5 X delay setting
TDR risetime	< 45 ps (measured in 12.42 GHz bandwidth, average mode)
TDR flatness	After 1 ns from edge $\pm 1\%$, $+5\%$, -3% to 1 ns from edge
Input reflection	Percent reflection: Channels 1 through 4 $\pm 5\%$ for 30 ps risetime External trigger $< 10\%$ for 100 ps risetime

¹Calibrated to 18 GHz only.

SECTION II EQUIPMENT REQUIREMENTS

4. Equipment Required. Table 2 identifies the specific equipment to be used in this calibration procedure. This equipment is issued with Secondary Reference Calibration Standards 4931-00-621-7878. Alternate items may be used by the calibrating activity. The items selected must be verified to perform satisfactorily prior to use and must bear evidence of current calibration. The equipment must meet or exceed the minimum use specifications listed in table 2. The accuracies listed in table 2 provide a four-to-one ratio between the standard and the TI. Where the four-to-one accuracy cannot be met the four-to-one accuracy will be listed and the actual accuracy of the equipment selected is shown in parenthesis.

5. Accessories Required. The accessories listed in table 3 are issued as indicated in paragraph 4 above and are used in this calibration procedure. When necessary, these items may be substituted by equivalent items, unless specifically prohibited.

Table 2. Minimum Specifications of Equipment and Special Accessories Required

Common name	Minimum use specifications	Manufacturer and model (part number)
FUNCTION GENERATOR	Range: 10 kHz to 10 MHz Amplitude accuracy: Sine wave: 10 to 100 kHz 0.1 dB Sine wave: 100 kHz to 10 MHz 0.3 dB Dc Offset: 0.003575 (Dc only: $\pm 4\%$ of full peak output for each range)	Agilent, Model 33250A (33250A)
MEASURING RECEIVER	Power range: -20 to +30 dBm Accuracy: -0.625 dBm rms at -20 dBm	Hewlett Packard, Model 8902A w/sensor, Hewlett Packard, Model 11792A (11792A), and microwave converter, model 11793A (11793A)
MULTIMETER	Range: 0 to 5 V Accuracy: 0.005%	Hewlett-Packard, Model 3458A (3458A)
POWER DIVIDER	Range: 50 MHz to 18 GHz Accuracy: ± 0.3 dB ¹	Wiltron, Model K241C (K241C)
RF AMPLIFIER	Range: 100 kHz to 1.3 GHz Accuracy: ± 1.5 dB ²	S. T. Research, Model AD1300 (AD1300)
SIGNAL GENERATOR	Frequency: 100 KHz to 2000 MHz Accuracy: -0.75 dB (± 2 dB)	SG-1207/U
SYNTHESIZED SIGNAL GENERATOR	Frequency: 2 to 18 GHz Level accuracy: -0.75 dB (2.0 to 12.0 GHz ± 2.0 dB) (>12.0 to 18.0 GHz ± 3 dB)	Anritsu, Model 68369NV (68369NV)

¹Use test report results.²The output signal should not exceed 2 V.

Table 3. Accessories

Common name	Description (part number)	
Delay line	22 ns, < 6 dB attenuation at 20 GHz Hewlett Packard, Model 54008A	1 each
Termination	50 Ω , APC 3.5 (f) and (m)	1 each
6 dB pad	APC 3.5 connector (f)	1 each
20 dB pad	APC 3.5 connector (f-m)	1 each
Wrench, torque	5 in-lb	1 each
Wrench, torque	8 in-lb	1 each

SECTION III CALIBRATION PROCESS

6. Preliminary Instructions

a. The instructions outlined in paragraphs 6 and 7 are preparatory to the calibration process. Personnel should become familiar with the entire bulletin before beginning the calibration.

b. Items of equipment used in this procedure are referenced within the text by common name as listed in table 2.

c. Unless otherwise specified, verify the results of each test and, whenever the test requirement is not met, take corrective action before continuing with the calibration. Adjustments required to calibrate the TI are included in this procedure. Additional maintenance information is contained in the manufacturer's manual for this TI.

d. Unless otherwise specified, all controls and control settings refer to TI.

7. Equipment Setup

WARNING

HIGH VOLTAGE is used or exposed during performance of this calibration. DEATH ON CONTACT may result if personnel fail to observe safety precautions. REDUCE OUTPUT(S) to minimum after each step within the performance check where applicable.

CAUTION

The four-channel test set is very sensitive to static discharge. All maintenance or operation should be performed with the antistatic mat and wrist strap, which are supplied with TI. All cables being connected to TI should be shorted to the antistatic mat, TI, or ground prior to connecting to TI.

a. Place antistatic mat in a suitable location and connect grounding lead and wrist strap to an earth ground.

b. Place TI on antistatic mat while using wrist strap.

c. Connect umbilical cable between mainframe and plug-in (rear connectors).

d. Connect TI mainframe to a 115 V ac source. Set **POWER STBY/ON** switch to **ON** and allow at least 15 minutes for equipment warm-up.

NOTE

When mating APC 3.5 connectors to APC 3.5 connectors or devices, torque all connections to 8 in/lbs. When mating APC 3.5 to SMA or SMA to SMA, torque all connections to 5 in/lbs.

8. Bandwidth

a. Performance Check

(1) Set **POWER STBY/ON** switch to **STBY**.

(2) Press and hold down the top or bottom **FUNCTION** key (vertical) and set **POWER STBY/ON** switch to **ON** continuing to hold key until the graticule lines are displayed.

(3) Set the display menu and mainframe settings to meet the following conditions:

(a) Press **Display** key. **Display Mode** to **Averaged** is highlighted. **NUMBER OF AVERAGES** to **# Averages = 64** is highlighted. **Screen** to **Single** is highlighted. **Graticule** to **GRID** is highlighted. **Bandwidth** to **12.4 GHz** is highlighted.

(b) Press **Channels** key. **Channel 1** display **On** is highlighted. **Channel 2** through **4** display **Off** is highlighted. **VOLTS/DIV** to **Sensitivity 80.00 mV/div.**

(c) Press **Timebase** key and set **TIME/DIV** to **Sweep Speed = 5.00 ns/ div.**

(4) Connect equipment as shown in figure 1, CONNECTION A.

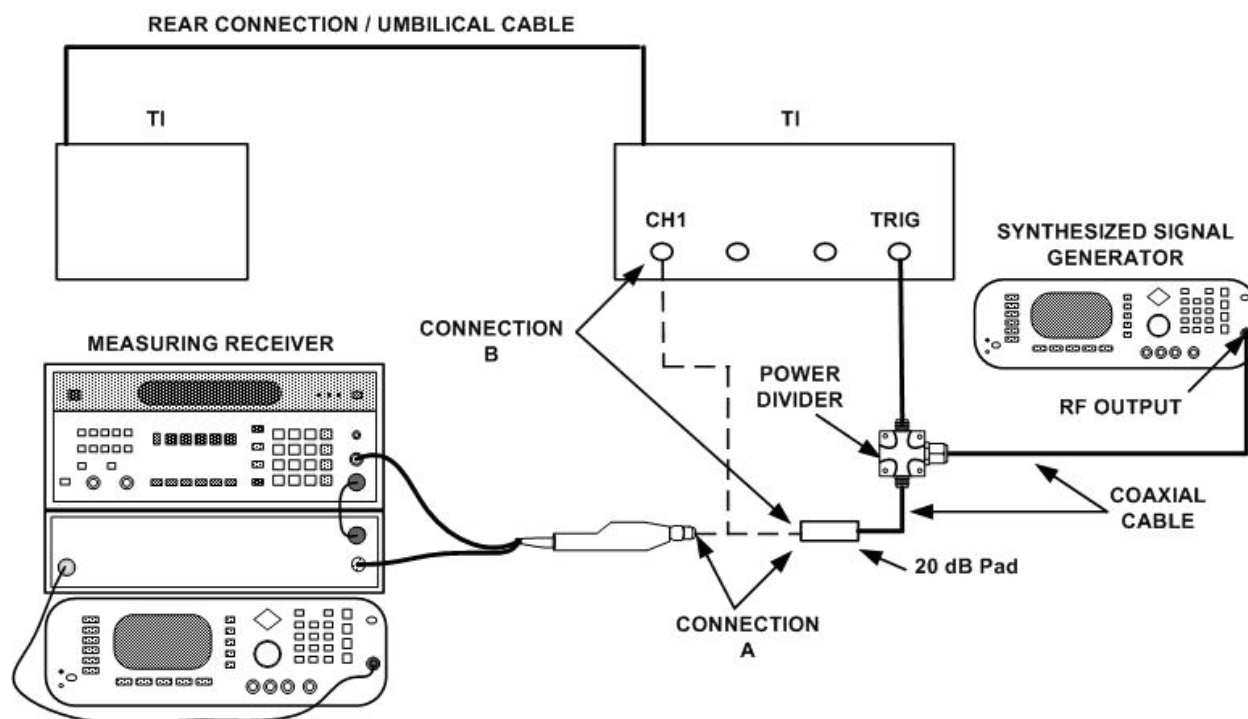


Figure 1. Low bandwidth - equipment setup.

(5) Set synthesized signal generator amplitude for 12.0 dBm and frequency of 50 MHz.

(6) Measure and record the mV reading of the synthesized signal generator and measuring receiver in table 4, part 1.

Table 4. Bandwidth Check

Part 1					
Synthesized signal generator power output readings					
50	MHz	_____mV			
12.42	GHz	_____mV			
18	GHz	_____mV			
Part 2					
Test instrument V rms readings from display					
Frequency		CH 1	CH 2	CH 3	CH 4
50	MHz	_____mV	_____mV	_____mV	_____mV
12.42	GHz	_____mV	_____mV	_____mV	_____mV
18	GHz	_____mV	_____mV	_____mV	_____mV
Part 3					
Example of formula to provide bandwidth checks					
<div>Gain = 10 log₁₀ $\left[\left[\frac{\text{Power meter reading 50 MHz}}{\text{Power meter reading high frequency}} \right]^2 \left[\frac{\text{V rms high frequency}}{\text{V rms 50 MHz}} \right]^2 \right]$</div>					

(7) Connect equipment as shown in figure 1, CONNECTION B.

(8) Press the **SYSTEM CONTROL /CLEAR DISPLAY** pushbutton and allow 64 averages to accumulate (top left corner of display).

(9) Press the **More** key. **Measure Chan 1** and **Precision Fine** will be highlighted.

(10) Press the **More** (vertical) key until **RMS Voltage** menu is displayed. Press **RMS Voltage** key and record RMS voltage of synthesized signal generator in table 4, part 2.

NOTE

If “Edges required for measurement not found” appears on the display during (11) below, it will be necessary to select **Channels** menu and set **Channel 1** display **Off** after **SYSTEM CONTROL/CLEAR DISPLAY** pushbutton is pushed and allow 64 averages to accumulate.

NOTE

The entire procedure must be completed before the bandwidth calculations can be determined.

(11) Repeat (7) through (10) above for **Channels 2, 3, and 4**.

(12) Connect equipment as shown in figure 2, CONNECTION A.

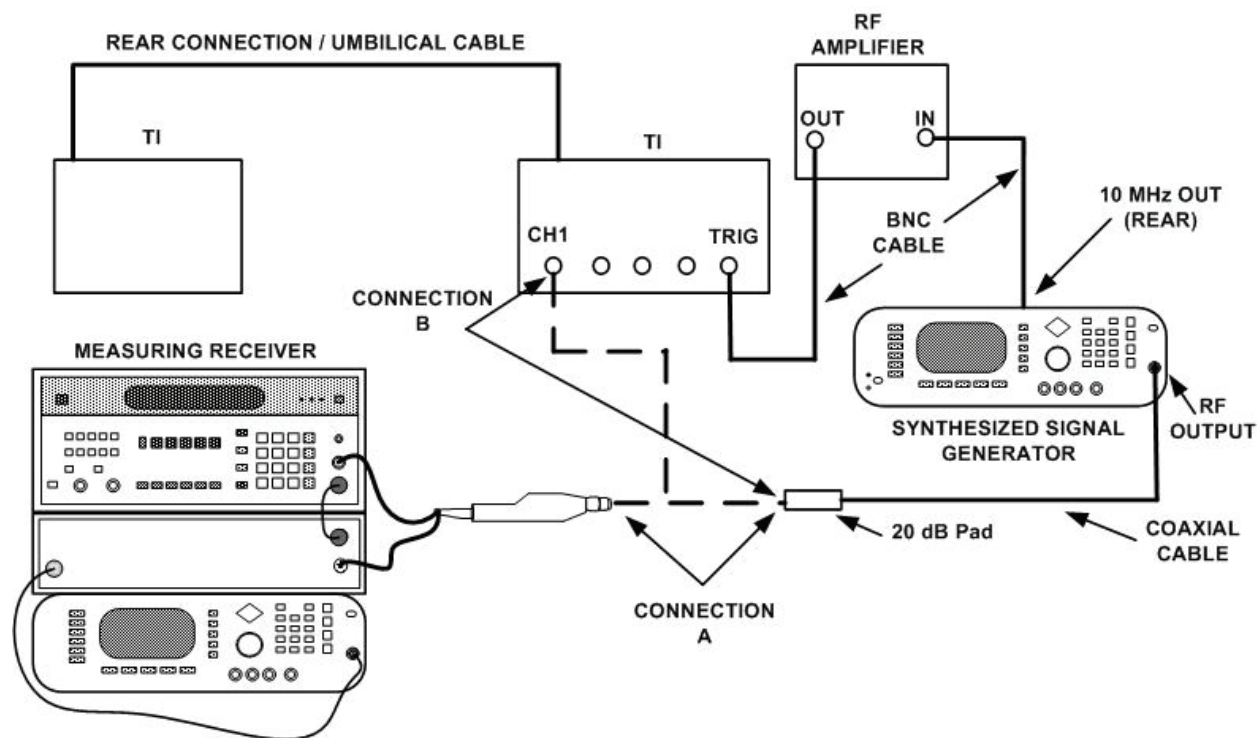


Figure 2. High bandwidth - equipment setup.

- (13) Set synthesized signal generator amplitude for +6 dBm and frequency of 12.42 GHz.
- (14) Measure and record the mV reading of synthesized signal generator and measuring receiver for frequency of 12.42 and 18 GHz in table 4, part 1.
- (15) Connect equipment as shown in figure 2, CONNECTION B.
- (16) Press **Timebase** key and set **TIME/DIV** to **Sweep Speed = 15.00 ps/div**.
- (17) Press **Display** key and set **Bandwidth to 20 GHz** is highlighted. Press **Channels** key and set **Channel 1** display **On** is highlighted.
- (18) Press the **SYSTEM CONTROL/CLEAR DISPLAY** pushbutton and allow 64 averages to accumulate (top left corner of display).
- (19) Press the **More** and **Measure** keys.
- (20) Press the **Precision** key until **Fine** is highlighted, then press **RMS Voltage** key. Record the RMS volts of synthesized signal generator in table 4, part 2.
- (21) Repeat (15) through (20) above for **Channels 2, 3, and 4**.
- (22) Using the formula provided in table 4, part 3, calculate the bandwidth gain of the TI at 50 MHz, 12.42 GHz, and 18 GHz. Bandwidth will be -3 dB or less.
- (23) Remove all connections from TI.

b. **Adjustments.** No further adjustments can be made.

9. Dc Voltage Measurement and RMS Noise

a. Performance Check

(1) Set the display menu and mainframe settings to meet the following conditions:

(a) Press **Display** key. **Display Mode** to **Averaged** is highlighted. **NUMBER OF AVERAGES** to **# Averages = 16**. **Screen** to **Single** is highlighted. **Graticule** to **Grid** is highlighted. **Bandwidth** to **12.4 GHz** is highlighted.

(b) Press **Channels** key. **Channel 1** through **4** display **Off** is highlighted. **VOLTS/DIV** to **Sensitivity = 5.000 mV/div**. **OFFSET** to **Offset = 0.000 V**. **PROBE ATTEN** to **Ch1 Atten Factor = 1.000**.

(c) Press **Timebase** key. **TIME/DIV** to **Sweep Speed = 1.00 ms/div**. **DELAY** to **Delay = 200.000 ns**. **Delay Ref at Left** is highlighted. **Freerun/Trg'd Sweep** to **Freerun** is highlighted. **FREERUN RATE** to **10 kHz** is highlighted.

(d) Press **Trigger** key. **TRIGGER LEVEL** to **Trigger Level = 0.000 V**. **Slope** to **Pos** is highlighted. **PROBE/ATTEN** to **Ext Atten Factor = 1.000**. **HF Sens** to **Off** is highlighted. **HF Reject** to **Off** is highlighted.

(e) Press **More** and **Network** keys. **Reflect/Trans/Cal** to **Reflect** is highlighted. **Step & Chan 1** to **Off** is highlighted.

(2) Press **SYSTEM CONTROL SAVE SETUP** and **ENTRY 1** pushbuttons.

(3) Press **More** and **Channels** keys and set **VOLTS/DIV** to **Sensitivity = 80 mV/div** for **Channel 1** through **4**.

(4) Press **Display** key. Set **Display Mode** to **Persist** and **Persistence = 300 ms** is highlighted.

(5) Press **SYSTEM CONTROL SAVE SETUP** and **ENTRY 2** pushbuttons.

(6) Press **SYSTEM CONTROL RECALL SETUP** and **ENTRY 1** pushbuttons. Press **Channels** key and set **Channel 1** to display **On** is highlighted.

(7) Press **Delta V** key. Set **V Markers On** and overlay both **MARKERS** on **Channel 1**. Press **Preset Levels** key until **50%-50%** is highlighted.

(8) Press **SYSTEM CONTROL CLEAR DISPLAY** pushbutton and wait for 16 averages to accumulate (**#Aves = 16** top left of display).

(9) Press **Auto Level Set** key. Display **V(1)** value will indicate 0 V (± 2.16 mV).

(10) Press **Display** key and change **Bandwidth** to **20 GHz** is highlighted.

(11) Press **SYSTEM CONTROL CLEAR DISPLAY** pushbutton and wait for 16 averages to accumulate. Press the **Delta V** and **Auto Level Set** keys. Display **V(1)** value will indicate 0 V (± 2.16 mV).

(12) Connect equipment as shown in figure 3.

- (13) Set function generator for 500 mV dc offset as indicated on multimeter.
- (14) Press **Channels** key and set **OFFSET to Offset = 500 mV**.
- (15) Press **Display** key and set **Bandwidth to 12.4 GHz** is highlighted.
- (16) Press **CLEAR DISPLAY** pushbutton and wait for 16 averages to accumulate.

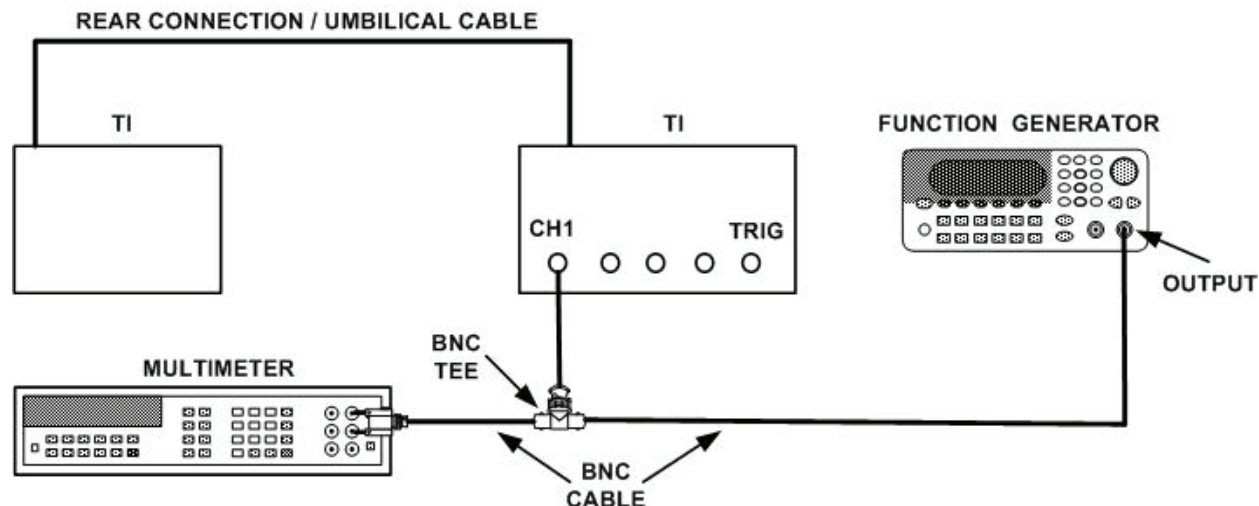


Figure 3. Dc voltage measurement - equipment setup.

- (17) Press **Delta V** key. Overlay **MARKER2** on center trace. Display **V(2)** value will indicate between 496 and 504 mV.
- (18) Set function generator for -500 mV dc offset as indicated on multimeter.
- (19) Press **Channels** key and set **OFFSET to Offset = - 500 mV**.
- (20) Press **SYSTEM CONTROL CLEAR DISPLAY** pushbutton and wait for 16 averages to accumulate.
- (21) Press **Delta V** key. Press **MARKER1 POSITION** key and overlay **MARKER1** on center trace. Display **V(1)** value will indicate between -496.6 and 500.4 mV. ΔV will indicate between 992.0 mV and 1.008 V.
- (22) Press **SYSTEM CONTROL RECALL SETUP** and **ENTRY 2** pushbuttons. Press **Channels** key and set **Channel 1 display to On** is highlighted.
- (23) Press **More** and **Wfm Math** keys. Press **Function** key until **1** is highlighted. Press **Display** key until **On** is highlighted.
- (24) Press first **Chan-Mem** key until **Chan 1** is highlighted. Press operation key (forth vertical key down) until **Only** is highlighted. Press **DISPLAY SCALING** key until **Volts/Div** is highlighted and set **Sensitivity = 5.000 mV/div**.

(25) Press **DISPLAY SCALING** key until **Offset** is highlighted and set **Offset = 250 mV**.

(26) Set function generator for 250 mV dc as indicated on multimeter.

(27) Press **More** and **Delta V** keys. Set **V Markers On** and overlay both **MARKERS** on **Func 1**. Press **Preset Levels** key until **50%-50%** is highlighted.

(28) Manually overlay **V MARKER1 POSITION** to center of trace. **V(1)** value will indicate between 240.34 and 259.66 mV.

(29) Press **More** and **Wfm Math** keys. Press **DISPLAY SCALING** key until **Offset** is highlighted. Set **Offset = -250 mV**.

(30) Set function generator for -250 mV dc as indicated on multimeter.

(31) Press **More** key.

(32) Manually overlay **V MARKER2 POSITION** to center of trace. Display **V(2)** value will indicate between -240.34 and -259.66 mV.

(33) Disconnect input from TI and press **RECALL SETUP** and **2** pushbuttons.

(34) Press **Display** key and **Display Mode** key until **Persist** is highlighted. Press **ENTRY**  pushbutton until **Persistence = Infinite**.

(35) Press **Timebase** and **DELAY** keys and set **Delay = 16.000 ns**.

(36) Press **Channels** key and set **Channel 1 VOLT/DIV** to **Sensitivity = 2.000 mV/div**. Press **OFFSET** key and set to **Offset = 0.000V**.

(37) Press **More** and **Histogram** keys. Press key for **Window/Acquire/Results** until **Window** is highlighted.

(38) Press **Time/Voltage Histogram** key until **Voltage** is highlighted.

(39) Set **WINDOW MARKER1** and **WINDOW MARKER2** to left and right of display.

(40) Press **Window/Acquire/Results** key until **Acquire** is highlighted. Set **Number of Samples = 1000 samples**.

(41) Press **Start Acquiring** key. Wait for TI to stop acquiring (**# Samples = 100%** at top left corner of display).

(42) Press **Window/Acquire/Results** key until **Results** is highlighted. Press **Sigma** key. The sigma value will indicate <1 mV.

(43) Press **More** and **Display** keys and set **Bandwidth to 20 GHz** is highlighted.

(44) Repeat (37) through (43) above for **20 GHz**. The sigma value will indicate <2 mV.

(45) Repeat (6) through (44) above for **Channels 2, 3, and 4**.

b. Adjustments. No further adjustments can be made.

10. Time Interval Accuracy Short Delta t and Long Delta t

a. Performance Check

(1) Set the display menu settings to meet the following conditions:

(a) Press **Display** key. **Display Mode to Average** is highlighted. **NUMBER OF AVERAGES to # Averages = 64**. **Screen to Single** is highlighted. **Graticule to Frame** is highlighted. **Bandwidth to 20 GHz** is highlighted.

(b) Press **Channels** key. **Channel 1 through 4 display Off** is highlighted. **VOLTS/DIV to Sensitivity = 20.00 mV/div** for Channel 1 through 4. **OFFSET to Offset = 0.000 V**. **PROBE ATTEN to Ch1 Atten Factor = 1.000**.

(c) Press **Timebase** key. **TIME/DIV to Sweep Speed = 10.0 ps/div**. **Delay to Delay = 16.0000 ns**. **Delay Ref at Left** is highlighted. **Freerun/Trg'd Sweep to Trg'd** is highlighted.

(d) Press **Trigger** key. **TRIGGER LEVEL to Trigger Level = 0.000 V**. **Slope to Pos** is highlighted. **PROBE ATTEN to Ext Atten Factor = 1.000**. **HF Sens to Off** is highlighted. **HF Reject to Off** is highlighted.

(e) Press **MORE** and **Network** keys. **Reflect/Trans/Cal to Reflect** is highlighted. **Step & Chan 1 to Off** is highlighted.

(2) Press **SYSTEM CONTROL SAVE SETUP** and **ENTRY 3** pushbutton. Press **More** and **Channels** keys and set **Channel 1 to display On** is highlighted.

(3) Connect equipment as shown in figure 4.

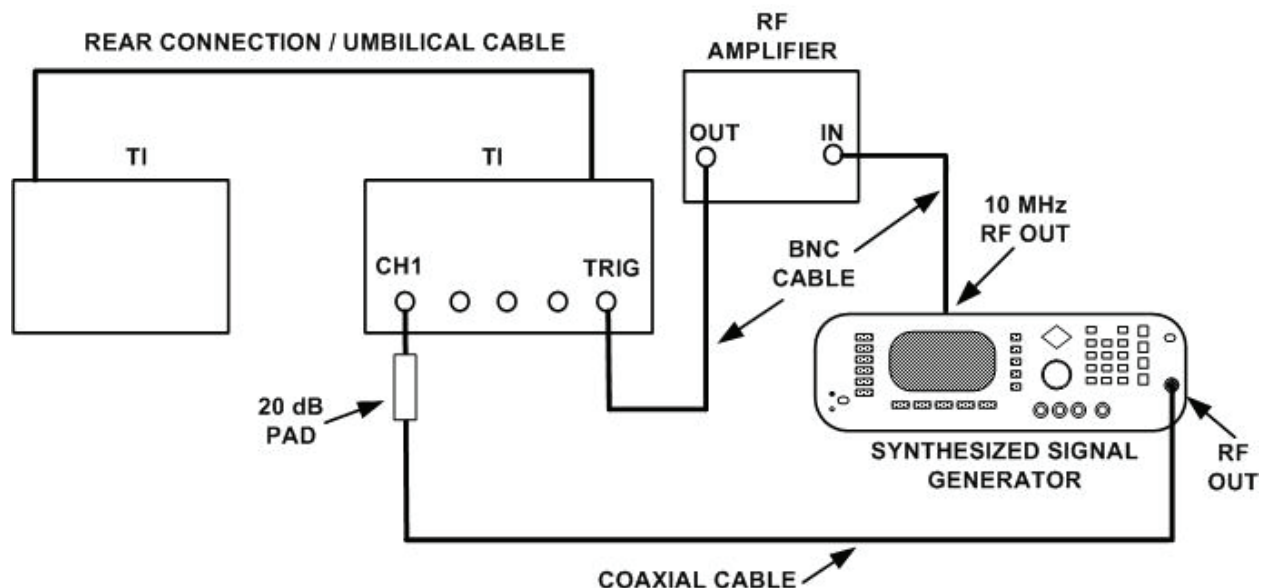


Figure 4. Time interval short delta t - equipment setup.

(4) Set synthesized signal generator for a frequency of 18 GHz and amplitude of +6 dBm.

(5) Press **SYSTEM CONTROL CLEAR DISPLAY** pushbutton and wait for 64 averages to accumulate.

(6) Press **More** and **Measure** keys. Press **Precision** key until **Fine** is highlighted.

(7) Press **Period** key to measure the period of 18 GHz sine wave. Period will indicate between 44.34 and 67.15 ps.

(8) Repeat (5) through (7) for **Timebase DELAY** settings of 18 ns, 19.9 ns, 19.95 ns, 23.95 ns, 27.95 ns and 55.95 ns. Period will indicate between 44.5 and 66.7 ps.

(9) Press **More** and **Timebase** keys. Set **DELAY** to **Delay = 16 ns**. Press **Display** key and set **Bandwidth** to highlight **12.4 GHz**.

(10) Repeat technique of (5) through (7) above for TI settings and synthesized signal generator settings listed in table 5.

NOTE

If the frequency and amplitude are set on the synthesized signal generator, signal generator, and function generator before the **Timebase TIME/DIV Sweep Speed = settings**, it may not be necessary to press **SYSTEM CONTROL/CLEAR DISPLAY** pushbutton as the **# Avgs** starts counting automatically when **Sweep Speed** is changed.

Table 5. Short Delta t

Synthesized signal generator frequency settings	Test instrument Timebase/TIME/DIV/ Sweep Speed Settings	Test instrument indications	
		Min	Max
10 GHz	50 ps/div	89.9 ps	110.1 ps
5 GHz	100 ps/div	189.8 ps	210.2 ps
2 GHz	250 ps/div	489.5 ps	510.5 ps
1 GHz ¹	500 ps/div	0.989 ns	1.011 ns
500 MHz	1 ns/div	1.988 ns	2.012 ns
200 MHz	2.5 ns/div	4.985 ns	5.015 ns
100 MHz	5 ns/div	9.980 ns	10.020 ns
50 MHz	1.0 ns/div	19.970 ns	20.030 ns
20 MHz	25 ns/div	49.940 ns	50.060 ns

¹Connect equipment as shown in figure 5. Set signal generator amplitude for 12 dBm.

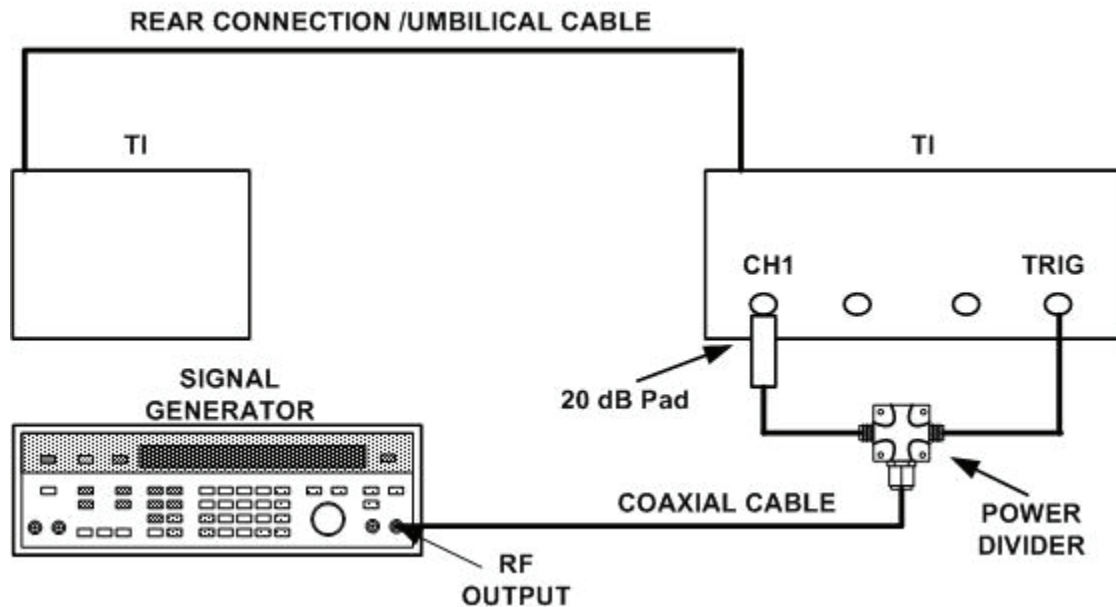


Figure 5. Time interval short Δt - equipment setup.

- (11) Press **SYSTEM CONTROL/ RECALL SETUP** and **ENTRY 3** pushbuttons. Press **Channel** key and set **Channel 1** to **Display On** is highlighted.
- (12) Connect equipment as shown in figure 6.

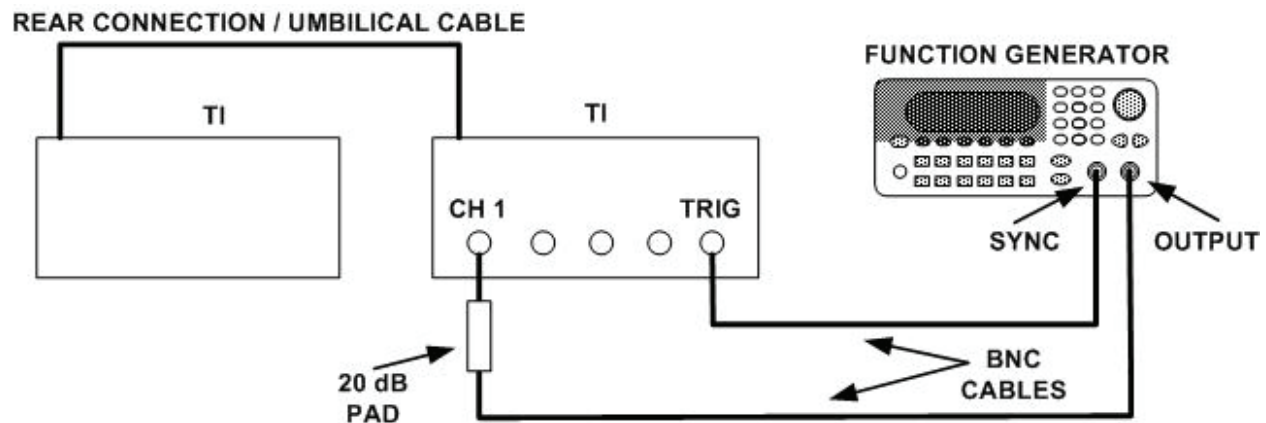


Figure 6. Time interval long Δt - equipment setup.

- (13) Set function generator for a frequency of 10 MHz sine wave and amplitude of 1.2 V p-p.
- (14) Press **More**, **Timebase**, and **TIME/DIV** keys and set **Sweep Speed** = 20.0 ns/div.
- (15) Press **Trigger** key and set **TRIGGER LEVEL** to **Trigger Level** = 500 mV.

(16) Press **SYSTEM CONTROL CLEAR DISPLAY** pushbutton and wait for 64 averages to accumulate.

(17) Press **More** and **Measure** keys. Press **Precision** key until **Fine** is highlighted.

(18) Press **Period** key and wait for TI to measure the period of 10 MHz sine wave. Period will indicate between 99.89 and 100.11 ns.

(19) Repeat technique of (16) through (18) above for TI settings and function generator settings listed in table 6.

Table 6. Long Delta t

Function generator frequency settings	Test instrument Timebase/TIME/DIV/Sweep Speed Settings	Test instrument indications	
		Min	Max
5 MHz	100 ns/div	199.790 ns	200.210 ns
2 MHz	250 ns/div	499.490 ns	500.510 ns
1 MHz	500 ns/div	998.99 ns	1.00101 ms
500 kHz	1 ms /div	1.99799 ms	2.00210 ms
200 kHz	2.5 ms /div	4.99499 ms	5.0050 ms
100 kHz	5 ms /div	9.98999 ms	10.01001 ms
50 kHz	10 ms /div	19.9799 ms	20.02001 ms
20 kHz	25 ms /div	49.9499 ms	50.05001 ms
10 kHz	50 ms /div	99.8999 ms	100.1000 ms

(20) Remove all connections from TI.

b. Adjustments. No further adjustments can be made.

11. Trigger Sensitivity and Jitter test

a. Performance Checks

(1) Set the display menu and mainframe settings to meet the following conditions:

(a) Press **Display** key. **Display Mode** to **Average** is highlighted. **NUMBER OF AVERAGES** to **# Averages = 4**. **Screen** to **Single** is highlighted. **Graticule** to **Frame** is highlighted. **Bandwidth** to **12.4 GHz** is highlighted.

(b) Press **Channels** key. **Channel 1** through **4** display **Off** is highlighted. **VOLTS/DIV** to **Sensitivity = 20.00 mV/div** for **Channel 1** through **4**. **OFFSET** to **Offset = 0.000 V**. **PROBE ATTEN** to **Chl Atten Factor = 1.000**.

(c) Press **Timebase** key. **TIME/DIV** to **Sweep Speed = 1.00 ms/div**. **DELAY** to **Delay = 16.0000 ns**. **Delay Ref at Left** is highlighted. **Freerun/Trg'd Sweep** to **Trg'd** is highlighted.

(d) Press **Trigger** key. **TRIGGER LEVEL** to **Trigger Level = 0.000 V**. **Slope** to **Pos** is highlighted. **PROBE/ATTEN** to **Ext Atten Factor = 1.000**. **HF Sens** to **Off** is highlighted. **HF Reject** to **Off** is highlighted.

(e) Press **MORE** and **Network** keys. **Reflect/Trans/Cal** to **Reflect** is highlighted. **Step & Chan 1** to **Off** is highlighted.

(2) Press **SYSTEM CONTROL SAVE SETUP** and **ENTRY 4** pushbuttons. Press **More** and **Channels** keys and set **Channel 1** and display **On** is highlighted.

(3) Connect equipment as shown in figure 7, CONNECTION A.

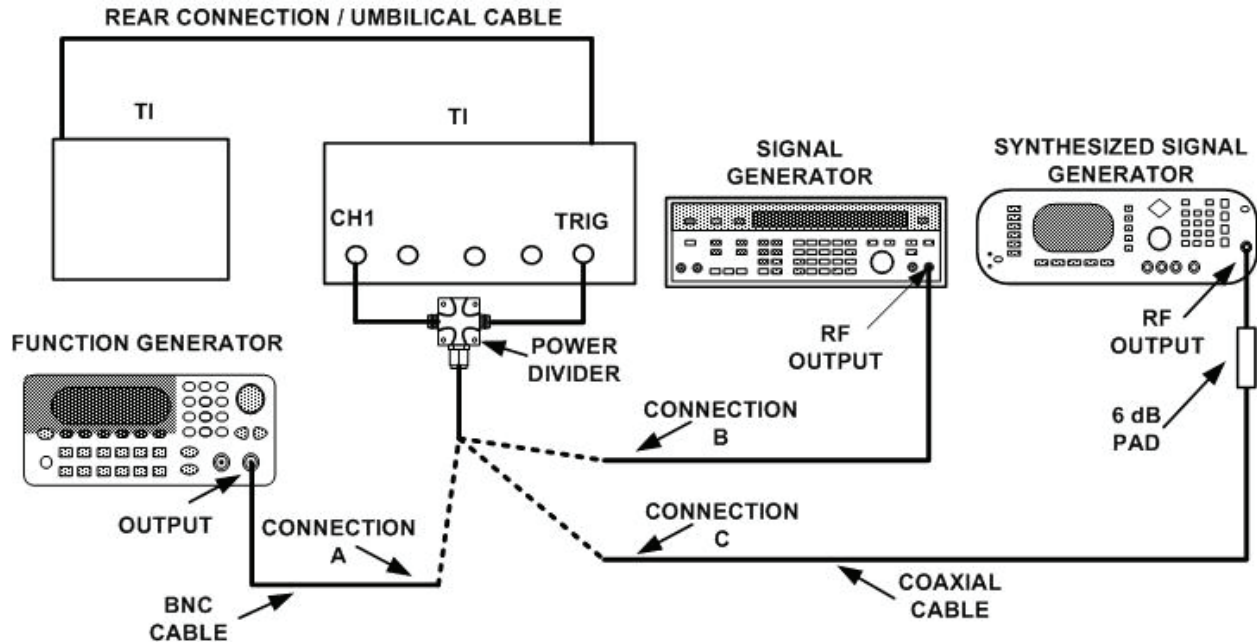


Figure 7. Trigger sensitivity low frequency, 100 MHz and 2.5 GHz - equipment setup.

(4) Set function generator for a frequency of 100 kHz and amplitude of 100 mV p-p sine wave.

(5) Adjust function generator for a signal of 100 mV p-p as indicated on TI display.

(6) Press **More**, **Trigger** and **TRIGGER LEVEL** keys. Slowly adjust the **RPG** control cw until trigger level on the TI just stops triggering. Press the **SYSTEM CONTROL CLEAR DISPLAY** pushbutton each time the trigger level is changed until no trigger is displayed. Record the trigger level setting (_____). This value is V_{pos} .

(7) Reset the trigger level to 0.000 V and slowly adjust the **RPG** control ccw until trigger level on the TI just stops triggering. Press the **SYSTEM CONTROL CLEAR DISPLAY** pushbutton each time the trigger level is changed until no trigger is displayed. Record the trigger level setting (_____). This value is V_{neg} .

(8) Calculate the hysteresis. $V_{hysteresis} = 100 \text{ mV} - (V_{pos} - V_{neg})$. The value will be $\approx 40 \text{ mV}$.

(9) Set the trigger level to 0.000 V. **HF Sens** and **HF Reject** to **Off** is highlighted.

(10) Press **Timebase** and **TIME/DIV** keys and set **Sweep Speed = 2.00 ns/div**.

(11) Connect equipment as shown in figure 7, CONNECTION B.

(12) Set signal generator for a frequency of 100 MHz and amplitude of V p-p 150 mV as displayed on screen.

(13) Slowly adjust the **RPG** control cw until trigger level just stops triggering. Record the trigger level setting (_____). This value is V_{pos} .

(14) Reset the trigger level to 0.000 V and slowly adjust the **RPG** control ccw until trigger level just stops triggering. Record the trigger level setting (_____). This value is V_{neg} .

(15) Calculate the sensitivity. $V_{sense} = 150 \text{ mV} - (V_{pos} - V_{neg})$. The value will be $\approx 40 \text{ mV}$.

(16) Reset the trigger level to 0.000 V.

(17) Set **HF Reject** to **On** is highlighted and repeat (13) through (15) above. The value will be $\approx 57 \text{ mV}$ (+ 3 dB).

(18) Reset the trigger level to 0.000 V.

(19) Press **Timebase** key and set **Sweep Speed = 100 ps/div**.

(20) Press **Channels** and **VOLTS/DIV** keys and set **Sensitivity = 50.00 mV/div**.

(21) Press **Trigger** key and set **TRIGGER LEVEL** to **Trigger Level = 0.000 V**; **HF Sens** and **HF Reject Off** is highlighted.

(22) Connect equipment as shown in figure 7, CONNECTION C.

(23) Set synthesized signal generator for a frequency of 2.5 GHz and amplitude of V p-p 200 mV as shown on display.

NOTE

It will be necessary to go to the **Measure Mode** to verify the measurement of the V p-p = 200 mV.

(24) Slowly adjust the **RPG** control cw until the trigger level just stops triggering. Record the trigger level setting (_____). This value is V_{pos} .

(25) Reset the trigger level to 0.000 v and slowly adjust the **RPG** control ccw until trigger level just stops triggering. Record the trigger level setting (_____). This value is V_{neg} .

(26) Calculate the sensitivity. $V_{sense} = 200 \text{ mV} - (V_{pos} - V_{neg})$. The value will be $< 200 \text{ mV}$.

(27) Set **Trigger Level = 0.000V**. Set delay to 35 ns.

(28) Connect equipment as shown in figure 8.

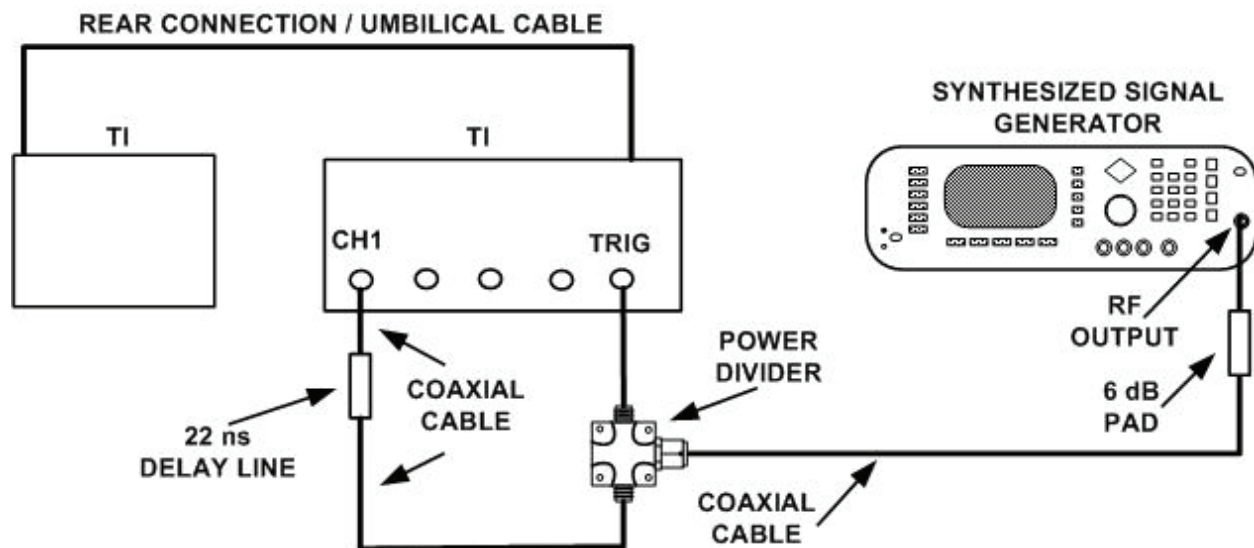


Figure 8. Trigger sensitivity jitter - equipment setup.

(29) Set synthesized signal generator for a frequency of 2.0 GHz and amplitude of V p-p 200 mV as displayed on screen.

(30) Press **Timebase** and **TIME/DIV** keys and set **Sweep Speed = 500 ps/div**, **Delay** to **22.0000 ns** (see NOTE below), and **Delay Ref at Center** is highlighted.

NOTE

The length of the coaxial cables being used to make connections in figure 8 must be measured, calculated, and added to the 22 ns delay line setting in (30) above. Example: Total cable length = 6 feet. $6' \times 1.6 \text{ ns} = 9.6 \text{ ns}$. ($22 \text{ ns} + 9.6 \text{ ns} = 31.6 \text{ ns}$).

(31) Slightly adjust synthesized signal generator frequency and select the trigger point that does not expand or contract with frequency of synthesized signal generator. (Press **Display** key and set **Display Mode** to **Persist** is highlighted. Pressing the **ENTRY** $\uparrow \Rightarrow$ pushbutton until **Persistence = Infinite** will help find the trigger.

(32) Press **Delta V** key. Set **V Markers On** and press **Preset Levels** key until **50%-50%** is highlighted. Press the **Auto Level Set** key.

(33) Press **Delta t** key. Set **T Markers On** and set the start marker on the 50% point on the positive slope of the selected trigger point. Record **Start Position** point (_____).

(34) Press **Timebase** and **TIME/DIV** keys and set **Sweep Speed = 200 ps/div**, and set **DELAY** to **Delay = the value of the START MARKER**.

(35) Adjust the delay of the TI to center the positive edge of the waveform on the display. Record the reading (**Delay = _____ ns**).

(36) Press **Timebase** and **TIME/DIV** key and set **Sweep Speed = 10.0 ps/div**. Press **Channels** key and set **VOLTS/DIV** to **Sensitivity = 5 mV/div**.

(37) Press **More** and **Histogram** keys. Press **Window/Acquire/Results** key until **Window** is highlighted.

(38) Press **Time/Voltage Histogram** key until **Time** is highlighted and set **WINDOW MARKERS1** to -0.25 mV and **WINDOW MARKERS2** to +0.25 mV.

(39) Press **Window/Acquire /Results** key until **Acquire** is highlighted and enter number of samples as **1000**. Press **Start Acquiring** key. Wait until acquire cycle is 100% complete.

(40) Press **Window/Acquire/Results** key until **Results** is highlighted. Press the **Sigma** key. The sigma value will be $< 2.5 \text{ ps} + (5\text{E-}5 \times \text{delay setting from value of step 35 above})$. If the TI does not meet the jitter specification, perform **SECTION IV**, paragraph 23, and repeat (30) through (40) above for delay setting of 20.5 ns. Example with a delay setting of 20.5 ns: $< 2.5 \text{ ps} + [(5 \times 10^{-5}) \times (20.5 \times 10^{-9})] = 2.5 \text{ ps} + 1.025 \text{ ps} < 3.525 \text{ ps}$.

(41) Remove all connections from TI.

b. Adjustments. No further adjustments can be made.

12. TDR System

a. Performance Checks

(1) Set **POWER STBY/ON** switch to **STBY**.

(2) Press and hold down the top or bottom **FUNCTION** keys and set **POWER STBY/ON** switch to **ON** continuing to hold keys until the graticules are displayed.

(3) Set the display menu and mainframe settings to meet the following conditions:

(a) Press **Display** key. **Display Mode** to **Average** is highlighted. **NUMBER OF AVERAGES** to **# Averages = 16**. **Screen** to **Single** is highlighted. **Graticule to Frame** is highlighted. **Bandwidth** to **12.4 GHz** is highlighted.

(b) Press **Channels** key. **Channel 1** display **On** is highlighted. **Channels 2 through 4** display **Off** is highlighted. **VOLTS/DIV** to **Sensitivity = 5.000 mV/div**. **OFFSET** to **Offset = 0.000 V**. **PROBE ATTEN** to **Ch1 Atten Factor = 1.000**.

(c) Press **Timebase** key. **TIME/DIV** to **Sweep Speed = 50.0 ps/div**. **DELAY** to **Delay = 16.0000 ns**. **Delay Ref at Left** is highlighted. **Freerun/Trg'd Sweep** to **Freerun** is highlighted. **FREERUN RATE** to **10 kHz** is highlighted.

(d) Press **Trigger** key. **TRIGGER LEVEL** to **Trigger Level = 0.000 V**. **Slope** to **Pos** is highlighted. **PROBE/ATTEN** to **Ext Atten Factor = 1.000**. **HF Sens** to **Off** is highlighted. **HF Reject** to **Off** is highlighted.

(e) Press **MORE** and **Network** keys. **Reflect/Trans/Cal** to **Reflect** is highlighted. **Step & Chan 1** to **On** is highlighted.

NOTE

If there is a rising edge on display, the TDR step adjustment must be performed before continuing this procedure (SECTION IV, paragraph 24 below).

NOTE

Use four terminal ohm measurement technique for (4) and (5) below.

- (4) Using necessary adapters, connect 50 Ω termination to multimeter. Record dc resistance _____ Ω .
- (5) Remove 50 Ω termination and connect APC 3.5 short as in (4) above. Record dc resistance _____ Ω .
- (6) Subtract the resistance (short) (5) above from the termination (4) above. Step (4) _____ Ω - Step (5) _____ Ω = Z_L _____ Ω .
- (7) Solve for E_R using this formula: $E_R = 200 ((Z_L - 50) + (Z_L + 50))$. Round to nearest 0.01 mV. (E_R can be a negative number). $E_R =$ _____ mV.
- (8) Connect 50 Ω termination to **Channel 1**.
- (9) Press **More** and **Delta V** keys. Press **TDR V Markers** key until **On** is highlighted.
- (10) Press **Preset Levels** key until **50-50%** is highlighted and press **Auto Level Set** key. **V(1)** will read **0 V \pm 2mV**. Record the value of **V(1)** = _____ mV.
- (11) Press **Timebase** key and set **TIME/DIV** to **Sweep Speed = 1.00 ns/div**.
- (12) Press **Channels** and **VOLTS/DIV** keys and set **Sensitivity = 80.00 mV/div** and **OFFSET** to **Offset = 200.0 mV**.
- (13) Press **Delta V** key and ensure that **Preset Levels** is still at **50-50%**. Press **Auto Level Set** key.
- (14) Press **Delta t** key and press **TDR T Markers** key until **On** is highlighted. Press **START ON EDGE** key until **POS 1** is highlighted and **STOP ON EDGE** key until **POS 1** is highlighted. Press **Precise Edge Find** key.
- (15) Record start position value (_____ ns).
- (16) Press **STOP MARKER** key and set **Stop Position** = the value of the **START MARKER** +1 ns.
- (17) Press **Timebase** key and set **TIME/DIV** to **Sweep Speed = 100 ns/div**, **DELAY** to **Delay** = the value of the **STOP MARKER**.
- (18) Press **Channels** and **VOLTS/DIV** keys and set **Sensitivity = 2.000 mV/div**.
- (19) Press **Delta V** and **MARKER1 POSITION** keys and overlay the trace at the right edge of display. Record **V(1)** value from display **V(1)** = _____ mV.
- (20) Subtract the value of E_R (7) above from the value recorded in (19) above. This value will be between 198 and 202 mV. Record this value _____ mV.

(21) Press **SYSTEM CONTROL CLEAR DISPLAY** pushbutton and allow 16 averages to accumulate.

(22) Press **MARKER2 POSITION** key and adjust marker to the highest point of signal on display. Record the ΔV reading. $\Delta V = \underline{\hspace{2cm}}$ mV.

(23) Divide the ΔV recorded in (22) above by the value of (20) above and multiply by 100%. ΔV reading $\underline{\hspace{2cm}}$ mV, step (20) $\underline{\hspace{2cm}}$ mV $\times 100\% = \underline{\hspace{2cm}}\%$. The absolute value of this number should be less than 1 % (+ 1 % at < 1 ns after edge).

(24) Adjust **MARKER2** to the lowest point of signal on display.

(25) Press **Timebase** and **TIME/DIV** keys. Press front panel **ENTRY**  increment pushbutton to select the next fastest sweep speed.

NOTE

If there is a point on the display lower than the previous position of **MARKER2 POSITION**, readjust **MARKER2 POSITION** to that lowest point.

(26) Repeat (25) above until **Sweep Speed = 1.00 ns/div**.

(27) Divide the value of ΔV obtained from display by the value obtained in (20) above. $\Delta V \underline{\hspace{2cm}}$ mV + step (20) $\underline{\hspace{2cm}}$ mV $\times 100\% = \underline{\hspace{2cm}}\%$. The absolute value will be <1 % (-1 % at <1 ns after edge).

(28) Press **Timebase** key and set **Sweep Speed = 200 ps/div**, **Delay Ref at Center** is highlighted and **DELAY** to **Delay =** the value of the **START MARKER**.

(29) Press **Channels** key and set **VOLTS/DIV** to **Sensitivity = 80.00 mV/div**.

(30) Press **Delta V** key. Press **Preset Level** key until **50-50%** is highlighted. Press **Auto Level Set** key.

(31) Press **Delta t** key and press **START ON EDGE** key until **POS 1** is highlighted. Press **STOP ON EDGE** key until **POS 1** is highlighted. Press **Precise Edge Find** key.

(32) Press the **START** and **STOP MARKER** keys and record start and stop positions. **START MARKER** $\underline{\hspace{2cm}}$ ns, **STOP MARKER** $\underline{\hspace{2cm}}$ ns.

(33) Press **Timebase** key and set **Delay Ref at Left** is highlighted. Set **DELAY** to **Delay =** the value of **START MARKER**.

(34) Press **Delta t** key and adjust **STOP MARKER** to the value of the **START MARKER** plus 500 ps.

(35) Press **Timebase** key and set **Sweep Speed = 100 ps/div**. Press **Channels** key and set **Sensitivity = 2.000 mV/div**.

(36) Press **Delta V** key and adjust **MARKER2** to the lowest point of signal displayed. DO NOT INCLUDE the rising edge of the signal. If the **Delta V** point is to the left of the **STOP MARKER**, subtract the value obtained in (20) above from **V(2)** on display. Record this value as in (37) below. **V(2)** = $\underline{\hspace{2cm}}$ mV.

NOTE

If the lowest point on the display is out of tolerance and is to the right of the STOP MARKER, change the 50 Ω termination.

(37) -3% test _____mV. Example -2.94 mV.

(38) Divide the value obtained in (37) above by the value obtained in (20) above and multiply by 100%. (Step (37) _____mV , step (20) _____mV x 100% = _____%. The absolute value of this number will be less than 3% (-3% at <1 ns after edge).

(39) Adjust **MARKER2** to the highest point of signal on the display. Record the value of V(2) = _____mV.

(40) Subtract the value obtained in (20) above from the value recorded in (39) above. Record this value as in (41) below.

(41) +5% test _____mV. Example 6.87 mV.

(42) Divide the value obtained in (41) above by the value obtained in (20) above and multiply by 100%. (Step (41) _____mV , step (20) _____mV) x 100% = _____%. The absolute value of this number will be less than 5% (+5% at <1 ns after edge).

(43) Using **ENTRY** pushbuttons, set **MARKER2** to the value obtained in (20) above. Using **ENTRY** pushbuttons, set **MARKER1** to the value recorded in (10) above.

(44) Press **Timebase** key and set **Sweep Speed = 30.00 ps/div**. Press **Delay** and press **Delay Ref at Center** is highlighted. Set **DELAY** to **Delay =** the value of the **START MARKER**.

(45) Press **Channel** key and set **Sensitivity = 30.00 mV/div** and **OFFSET** for 100 mV.

(46) Press **Delta V** key. Press **Preset Levels** key until **10%-90%** is highlighted. DO NOT PRESS **Auto Level Set** key.

(47) Press **Delta t** key and press **START ON EDGE** key until **POS 1** is highlighted. Press **STOP ON EDGE** key until **POS 1** is highlighted.

(48) Press the **Precise Edge Find** key. The measured risetime (Δt) will be less than <45 ps.

b. Adjustments. No further adjustments can be made.

13. Input Reflection

a. Performance Check

(1) Connect the short end of the semi-rigid U cable to the short end of the semi-rigid S cable through an APC 3.5 (f-f) adapter. DO NOT tighten connections until told to do so.

(2) Connect the other end of the semi-rigid U cable to **Channel 1**.

(3) Without bending or damaging the semi-rigid cables, bring the other end of the semi-rigid S cable toward **Channel 2**. You will be told to make connection to **Channel 2**.

- (4) Tighten all the cable connections.
- (5) Set **POWER STBY/ON** switch to **STBY**.
- (6) Press and hold down the top or bottom vertical **FUNCTION** key, and set **POWER STBY/ON** switch to **ON** continuing to hold key until the graticule lines are displayed.
- (7) Set the display menu and mainframe settings to meet the following conditions:
 - (a) Press **Display** key. **Display Mode** to **Average** is highlighted. **NUMBER OF AVERAGES** to **# Averages = 16**. **Screen** to **Single** is highlighted.
 - (b) Press **Channels** key. **Channel 1** display **On** is highlighted. **Channel 2** through **4** display **Off** is highlighted. **VOLTS/DIV** to **Sensitivity = 5.000 mV/div**. **OFFSET** to **Offset = 200.0 mV**.
 - (c) Press **Timebase** key. **TIME/DIV** to **Sweep Speed = 350 ps/div**. **DELAY** to **Delay = 23.5000 ns**.
 - (d) Press **MORE** and **Network** key. **Reflect/Trans/Cal** to **Reflect** is highlighted. **Step & Chan 1** to **On** is highlighted.
- (8) Press **Timebase** and **DELAY** keys. Adjust the delay so the second rising edge of the signal (representing an open circuit) is 4 divisions left of center of display.
- (9) Press **Network** key and press the **Reflect/Trans/CAL** key until **CAL** is highlighted.
- (10) Press **Reflect Cal** key. Connect a short with an APC 3.5 (f) connector to the semi-rigid cable, and press **Reflect Cal** key.
- (11) Remove the short from the semi-rigid cable and connect a 50 Ω termination to the semi-rigid cable. Press **Reflect Cal** key.
- (12) Remove the 50 Ω termination from the semi-rigid cable and connect the semi-rigid cable to **Channel 2**. Press **SYSTEM CONTROL CLEAR DISPLAY** pushbutton and allow 16 averages to accumulate.
- (13) Press **More** and **Network** keys. Press **Reflect/Trans/Cal** key until **Reflect** is highlighted.
- (14) Set the **NORMALIZED RISETIME** to **Filter Risetime = 30 ps**. Press the **Normalize** to **Mem 1** key.
- (15) Press **SYSTEM CONTROL STOP** and **CLEAR DISPLAY** pushbuttons.
- (16) Press **Cursor** key until **mem 1** is highlighted.
- (17) Press **Min & Max Reflect** key. The absolute value of Rho minimum and Rho maximum will be less than 5% (<5%).
- (18) Press **SYSTEM CONTROL RUN** pushbutton.
- (19) Loosen the connection where the S and U cables connect together, and move the semi-rigid cable from **Channel 2** to **Channel 3**. Press **SYSTEM CONTROL CLEAR DISPLAY** pushbutton and retighten the connection where the semi-rigid S and U cables join together.

(20) Repeat (14) through (18) above for **Channel 3**.

(21) Loosen the connection where the S and U cables connect together, and move the semi-rigid cable from **Channel 3** to **Channel 4**. Press **SYSTEM CONTROL CLEAR DISPLAY** pushbutton and retighten the connection where the semi-rigid S and U cables join together.

(22) Repeat (14) through (18) above for **Channel 4**.

(23) Loosen the connection where the S and U cables connect together, and move the semi-rigid cable from **Channel 4** to **External Trigger Input**. Press **SYSTEM CONTROL/CLEAR DISPLAY** pushbutton and retighten the connection where the semi-rigid S and U cables join together.

(24) Set the **NORMALIZED RISETIME** to **Filter Risetime = 100 ps** and Rho limits for 10%. Repeat (14) through (18) above for external trigger.

(25) Remove the semi-rigid S and U cables from TI and connect the precision short to **Channel 1** input.

(26) Press **Wfm Save** key. Press **WAVEFORM MEMORY** key until **1** is highlighted and press **Display** key until **Off** is highlighted.

(27) Press **Channels** key and set **OFFSET** to **Offset = 0.000 V**. Press **Timebase** key and set **TIME/DIV** to **Sweep Speed = 2.00 ns/div**.

(28) Press **Delta V** key and overlay both V markers on **Channel 1**.

(29) Press **MARKER1 POSITION** key and overlay this marker on the center of the trace.

(30) Press **MARKER2 POSITION** key and overlay this marker on the highest portion of the ringing that occurs near the center of the display and is greater than **MARKER1**.

(31) The ΔV value will be less than 10 mV (+5%).

(32) Reposition **MARKER2** to the lowest position of the ringing that occurs near the center of the display and is less than **MARKER1**.

(33) The absolute value of Delta V should be <10 mV (+5%).

b. Adjustments. No further adjustments can be made.

14. Final Procedure

a. De-energize and disconnect all equipment and reinstall protective cover on TI.

b. Annotate and affix DA label/form on accordance with TB 750-25.

SECTION IV ADJUSTMENTS PROCEDURES

15. Power Supply Adjustment

- a. Set **POWER STBY/ON** switch to **STBY**.
- b. Remove top feet (rear) and top cover from TI mainframe.
- c. Set **POWER STBY/ON** switch to **ON** and allow 2 minutes for TI to warm-up.
- d. Connect multimeter positive lead to **+5 V** test point and negative lead to **-5 V** test point. Multimeter will indicate between 10.39 and 10.41 V; if not, perform e through l below.

NOTE

Test point locations and adjustment locations are marked on the power supply cover and on the Digital PC assembly (A13).

NOTE

Hazardous voltages capable of causing injury or death are present on the power supply assembly A11 when power is applied and for a period of time after power is removed from the TI. To avoid this hazard, **DO NOT REMOVE THE POWER SUPPLY SHIELD** until the LED on the ac power supply assembly is extinguished. This LED is visible through an inspection hole in the cover labeled “+300 V WHEN LAMP IS ON.”

- e. Set **POWER STBY/ON** switch to **STBY**. Remove multimeter connections and power cord from ac source.
- f. When the **+300 V LED** is extinguished, remove the power supply top cover.
- g. Connect multimeter positive lead to **+5 V** test point and negative lead to **-5 V** test point.
- h. Reconnect power cord to ac source. Set **POWER STBY/ON** switch to **ON** and allow 2 minutes for TI to warm-up.
- i. Adjust A13R56 (see NOTE above) for a multimeter reading of +10.4 V dc (R).
- j. Set **POWER STBY/ON** switch to **STBY**. Remove multimeter connections and power cord from ac source.
- k. When the **+300 V LED** is extinguished, replace the power supply top cover.
- l. Reconnect power cord to ac source. Set **POWER STBY/ON** switch to **ON**.

16. Timebase Data Adjustment

- a. Set **POWER STBY/ON** switch to **STBY**.

- b.** Remove HORIZ. CONTROL BOARD A3 (fig. 9) as necessary to perform **c** and **d** below.
- c.** Using four-wire resistance measurement technique, connect multimeter negative leads to A3TP3 and positive leads to A3TP2 (fig. 9).
- d.** Measure and record the dc resistance value in ohms of A3R46 (fig. 9) in **l** and **n** below. (Two places after the decimal are required. Example: 200.06 Ω).
- e.** Reinstall HORIZ. CONTROL BOARD A3 (fig. 9).
- f.** Disconnect ribbon cables from A3J1 of HORIZ. CONTROL BOARD A3 (fig. 9) and A4J1 of ADC BOARD A4 (fig. 10) (rear of chassis).

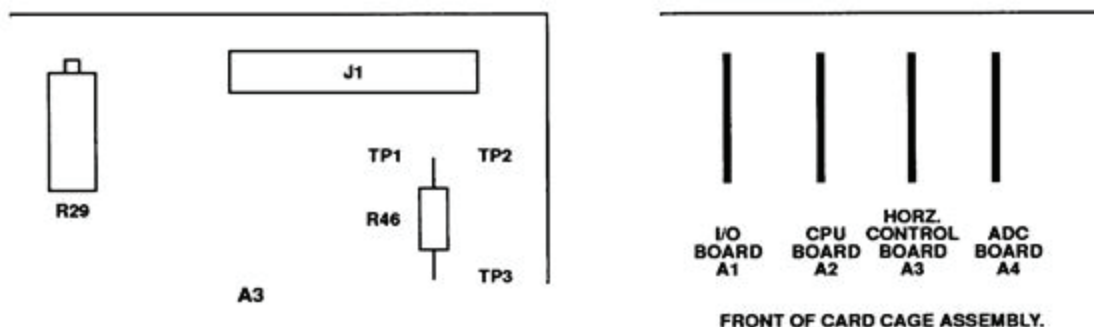


Figure 9. Top rear corner of horizontal control board A3 and top view of mainframe card cage.

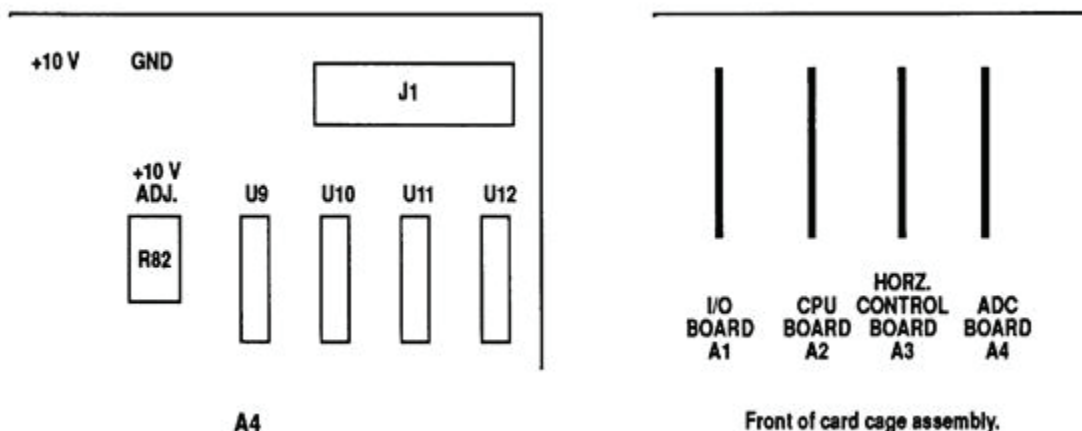


Figure 10. Top rear corner of ADC board A4 and top view of mainframe card cage.

- g.** Remove multimeter four-wire measurement technique connections and connect negative leads to A3TP3 and positive leads to A3TP2 on HORIZ. CONTROL BOARD A3 (fig. 9).
- h.** Connect a short to A3TP1 and A3TP2 on HORIZ. CONTROL BOARD A3 (fig. 9).

- i. Set **POWER STBY/ON** switch to **ON**.
- j. Press **Timebase** key and set **DELAY** to **Delay = 16.0000 ns**.
- k. Measure and record multimeter voltage value indication in **l** below. (Five places after the decimal are required. Example: -1.00039 mA).
- l. Record multimeter voltage value: _____ V. Record multimeter ohms value: _____ W. Divide the voltage value by the ohms value to obtain current value. Result = _____ mA. (Four places after the decimal are required and drop the negative sign. Example: 5.0004 mA).
- m. Subtract the mA value obtained in **l** above from the desired delta current 9.7632 mA. (9.7632 mA - _____ mA = _____ mA). Record this value in **n** below. Example: 9.7632 mA - 5.0004 mA = 4.7628 mA.
- n. Convert calculated current from **m** above as follows: Record calculated mA value from **m** above: _____ mA. Record multimeter ohms value from **d** above: _____ W. Multiply mA value times the ohms value to obtain voltage value. Result = _____ V. Example: 4.7628 mA x 200.06W = 0.952845768 V.
- o. Round and record the voltage value obtained in **n** above to five decimal places: _____ V. Example: 0.95285 V.
- p. Press **Timebase** key and set **DELAY** to **Delay = 19.999 ns**.
- q. Multimeter will indicate the voltage obtained in **o** above; if not, adjust A3R29 HORIZ. CONTROL BOARD (fig. 9) to the value obtained in **o** above (R).
- r. Set **POWER STBY/ON** switch to **STBY**. Remove all connections from A3TP1, A3TP2, and A3TP3 (fig. 9).
- s. Reconnect ribbon cables that were removed in **f** above.

17. +10 Volt Reference Adjustment

- a. Set **POWER STBY/ON** switch to **STBY**.
- b. Connect multimeter positive lead to +10 V test point and negative lead to GND test point on ADC BOARD A4 (fig. 10).
- c. Set **POWER STBY/ON** switch to **ON**. Multimeter indication will indicate between 9.999 and 10.001 V; if not, adjust +10 V ADJ. R82 on ADC BOARD A4 (fig. 10) for 10.000 V (R).
- d. Set **POWER STBY/ON** switch to **STBY**. Remove multimeter connections and replace TI top cover and feet.

18. Range Adjustment

- a. Remove the top and bottom cover from the four-channel test set.
- b. Set the **ON/STBY** power switch to **STBY**. Press and hold the top and bottom vertical keys on right side of mainframe. Set power switch to **ON**. Continue to hold pushbuttons until the graticule lines are displayed. Ignore the "Front Panel Cals Lost Recal thru Utility Menu" warnings on top of the display; Cals will be performed later.

c. Press **Timebase** and **DELAY** keys. Set to **Delay = 18 ns** and press **Freerun/Trg'd Sweep** key until **Trg'd** is highlighted.

d. Connect the positive lead of multimeter to horizontal assembly A1TP1 (fig. 11) and negative to chassis ground and adjust the **RANGE** (fig. 11) for 5 V (R).

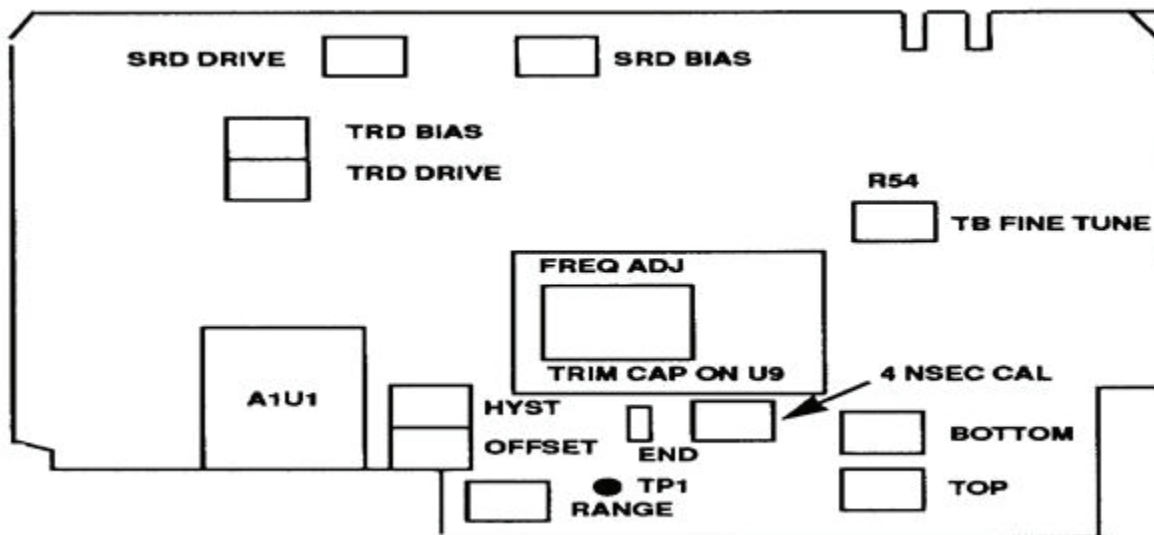


Figure 11. Horizontal assembly A1 adjustments.

19. Step Recovery Diode Adjustment

a. Set the display menu and mainframe settings to meet the following conditions:

(1) Press **Display** key. **Display Mode** to **Average** is highlighted. **NUMBER OF AVERAGES** to **# Averages = 4**. **Screen** to **Single** is highlighted. **Graticule** to **Grid** is highlighted. **Bandwidth** to **12A GHz** is highlighted.

(2) Press **Channels** key. **Channel 1** to display **On** is highlighted. **Channel 2** through **4** display **Off** is highlighted. **VOLTS/DIV** to **Sensitivity = 20.00 mV/div** for **Channel 1** through **4**. **OFFSET** to **Offset = 0.000V**. **PROBE ATTEN** to **Chl Atten Factor = 1.000**.

(3) Press **Timebase** key. **TIME/DIV** to **Sweep Speed = 500 ps/div**. **DELAY** to **Delay = 16.0000 ns**. **Delay Ref** at **Left** is highlighted. **Freerun/Trg'd Sweep** to **Trg'd** is highlighted.

(4) Press **Trigger** key. **TRIGGER LEVEL** to **Trigger Level = 0.000 V**. **Slope Pos** to **Pos** is highlighted. **PROBE ATTEN** to **Ext Atten Factor = 1.000**. **HF Sens** to **Off** is highlighted. **HF Reject** to **Off** is highlighted.

b. Connect equipment as shown in figure 5.

c. Set signal generator for a frequency of 250 MHz and amplitude of +12 dBm.

d. Preset LB1 and OG1 on the vertical assembly A2 (fig. 12) to mechanical center.

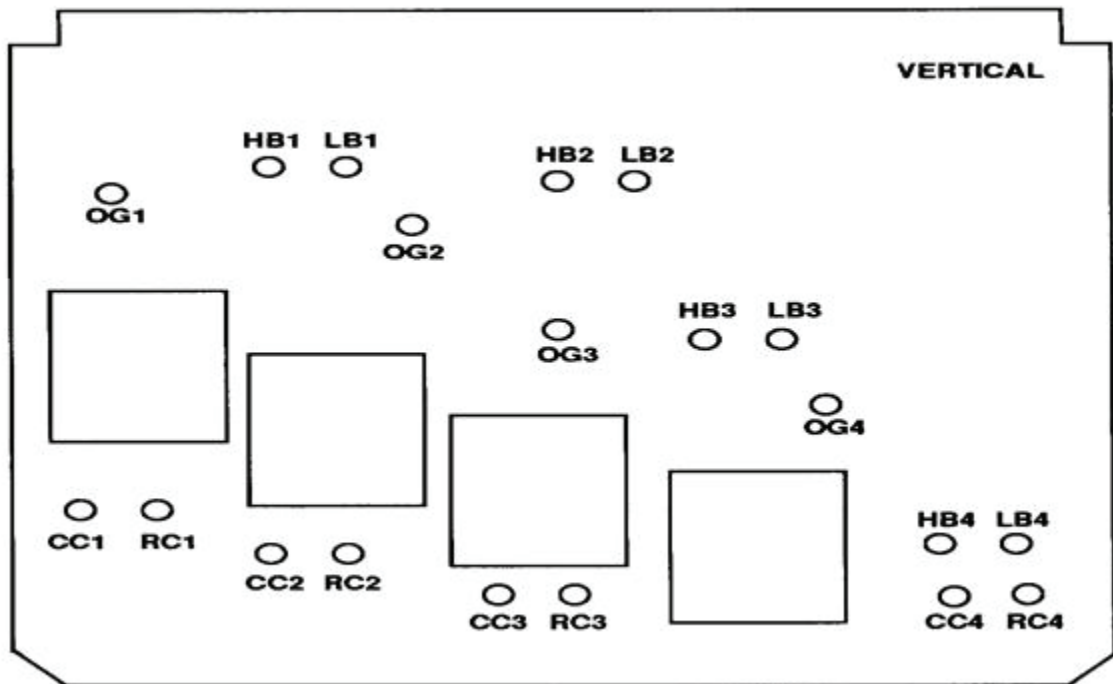


Figure 12. Vertical assembly A2 adjustments.

- e. Readjust the channel offset to re-center the signal on display.
- f. Press **Delta V** key. Set both **V MARKERS ON** and overlay them on **Channel 1**.
- g. Press **Preset Levels** key until **Preset Levels 0-100%** is highlighted.
- h. Press **Channel** and **OFFSET** keys and adjust **RPG** control to center signal on display.
- i. Press **Delta V** and **Auto Level Set** keys.
- j. Press **Display** key. Press **Display Mode** key until **Persist** is highlighted and set **Persistence = 300 ms**.
- k. Preset SRD BIAS on horizontal assembly A1 (fig. 11) to mechanical center.
- l. Adjust SRD DRIVE on horizontal assembly A1 (fig. 11) for a signal amplitude of 0% and + 100% on display.

NOTE

An offset may exist in the signal during this portion of the adjustments. If the signal peaks do not overlay the 0% and 100% markers, adjust SRD DRIVE (fig. 11) for equal amounts of signal above or below the markers in the following steps. The **OFFSET** level may be adjusted anytime during this procedure.

m. Slowly adjust SRD BIAS on horizontal assembly A1 (fig. 11) for maximum signal amplitude. The waveform will compress and slightly increase in amplitude. SRD BIAS (fig. 11) must be adjusted slowly to see the slight amplitude increase.

n. Repeat **l** and **m** above until maximum signal amplitude is 0% and +100%.

o. Press **Delta V** key and set **V MARKERS Off**.

20. Frequency Adjustment

a. Set the display menu and mainframe settings to meet the following conditions:

(1) Press **Display** key. **Display Mode** to **Average** is highlighted. **NUMBER OF AVERAGES** to **# Averages = 4**. **Screen** to **Single** is highlighted. **Graticule** to **Grid** is highlighted. **Bandwidth** to **12.4 GHz** is highlighted.

(2) Press **Channels** key. **Channel 1** to display **On** is highlighted. **Channel 2** through **4** display **Off** is highlighted. **VOLTS/DIV** to **Sensitivity = 20 mV/div** for **Channel 1** through **4**. **OFFSET** to **Offset = 0.000V**. **PROBE ATTEN** to **Ch1 Atten Factor = 1.000**.

(3) Press **Timebase** key. **TIME/DIV** to **Sweep Speed 500 ps/div**. **DELAY** to **Delay = 16.0000 ns**. **Delay Ref at Left** is highlighted. **Freerun/Trg'd Sweep** to **Trg'd** is highlighted.

(4) Press **Trigger** key. **TRIGGER LEVEL** to **Trigger Level = 0.000 V**. **Slope Pos** to **Pos** is highlighted. **PROBE ATTEN** to **Ext Atten Factor = 1.000**. **HF Sens** to **Off** is highlighted. **HF Reject** to **Off** is highlighted.

b. Connect equipment as shown in figure 5.

c. Set signal generator for a frequency of 250 MHz and amplitude of +12 dBm.

NOTE

If the course adjustment needs to be performed, a non-metallic tool with a blade 0.010 inches thick and 0.040 inches wide must be used.

d. Press **Channels** and **OFFSET** keys. Adjust TI offset to center the signal vertically.

e. Press **Trigger** and **TRIGGER LEVEL** keys. Adjust TI **Trigger Level** until the positive or negative slope of the trace begins near the center horizontal graticule on the left side of display and remains triggered.

f. Press **Measure** and **Frequency** keys. If frequency does indicate between 249.750 and 250.250 MHz, perform **g** and **h** below. If within tolerance, perform **i** below.

g. Remove tape from the **FREQ ADJ TRIM CAP ON U9** on horizontal assembly A1 (fig. 11).

h. Re-measure the frequency while making small incremental adjustments to **FREQ ADJ TRIM CAP ON U9** (fig. 11) until frequency is 250 MHz \pm 250 kHz (between 249.750 and 250.250 MHz) (R).

- i. Press **More**, **Timebase**, and **TIME/DIV** keys and set **Sweep Speed = 200 ns/div**.
- j. If the trace is not horizontally flat ± 1 major division, perform **k** through **n** below. If within tolerance, perform **o** below.
- k. Preset the TB FINE TUNE (R54) on the horizontal assembly A1 (fig. 11) to mechanical enter.
- l. Adjust the FREQ ADJ TRIM CAP ON U9 on the horizontal assembly A1 (fig. 11) until the trace is flat ± 1 major division (R).
- m. Replace the tape over the FREQ ADJ TRIM CAP ON U9 (fig. 11). (Masking or electrical tape can be used.)
- n. Allow 10 minutes for U9 to stabilize its temperature, with the tape over the FREQ ADJ TRIM CAP ON U9 (fig. 11) hole.
- o. Press **Timebase** key and set **TIME/ DIV = 1.00 ms/div**.
- p. Adjust the R54 TB FINE TUNE (fig. 11) on the horizontal assembly A1 for the flattest trace possible on display (R).

21. END and 4 ns CAL Adjustment

- a. Set the display menu and mainframe settings to meet the following conditions:
 - (1) Press **Display** key. **Display Mode** to **Average** is highlighted. **NUMBER OF AVERAGES** to **# Averages = 4**. **Screen** to **Single** is highlighted. **Graticule** to **Grid** is highlighted. **Bandwidth** to **12A GHz** is highlighted.
 - (2) Press **Channels** key. **Channel 1** to display **On** is highlighted. **Channel 2** through **4** display **Off** is highlighted. **VOLTS/DIV** to **20.00 mV/div** for **Channel 1** through **4**. **OFFSET** to **Offset = 0.000V**. **PROBE ATTEN** to **Ch1 Atten Factor = 1.000**.
 - (3) Press **Timebase** key. **TIME/DIV** to **Sweep Speed = 500 ps/div**. **DELAY** to **Delay = 16.0000 ns**. **Delay Ref at Left** is highlighted.
 - (4) Press **Trigger** key. **TRIGGER LEVEL** to **Trigger Level = 0.000 V**. **Slope** to **Pos** is highlighted. **PROBE/ATTEN** to **Ext Atten Factor = 1.000**. **HF Sens** to **Off** is highlighted. **HF Reject** to **Off** is highlighted.
- b. Connect equipment as shown in figure 5.
- c. Set signal generator for a frequency of 250 MHz and amplitude of +12 dBm.
- d. Adjust the 4 NSEC CAL on horizontal assembly A1 (fig. 11) fully ccw.
- e. Adjust the END on horizontal assembly A1 (fig. 11) for a small amount of trace discontinuity at the beginning of the eighth vertical graticule division (fig. 13). If necessary, adjust trigger level to center the trace discontinuity vertically on display.

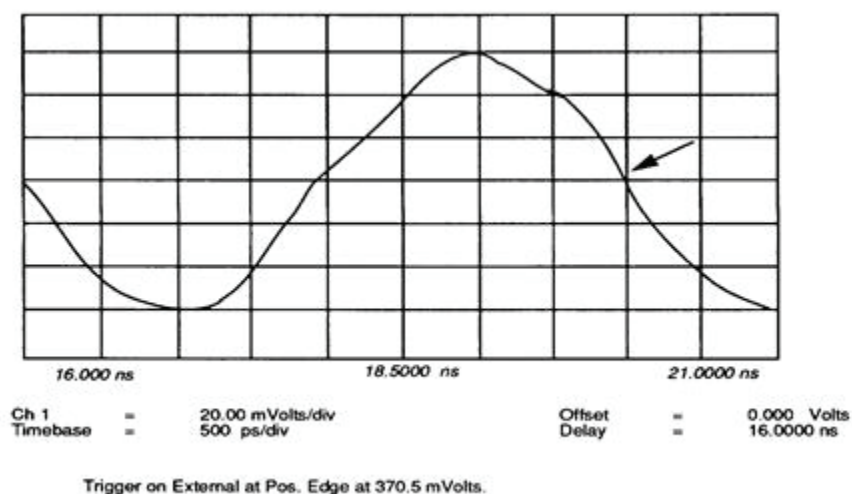


Figure 13. Trace discontinuity at eighth graticule.

f. Press **Timebase** key and set **TIME/DIV** to **Sweep Speed = 10.00 ps/div**. Press **DELAY** key and set to **Delay = 59.95 ns**.

g. Press **Channels** key and set **VOLTS/DIV** to **2.000 mV/div** and **OFFSET** to **Offset = 60.00 mV**.

h. If necessary, adjust the trigger level to center the trace discontinuity vertically on display (fig. 14).

i. Readjust the **END** adjust on horizontal assembly A1 (fig. 11) to eliminate the trace discontinuity (fig. 15).

j. Press **Timebase** and **DELAY** keys. Set **Delay = 19.95 ns**.

k. Adjust the 4 NSEC CAL on horizontal assembly A1 (fig. 11) from its ccw limit to the first null point (minimum trace discontinuity).

NOTE

Adjusting to the second null point may cause timebase errors.
It is all right to leave the adjustment fully ccw.

l. Press **Timebase** and **DELAY** keys. Set **Delay = 59.95 ns**. If discontinuity is not minimized at 19.95 and 59.95 ns, it may be necessary to repeat i through k above.

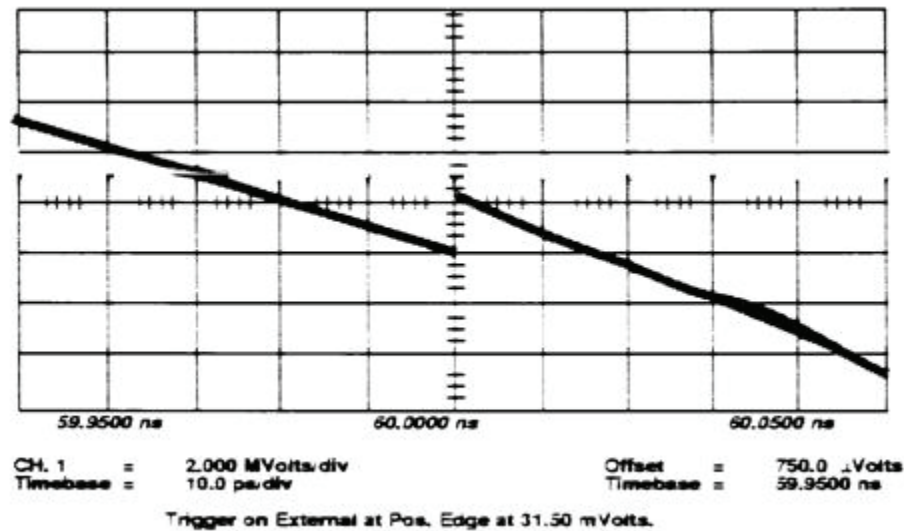


Figure 14. Expanded trace discontinuity.

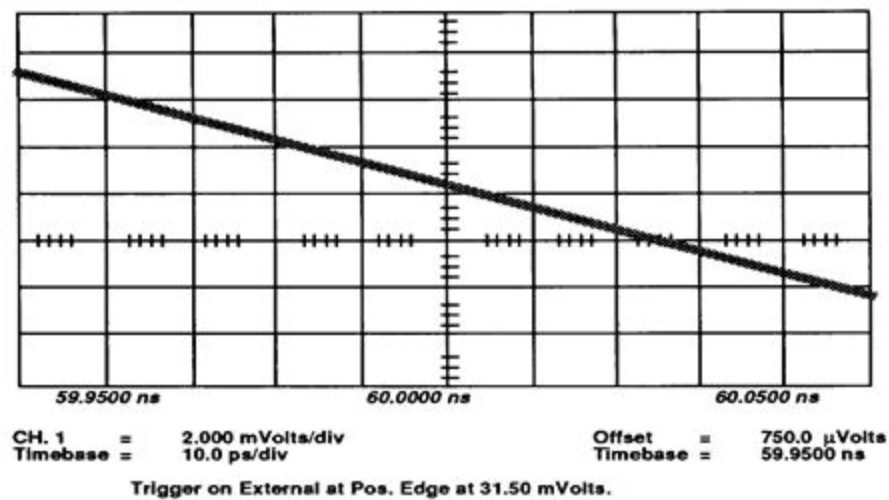


Figure 15. Correct and adjustment - no discontinuity.

22. Sampler Bias Adjustment

- a. Set the display menu and mainframe settings to meet the following conditions:

(1) Press **Display** key. **Display Mode** to **Average** is highlighted. **NUMBER OF AVERAGES** to **# Averages = 4**. **Screen** to **Single** is highlighted. **Graticule** to **Grid** is highlighted. **Bandwidth** to **12.4 GHz** is highlighted.

(2) Press **Channels** key. **Channel 1** to display **On** is highlighted. **Channel 2** through **4** display **Off** is highlighted. **VOLTS/DIV** to **20.000 mV/div** for **Channel 1** through **4**. **OFFSET** to **Offset = 0.000 V**. **PROBE ATTEN** to **Chl Atten Factor = 1.000**.

(3) Press **Timebase** key. **TIME/DIV** to **Sweep Speed = 1.00 ns/div**. **DELAY** to **Delay = 16.0000 ns**. **Delay Ref at Left** is highlighted. **Freerun/Trg'd Sweep** to **Trg'd** is highlighted.

(4) Press **Trigger** key. **TRIGGER LEVEL** to **Trigger Level = 0.000 V**. **Slope** to **Pos** is highlighted. **PROBE/ATTEN** to **Ext Atten Factor = 1.000**. **HF Sens** to **Off** is highlighted. **HF Reject** to **Off** is highlighted.

b. Connect equipment as shown in figure 5.

c. Set signal generator for a frequency of 250 MHz and amplitude of +12 dBm.

d. Press **Delta V** key and set **V MARKERS On**.

e. Press **Preset Levels** key until **0-100%** is highlighted and press **Auto Level Set** key.

f. Press **Display** key. Press **Display Mode** key until **Persist** is highlighted and set **Persistence = 300 ms**.

g. Adjust LB1 on vertical assembly A2 (fig. 12) (**Channel 1** low bandwidth) for a signal amplitude of 0 to 100 percent (fig. 16). If signal does not line up with the markers, adjust for equal amounts above or below markers (R).

h. Press **Display** key. Press **Display Mode** until **Average** is highlighted and press **Bandwidth** to **20 GHz** is highlighted.

i. Press **Delta V** key.

j. Press **Preset Levels** key until **Variable** is highlighted. Press **VARIABLE LEVELS** key and using **ENTRY** pushbuttons, place **Set Levels** to **30%-70%**.

k. Press **Auto Level Set** key.

l. While in the persistence/bandwidth mode, toggle the **BANDWIDTH** key. If TI toggles between 12.4 and 20 GHz perform (1) below; if not, perform (2) below.

(1) Press **Display** key. Press **Display Mode** key until **Persist** is highlighted and set **Persistence = 300 ms** and **Bandwidth to 20 GHz**.

(2) Press **Display Mode** until **Average** is highlighted and press **Bandwidth** to **20 GHz** is highlighted.

m. Press **SYSTEM CONTROL CLEAR DISPLAY** pushbutton and notice that the signal on the display temporarily decreases in size. Continue pressing the **CLEAR DISPLAY** pushbutton about two times a second while making small adjustment increments in **n** below.

n. Adjust HB1 on the vertical assembly A2 (fig. 12) (**Channel 1** high bandwidth) for a signal amplitude to overlay the 30 and 70 percent markers (fig. 17).

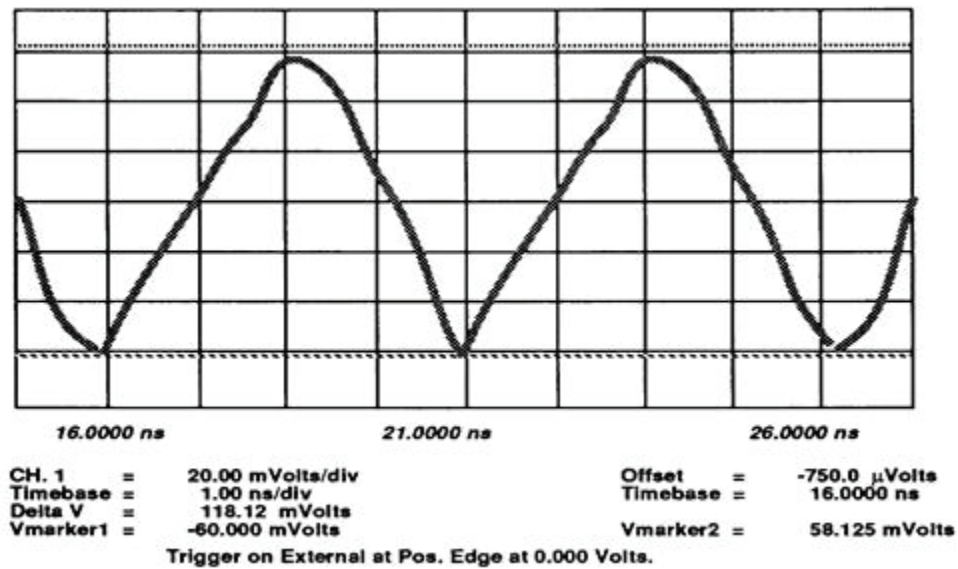


Figure 16. Low bandwidth adjustment with markers.

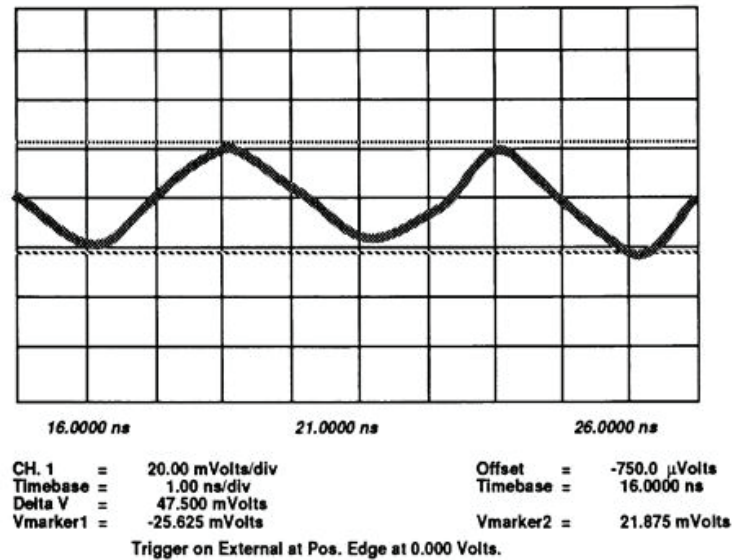


Figure 17. High bandwidth adjustment with markers.

o. Press **Channels** keys and set **Channel 1** display **Off** and set **Channel 2** display **On**. Press **Display Mode** to **Average** is highlighted and set **Bandwidth** to **12.4 GHz** is highlighted.

p. Move connection from **Channel 1** to **Channel 2**.

q. Repeat **d** through **o** above for **Channel 2** except use LB2 and HB2 on vertical assembly A2 (fig. 12).

- r. Press **Channels** key and set **Channel 2** display **Off** and set **Channel 3** display **On**. Press **Display Mode** until **Average** is highlighted and set **Bandwidth** to **12.4 GHz** is highlighted.
- s. Move connection from **Channel 2** to **Channel 3**.
- t. Repeat **d** through **o** above for **Channel 3** except use **LB3** and **HB3** (fig. 12) on vertical assembly A2.
- u. Press **Channels** key and set **Channel 3** display **Off** and set **Channel 4** display **On**. Press **Display Mode** until **Average** is highlighted and set **Bandwidth** to **12.4 GHz** is highlighted.
- v. Move connection from **Channel 3** to **Channel 4**.
- w. Repeat **d** through **o** above for **Channel 4** except use **LB4** and **HB4** on vertical assembly A2 (fig. 12).
- x. Press **Delta V** key and set **MARKERS Off**.
- y. Press **More**, **Utility**, and **Cal Menu** keys.
- z. Press **Channel Vertical Cal** key and follow the instructions on the display. When **Calibrating** stops flashing on the display press **Exit Cal Menu** and **More** keys.

23. Offset Gain Adjustment

- a. Set the display menu and mainframe settings to meet the following conditions:
 - (1) Press **Display** key. **Display Mode** to **Averaged** is highlighted. **NUMBER OF AVERAGES** to **# Averages = 8**. **Screen** to **Single** is highlighted. **Graticule** to **Grid** is highlighted. **Bandwidth** to **12.4 GHz** is highlighted.
 - (2) Press **Channels** key. **Channel 1** display **On** is highlighted. **Channel 2** through **4** display **Off** is highlighted. **VOLTS/DIV** to **1.000 mV/div**. **OFFSET** to **Offset = 0.000 V**. **PROBE ATTEN** to **Ch1 Atten Factor = 1.000**.
 - (3) Press **Timebase** key. **TIME/DIV** to **Sweep Speed = 1.00 μ s/div**. **DELAY** to **Delay = 200.000 ns**. **Delay Ref at Left** is highlighted. **Freerun/Trg'd/Sweep** to **Freerun** is highlighted. **FREERUN RATE** to **10 kHz** is highlighted.
 - (4) Press **Network** key. **Reflect/Trans/Cal** to **Reflect** is highlighted. **Step & Chan 1** to **Off** is highlighted.
- b. Remove all input connections from **TI**.
- c. Press **Utility**, **Cal Menu**, and **Channel Vertical Cal** keys and follow the instructions on the display. When **Calibrating** stops flashing and **#Avgs = 8** appears on the display, press **Exit Cal Menu** and **More** keys.

CAUTION

Exceeding 2 V on function generator may damage the TI input.

- d. Connect equipment as shown in figure 3.

- e. Set function generator for an output of 490 mV dc and observe that the dc voltage on multimeter reads between 489.9 and 490.1 mV.
- f. Press **Channels** and **OFFSET** keys and set **Offset = 490 mV**.
- g. Adjust OG1 (fig. 12) on vertical assembly A2 (**Channel 1** offset gain) until trace is on the center graticule. Slowly adjust OG1 (fig. 12) in small increments and wait for 8 averages to accumulate.
- h. Set **Channel 1** display **Off** and set **Channel 2** display **On** and move input connector to **Channel 2**.
- i. Repeat e through g above for **Channel 2** except adjust OG2 (fig. 12) on vertical assembly A2.
- j. Set **Channel 2** display **Off** and set **Channel 3** display **On** and move input connector to **Channel 3**.
- k. Repeat e through g above for **Channel 3** except adjust OG3 (fig. 12) on vertical assembly A2.
- l. Set **Channel 3** display **Off** and set **Channel 4** display **On** and move input connector to **Channel 4**.
- m. Repeat e through g above for **Channel 4** except adjust OG4 (fig. 12) on vertical assembly A2.
- n. Remove all connections.
- o. Press **More**, **Utility**, **Cal Menu**, and **Channel Vertical Cal** keys and follow the instructions on the display.

24. TDR Step Adjustment

- a. Set the display menu and mainframe settings to meet the following conditions:
 - (1) Press **Display** key. **Display Mode** to **Average** is highlighted. **NUMBER OF AVERAGES** to **# Averages = 16**. **Screen** to **Single** is highlighted. **Graticule** to **Frame** is highlighted. **Bandwidth** to **12A GHz** is highlighted.
 - (2) Press **Channels** key. **Channel 1** display **On** is highlighted. **Channel 2** through **4** display **Off** is highlighted. **VOLTS/DIV** to **30.00 mV/div**. **OFFSET** to **Offset = 100.00 mV**. **PROBE ATTEN** to **Ch1 Atten Factor = 1.000**.
 - (3) Press **Timebase** key. **TIME/DIV** to **Sweep Speed = 200 ps/div**. **DELAY** to **Delay = 16.000 ns**. **Delay Ref at Left** is highlighted. **Freerun/Trg'd/Sweep** to **Freerun** is highlighted. **FREERUN RATE** to **10 kHz** is highlighted.
 - (4) Press **Network** key. **Reflect/Trans/Cal** to **Reflect** is highlighted. **Step & Chan 1** to **On** is highlighted.

NOTE

Use four-terminal ohm measurement technique in **b** and **c** below.

b. Using necessary adapters and connectors, connect the 50 Ω termination to multimeter. Record the dc resistance of 50 Ω termination. _____ Ω .

c. Remove 50 Ω termination and connect APC 3.5 short. Record the dc resistance of APC 3.5 short. _____ Ω .

d. Subtract dc resistance recorded in c above from dc resistance recorded in b above.

Example:

Step (2) _____ Ω - Step (3) _____ Ω = Z_L _____ Ω .

e. Using this formula, solve for E_R (E_R may be a negative number).

$$E_R = 200 ((Z_L - 50) , (Z_L + 50)) \text{ (rounded to nearest 0.01 mV).}$$

f. Add 200 mV to the value obtained in e above rounded to the nearest 0.01 mV.

Example:

E_R (Step (5) + 200 mV = _____ mV

g. Connect 50 Ω termination to **Channel 1** input.

h. Adjust timebase delay until the rising edge is approximately 2 divisions from the left side of the display (fig. 18).

i. Adjust TDR DRIVE on horizontal assembly A1 (fig. 11) fully cw. Position the delay setting to place the edge 2 divisions from the left side of display.

j. Adjust TDR BIAS on horizontal assembly A1 (fig. 11) fully ccw, then slowly adjust TDR BIAS (fig. 11) cw until the pulse overshoot just starts to appear (first overshoot) (fig. 18). If overshoot is already on the display with TDR BIAS (fig. 11) fully ccw, adjust TDR DRIVE (fig. 11) slightly ccw until overshoot disappears. Then adjust TDR BIAS (fig. 11) cw until overshoot appears.

k. Press **Delta t** key and set **MARKERS ON**.

l. Set the **START MARKER** to the leading edge of the step, and set the **STOP MARKER** 500 ps to the right of **START MARKER** (fig. 18).

m. Adjust TDR BIAS on horizontal assembly A1 (fig. 11) until the rising edge of the step coincides with the **STOP MARKER** (fig. 19). If this adjustment does not line up with the **STOP MARKER**, return to j above and adjust TDR DRIVE (fig. 11) slightly more cw.

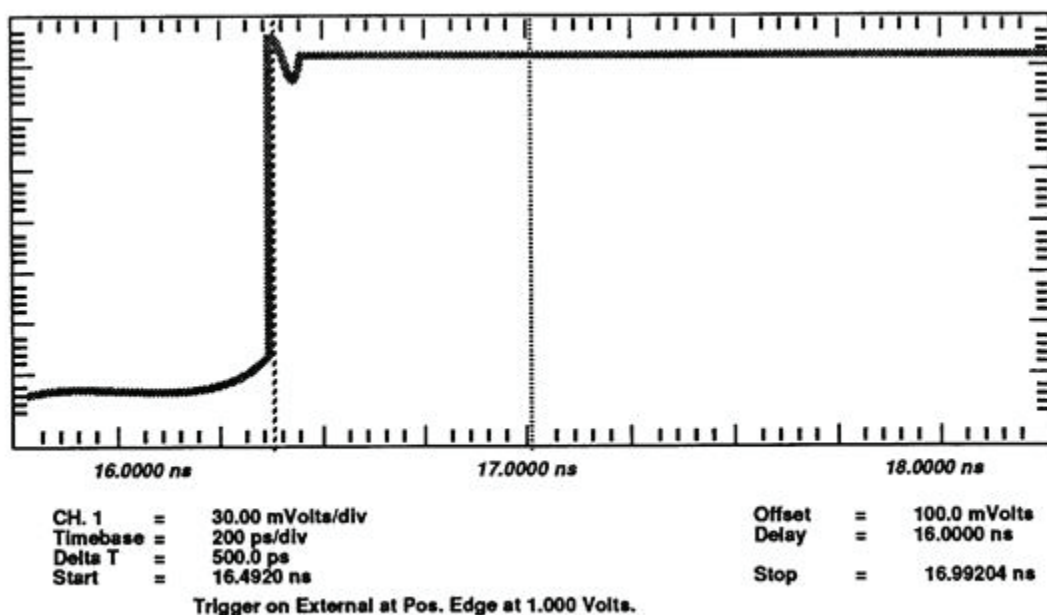


Figure 18. Setting start and stop markers.

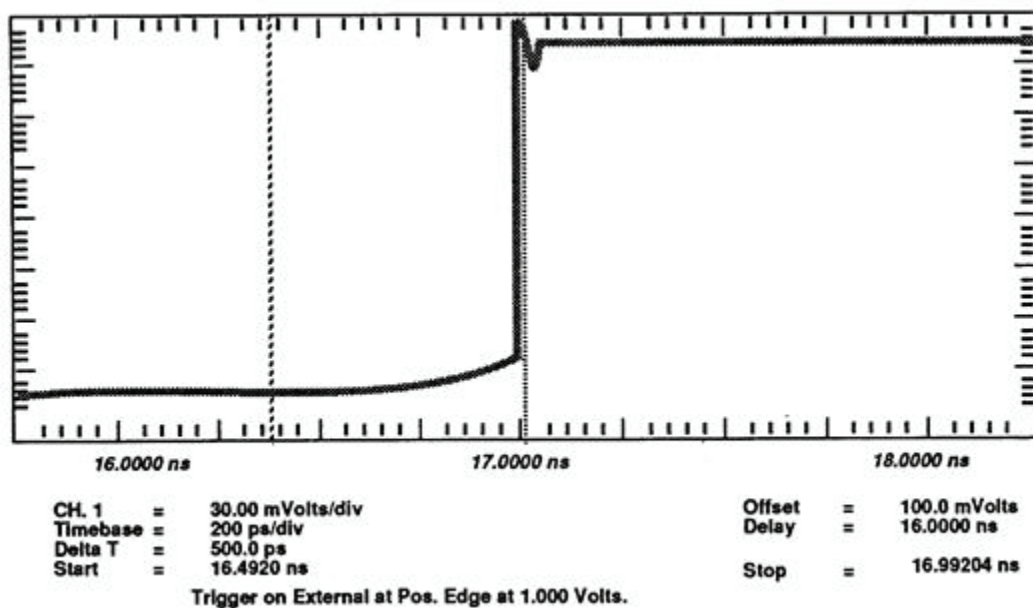


Figure 19. Adjusting TDR pulse to stop marker.

n. Adjust the TDR DRIVE on horizontal assembly A1 (fig. 11) so that the pulse overshoot is between 2.5 to 3.5 percent; use the **Measure Menu** to check this adjustment. If the TDR DRIVE (fig. 11) adjustment moves the edge off the display, reposition the edge with more **Delay In the Timebase** menu.

o. Press **Delta V** key and press **Preset Levels** key until **50-50%** is highlighted. Press **Auto Level Set** key.

p. Press **Delta t** key and press **START ON EDGE** key until **POS 1** is highlighted. Press the **STOP ON EDGE** key until **POS 1** is highlighted, then press **Precise Edge Find** key.

q. Press **Channels** key and set **Channel 1 Off** and back **On**. Set **VOLTS/DIV** to **Sensitivity = 2.000 mV** and **OFFSET** to **Offset = 0.000 V**.

r. Press **Delta V** key and press **Preset Level** key until **50-50%** is highlighted. Press **Auto Level Set** key. If **V(I)** is greater than 0.5 mV, perform a channel vertical cal (see **Utility** menu). Change the value of **MARKER2** to **200 mV**. Adjust the **RPG** control until the **Delta V** equals the value recorded in step f above (marker resolution limits this to within 0.06 mV at this sensitivity).

s. Press **Network** key and press **Reflect/Trans/Cal** key until **Reflect** is highlighted. Press **Step & Chan 1** key until **On** is highlighted.

t. Press the **Delta t** key and change the value of the **STOP MARKER** to the value of the **START MARKER** +1 ns.

u. Press **Channels** key and set **Channel 1 OFFSET** to **Offset to = 200 mV**.

v. Press **Timebase** key and set **TIME/DIV** to **Sweep Speed = 100 ns**, **DELAY** to **Delay = value of START MARKER**.

w. Press **Delta V** key and ensure that the **MARKER2** position is highlighted.

x. Adjust TOP on horizontal assembly A1 (fig. 11) until the trace on the right of display coincides with **MARKER2** position (fig. 20).

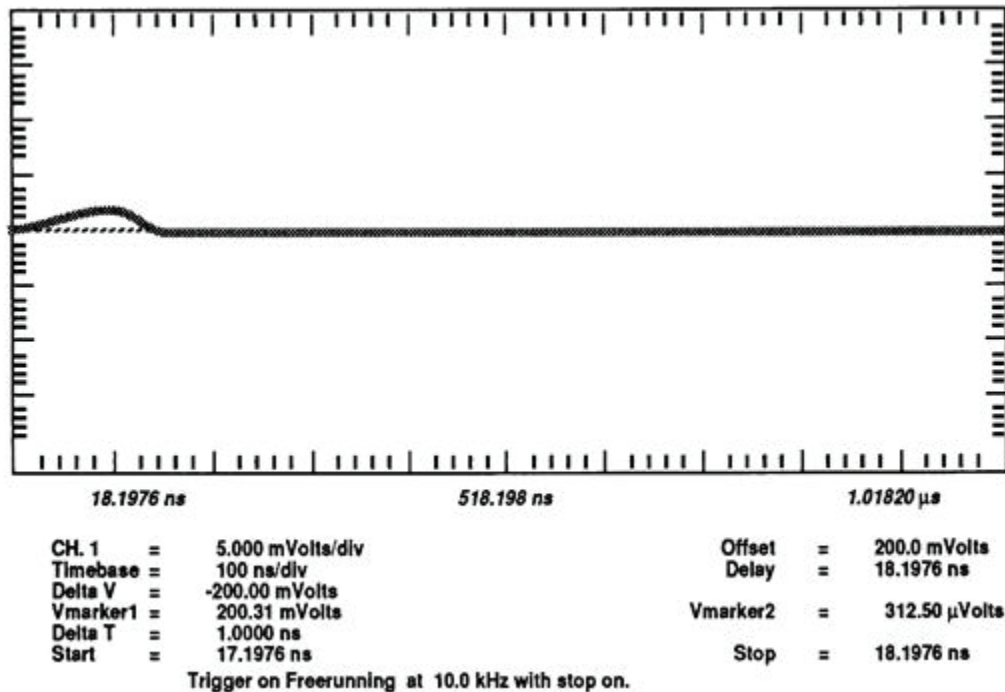


Figure 20. Top adjustment.

- y. Press **Channels** key and set **CHANNEL 1 OFFSET** to **Offset = 0.000V**.
- z. Press **Timebase** key and set **TIME/DIV** to **Sweep Speed = 50.0 ps/div**, **DELAY** to **Delay = 16.0000 ns**.
 - aa. Press **Timebase** key and set **Sweep Speed = 50 ps/div** and **Delay** to **16 ns**.
 - ab. Press **Delta V** key and ensure that the **MARKER1** position is highlighted.
 - ac. Adjust **BOTTOM** on horizontal assembly A1 (fig. 11) until the trace coincides with **MARKER1** position.
 - ad. Press **Channels** key and set **CHANNEL 1 OFFSET** to **Offset = 200.0 mV**.
 - ae. Press **Timebase** key and set **DELAY** to **Delay = value of the START MARKER**.
 - af. Press **Timebase** key and set **Delay = value of the START MARKER**.
 - ag. Press **Delta V** key. Change the value of **MARKER1** to equal the value obtained in step f above. Press **MARKER2** key until that cursor is highlighted. Adjust the **RPG** control for a **Delta V** reading of between 5 and 7 mV (this will correspond to an overshoot of about 2.5 to 3.5 percent).
 - ah. Slowly adjust the **TDR DRIVE** on horizontal assembly A1 (fig. 11) until the peak of the overshoot coincides with the **MARKER2** position (fig. 21). If the overshoot moves off the display, reposition the waveform with **Delay**. If this adjustment fails, repeat the **TOP** and **BOTTOM** (fig. 11) adjustments.

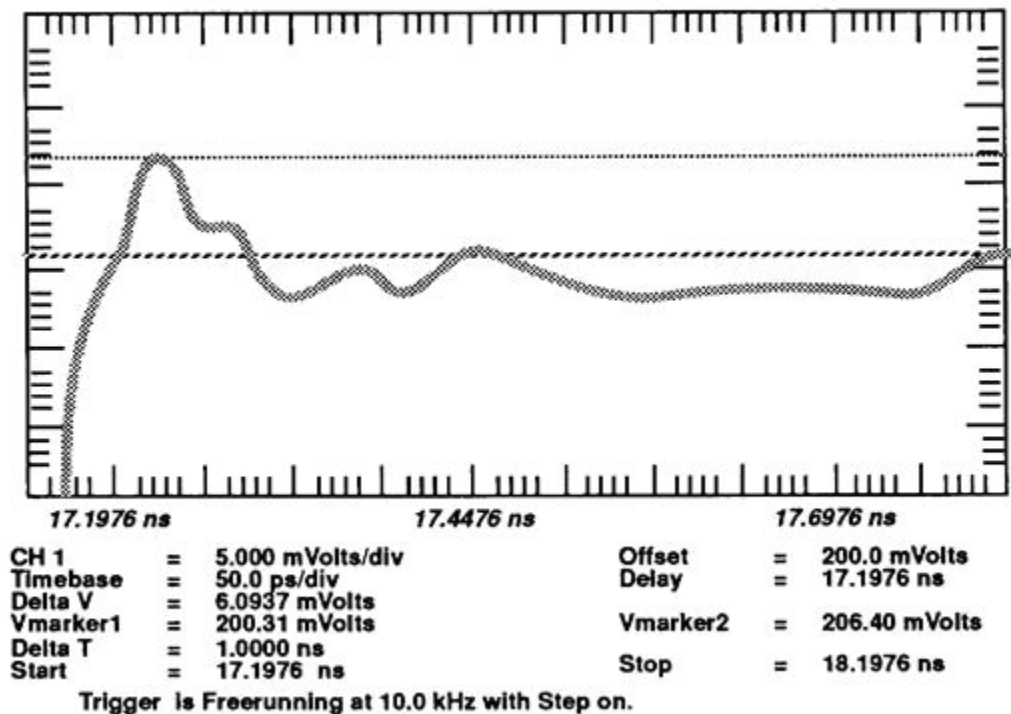


Figure 21. Overshoot fine adjustments.

25. Feedthrough Compensation Adjustment

a. Set the display menu and mainframe settings to meet the following conditions:

(1) Press **Display** key. **Display Mode** to **Persist** is highlighted. **DISPLAY TIME** to **Persistence = 500 ms**. **Screen** to **Single** is highlighted. **Graticule** to **Grid** is highlighted. **Bandwidth** to **12.4 GHz** is highlighted.

(2) Press **Channels** key. **Channel 1** display **On** is highlighted. **Channel 2** through **4** display **Off** is highlighted. **VOLTS/DIV** to **10.00 mV/div**. **OFFSET** to **Offset = 200 mV**. **PROBE ATTEN** to **Ch1 Atten Factor = 1.000**.

(3) Press **Timebase** key. **TIME/DIV** to **Sweep Speed = 20 ms/div**. **DELAY** to **Delay = 16.0000 ns**. **Delay Ref at Left** is highlighted. **Freerun/Trg'd Sweep** to **Freerun** is highlighted. **FREERUN RATE** to **3 kHz** is highlighted.

(4) Press **Network** key. **Reflect/Trans/Cal** to **Reflect** is highlighted. **Step & Chan 1** to **On** is highlighted.

b. Connect semi-rigid S and U cables from **Channel 1** to **Channel 2**.

c. Preset the eight adjustments RC1 through RC4 and CC1 through CC4 (fig. 12) on the vertical assembly A2 fully ccw.

d. The signal on the display should resemble figure 22.

e. Adjust RC1 (fig. 12) on the vertical assembly A2 until the positive and negative pulse peaks are equidistant from the flat portion of the pulse, $V_P = V_N$. The **Delta V Markers** can help determine when the pulses are equidistant (fig. 23).

f. Adjust CC1 (fig. 12) on vertical assembly A2 until the positive and negative plus peaks are lowest in amplitude. Readjust RC1 and CC1 (fig. 12) until the pulse top is as flat as possible.

g. Press **Channels** key and set **Channel 1 VOLTS/DIV** to **Sensitivity = 1 mV** and **OFFSET** to **Offset = 300.0 mV**.

h. Do not turn **Channel 1** display **Off**. Set **Channel 2** display **On** and move semi-rigid cables from **Channel 1** to **Channel 2**.

i. Repeat e and f above except adjust RC2 and CC2 (fig. 12).

j. Set **Channel 2** display **Off** and **Channel 3** display **On**. Move semi-rigid cables from **Channel 2** to **Channel 3**.

k. Repeat e and f above except adjust RC3 and CC3 (fig. 12).

l. Set **Channel 3** display **Off** and **Channel 4** display **On**. Move semi-rigid cables from **Channel 3** to **Channel 4**.

m. Repeat e and f above except adjust RC4 and CC4 (fig. 12).

n. Remove semi-rigid cables from TI.

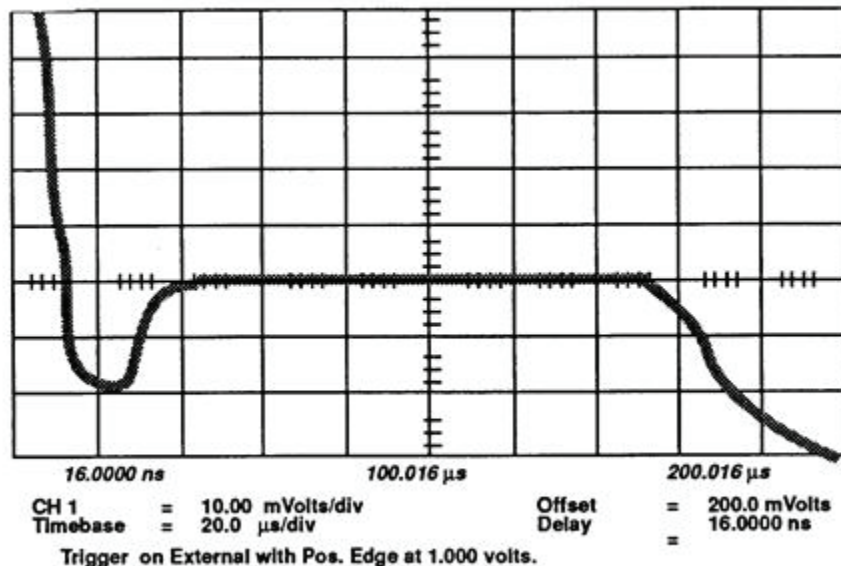


Figure 22. Feedthrough not compensated.

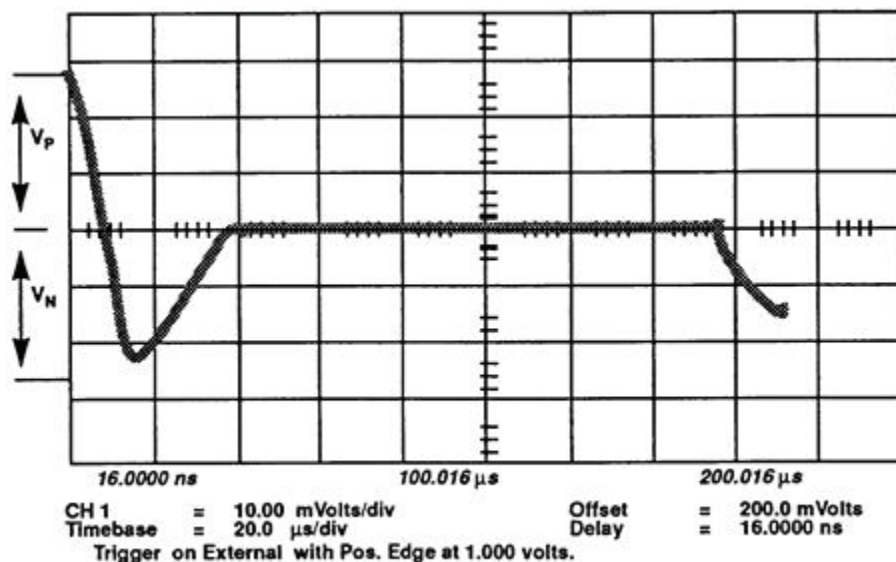


Figure 23. Adjusting RC1 for equidistant pulse peaks.

26. Trigger Adjustment

a. Set the display menu and mainframe settings to meet the following conditions:

(1) Press **Display** key. **Display Mode** to **Average** is highlighted. **NUMBER OF AVERAGES** to **# Averages = 4**. **Screen** to **Single** is highlighted. **Graticule** to **Grid** is highlighted. **Bandwidth** to **12.4 GHz** is highlighted.

(2) Press **Channels** key. **Channel 1** display **On** is highlighted. **Channel 2** through **4** display **Off** is highlighted. **VOLTS/DIV** to **Sensitivity = 10.00 mV/div**. **OFFSET** to **Offset = 0.000 V**. **PROBE ATTN** to **Ch1 Atten Factor = 1.000**.

(3) Press **Timebase** key. **TIME/DIV** to **Sweep Speed 1.00 ms/div**. **DELAY** to **Delay = 16.000 ns**. **Delay Ref at Left** is highlighted. **Freerun/ Trg'd Sweep** to **Trg'd** is highlighted.

(4) Press **Trigger** key. **TRIGGER LEVEL** to **Trigger Level = 0.000 V**. **HF Sens** to **Off** is highlighted. **HF Reject** to **Off** is highlighted. **Attenuation** to **1**.

(5) Press **Network** key. **Reflect/Trans/Cal** to **Reflect** is highlighted. **Step & Chan 1** to **Off** is highlighted.

b. Connect equipment as shown in figure 7, CONNECTION A.

c. Set function generator for an output frequency of 100 kHz and amplitude of 100 mV p-p.

d. One period of the 100 kHz sine wave with an amplitude of approximately 50 mV p-p will be on the display. If not, adjust HYST (fig. 11) horizontal assembly A1 fully ccw and adjust the OFFSET (fig. 11) to center the starting point on the left side of the display.

e. While switching trigger slope between positive and negative, adjust the trigger hysteresis HYST (fig. 11) on the horizontal assembly A1 until there is 15 mV (6 minor divisions or 1.5 major divisions) between the starting point of the sine wave for the positive slope versus the starting point of the negative slope at the left side of the display.


f. Continue switching the slope between the positive and negative as the OFFSET (fig. 11) on the horizontal assembly A1 is adjusted until the starting point of the sine wave is centered vertically around the center of the display.

27. Final Procedure

- a. De-energize and disconnect all equipment and reinstall protective cover on TI.
- b. Annotate and affix DA Label/Form on accordance with TB 750-25.

By Order of the Secretary of the Army:

Official


JOYCE E. MORROW
*Administrative Assistant to the
Secretary of the Army*

0719044

GEORGE W. CASEY, JR.
*General, United States Army
Chief of Staff*

Distribution:

To be distributed in accordance with STD IDS No. RLC-1500, 2 January 2003 requirements for calibration procedure TB 9-4931-538-40.

Instructions for Submitting an Electronic 2028

The following format must be used if submitting an electronic 2028. The subject line must be exactly the same and all fields must be included; however, only the following fields are mandatory: 1, 3, 4, 5, 6, 7, 8, 9, 10, 13, 15, 16, 17, and 27.

From: "Whomever" whomever@redstone.army.mil
To: <2028@redstone.army.mil>

Subject: DA Form 2028

1. **From:** Joe Smith
2. **Unit:** home
3. **Address:** 4300 Park
4. **City:** Hometown
5. **St:** MO
6. **Zip:** 77777
7. **Date Sent:** 19-OCT -93
8. **Pub no:** 55-2840-229-23
9. **Pub Title:** TM
10. **Publication Date:** 04-JUL-85
11. **Change Number:** 7
12. **Submitter Rank:** MSG
13. **Submitter FName:** Joe
14. **Submitter MName:** T
15. **Submitter LName:** Smith
16. **Submitter Phone:** 123-123-1234
17. **Problem:** 1
18. **Page:** 2
19. **Paragraph:** 3
20. **Line:** 4
21. **NSN:** 5
22. **Reference:** 6
23. **Figure:** 7
24. **Table:** 8
25. **Item:** 9
26. **Total:** 123
27. **Text**

This is the text for the problem below line 27.

