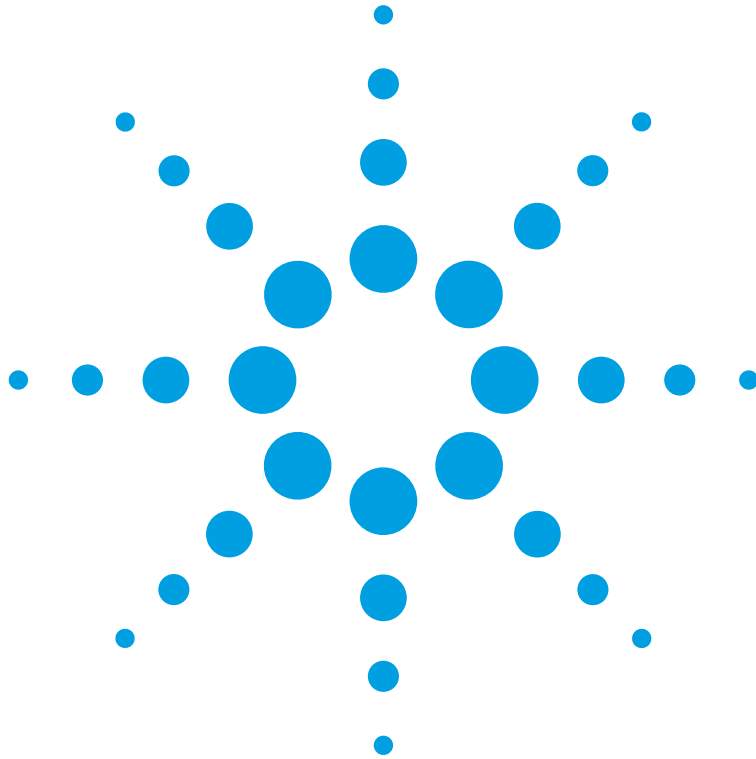


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# **Agilent 54753A and 54754A TDR Plug-in Modules Service Guide**



**Agilent Technologies**

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Caution denotes a hazard. It calls attention to a procedure which, if not correctly performed or adhered to, could result in damage to or destruction of the product. Do not proceed beyond a caution sign until the indicated conditions are fully understood and met.

**WARNING**

Warning denotes a hazard. It calls attention to a procedure which, if not correctly performed or adhered to, could result in injury or loss of life. Do not proceed beyond a warning sign until the indicated conditions are fully understood and met.

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## Introduction

The 54753A and 54754A TDR plug-in modules provide TDR and TDT measurement features for 86100A/B/C Digital Communications Analyzers, 54750A Digitizing Oscilloscope mainframe, or the 83480A Digital Communications Analyzer (equipped with Option 54755A TDR firmware upgrade). TDT is the acronym for Time Domain Transmission. In addition to the TDR and TDT measurement features, the plug-ins provide two accurate oscilloscope measurement channels with user selectable 12.4 or 18/20 GHz bandwidths. Each module contains the TDR step generators, samplers, and IF amplifiers. TDR is the acronym for Time Domain Reflectometer.

The stepped procedures contained in this book, refer to key presses on the 54750A and 83480A mainframes.

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**NOTE**

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Agilent 54753A and 54754A operation requires Rev 2.02 or higher operating system firmware in 54750A or 83480A mainframes.

The 54753A TDR Module provides:

- Automatic and manual single-ended TDR and TDT measurement capability
- Automatic and manual waveform, histogram, FFT, waveform math, eye pattern measurements, statistical measurements, and limit testing capabilities.
- User selectable 12.4 or 18 GHz bandwidth and TDR on channel 1
- User selectable 12.4 or 20 GHz bandwidth on channel 2
- 2.5 GHz bandwidth trigger channel
- 3.5 mm (m) connectors

The 54754A Differential TDR Module provides:

- Automatic and manual differential and single-ended TDR measurement capability
- Automatic and manual TDT measurement capability
- Automatic and manual waveform, histogram, FFT, waveform math, eye pattern measurements, statistical measurements, and limit testing capabilities
- User selectable 12.4 or 18 GHz bandwidth and TDR on channel 1 and channel 2
- 2.5 GHz bandwidth trigger channel
- 3.5 mm (m) connectors

## General Safety Considerations

This product has been designed and tested in accordance with the standards listed on the Manufacturer's Declaration of Conformity and has been supplied in a safe condition. The documentation contains information and warnings that must be followed by the user to ensure safe operation and to maintain the product in a safe condition.

Install the instrument according to the enclosure protection provided. This instrument does not protect against the ingress of water. This instrument protects against finger access to hazardous parts within the enclosure.

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**WARNING**

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**If this product is not used as specified, the protection provided by the equipment could be impaired. This product must be used in a normal condition (in which all means for protection are intact) only.**

---

**WARNING**

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**No operator serviceable parts inside. Refer servicing to qualified personnel. To prevent electrical shock, do not remove covers.**

---

**WARNING**

---

**If this product is not used as specified, the protection by the equipment could be impaired. This product must be used in a normal condition (in which all means for protection are intact) only.**

---

**WARNING**

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**These servicing instructions are for use by qualified personnel only. To avoid electrical shock, do not perform any servicing unless you are qualified to do so.**

---

**CAUTION**

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Electrostatic discharge (ESD) can damage circuits associated with front-panel connectors. Therefore, before connecting any cable to a front-panel connector, momentarily short the center and outer conductors of the cable together. Avoid touching the rear-panel connectors without first touching the frame of the instrument. Be sure that the instrument is properly earth-grounded to prevent buildup of static charge.

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## Electrostatic Discharge Information

Electrostatic discharge (ESD) can damage or destroy electronic components. Read the following information before using or repairing the 54753A or 54754A modules.

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### Input connectors

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**CAUTION**

The input connectors are very sensitive to electrostatic discharge (ESD). When you connect a device or cable that is not fully discharged to these input connectors, you risk damage to the module and expensive instrument repairs.

Agilent has provided a cable discharge device, the ESD gate (p/n 54753-60001), and a knurled attachment nut (p/n 54754-25701) with your TDR module. The ESD gate should be attached to the TDR input with the knurled nut as shown in Figure 1. Use the ESD gate to discharge any static charge on cables connected to the device that you are testing. A static charge potential frequently builds up between the connecting cable's center conductor and the shield. Because electrostatic discharge can damage or destroy the instrument and electronic components, all measurements should be performed at a static-safe work station.

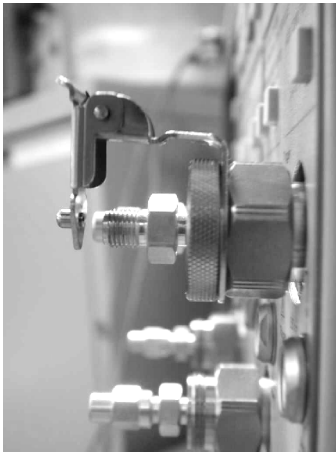


Figure 1. ESD gate.



Figure 2. Shorting test cable.



Figure 3. Cable connection.

#### To avoid ESD damage

- 1 Use ESD accessories to make your work station static-safe, as shown on the following page. Make sure the ESD gate is installed as shown in Figure 1.
- 2 Connect a test cable to the device you are testing.
- 3 On the other end of the test cable, short the cable's center conductor and shield to the ground contact on the ESD gate, as shown in Figure 2.

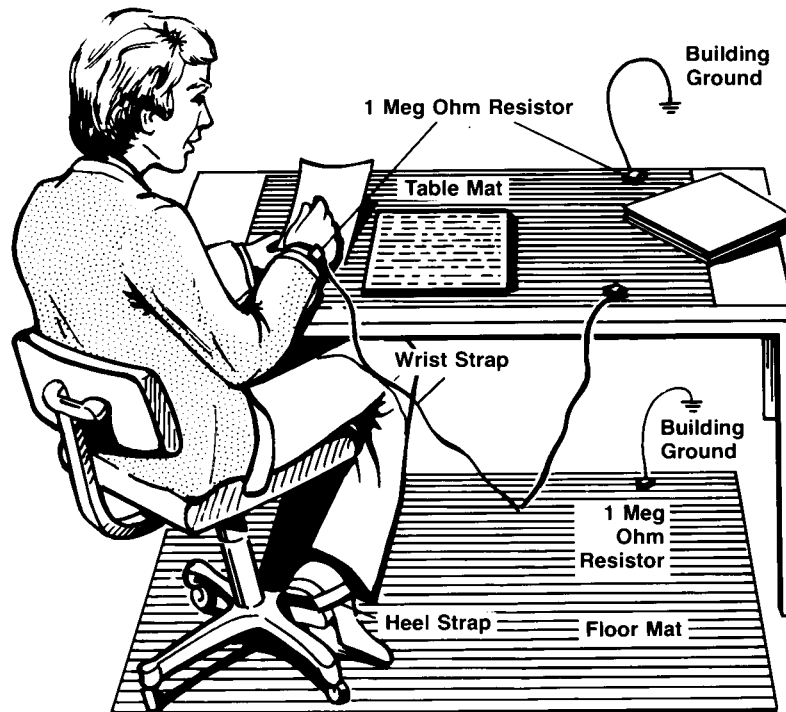
- 4 Lift the ESD gate out of the way, and connect the test cable. See Figure 3.

---

## Static-safe work station

All work on electronic assemblies should be performed at a static-safe work station. The following figure shows an example of a static-safe work station using two types of ESD protection:

- Conductive table-mat and wrist-strap combination.
- Conductive floor-mat and heel-strap combination.



Both types, when used together, provide a significant level of ESD protection. Of the two, only the table-mat and wrist-strap combination provides adequate ESD protection when used alone.

To ensure user safety, the static-safe accessories must provide at least 1 M $\Omega$  of isolation from ground. Refer to Table 1-1 for information on ordering static-safe accessories.

---

### WARNING

**These techniques for a static-safe work station should not be used when working on circuitry with a voltage potential greater than 500 volts.**

**Table 1-1. Static-Safe Accessories**

<b>Part Number</b>	<b>Description</b>
9300-0797	3M static control mat 0.6 m × 1.2 m (2 ft× 4 ft) and 4.6 cm (15 ft) ground wire. (The wrist-strap and wrist-strap cord are not included. They must be ordered separately.)
9300-0980	Wrist-strap cord 1.5 m (5 ft).
9300-1383	Wrist-strap, color black, stainless steel, without cord, has four adjustable links and a 7 mm post-type connection.
9300-1169	ESD heel-strap (reusable 6 to 12 months).

## Returning the Instrument for Service

The instructions in this section show you how to properly return an instrument or module for repair or calibration. Always call the Agilent Technologies Instrument Support Center first to initiate service *before* returning your instrument to a service office. This ensures that the repair (or calibration) can be properly tracked and that your instrument will be returned to you as quickly as possible. Call this number regardless of where you are located. Refer to “Agilent Technologies Service Offices” on page ix for a list of service offices.

Agilent Technologies Instrument Support Center . . . . . (800) 829-4444

If the instrument is still under warranty or is covered by an Agilent Technologies maintenance contract, it will be repaired under the terms of the warranty or contract (the warranty is at the front of this manual). If the instrument is no longer under warranty or is not covered by an Agilent Technologies maintenance plan, Agilent Technologies will notify you of the cost of the repair after examining the unit.

When an instrument is returned to an Agilent Technologies service office for servicing, it must be adequately packaged and have a complete description of the failure symptoms attached. When describing the failure, please be as specific as possible about the nature of the problem. Include copies of additional failure information (such as the instrument failure settings, data related to instrument failure, and error messages) along with the original cal data disks and the instrument being returned.

---

## Preparing the Instrument for Shipping

- 1 Write a complete description of the failure and attach it to the instrument. Include any specific performance details related to the problem. The following information should be returned with the instrument.
  - Type of service required.
  - Date instrument was returned for repair.
  - Description of the problem:
    - Whether problem is constant or intermittent.
    - Whether instrument is temperature-sensitive.
    - Whether instrument is vibration-sensitive.
    - Instrument settings required to reproduce the problem.
    - Performance data.
  - Company name and return address.
  - Name and phone number of technical contact person.
  - Model number of returned instrument.
  - Full serial number of returned instrument.
  - List of any accessories returned with instrument.
- 2 Cover all front or rear-panel connectors that were originally covered when you first received the instrument.



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**CAUTION**

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Cover electrical connectors to protect sensitive components from electrostatic damage. Cover optical connectors to protect them from damage due to physical contact or dust.

---

**CAUTION**

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Instrument damage can result from using packaging materials other than the original materials. Never use styrene pellets as packaging material. They do not adequately cushion the instrument or prevent it from shifting in the carton. They may also cause instrument damage by generating static electricity.

- 3 Pack the instrument in the original shipping containers. Original materials are available through any Agilent Technologies office. Or, use the following guidelines:
  - Wrap the instrument in antistatic plastic to reduce the possibility of damage caused by electrostatic discharge.
  - For instruments weighing less than 54 kg (120 lb), use a double-walled, corrugated cardboard carton of 159 kg (350 lb) test strength.
  - The carton must be large enough to allow approximately 7 cm (3 inches) on all sides of the instrument for packing material, and strong enough to accommodate the weight of the instrument.
  - Surround the equipment with approximately 7 cm (3 inches) of packing material, to protect the instrument and prevent it from moving in the carton. If packing foam is not available, the best alternative is S.D-240 Air Cap™ from Sealed Air Corporation (Commerce, California 90001). Air Cap looks like a plastic sheet filled with air bubbles. Use the pink (antistatic) Air Cap™ to reduce static electricity. Wrapping the instrument several times in this material will protect the instrument and prevent it from moving in the carton.
- 4 Seal the carton with strong nylon adhesive tape.
- 5 Mark the carton “FRAGILE, HANDLE WITH CARE”.
- 6 Retain copies of all shipping papers.

## Agilent Technologies Service Offices

Before returning an instrument for service, call the Agilent Technologies Instrument Support Center at (800) 829-4444, visit the Test and Measurement Web Sites by Country page at <http://www.tm.agilent.com/tmo/country/English/index.html>, or call one of the numbers listed below.

### Agilent Technologies Service Numbers

---

Austria	01/25125-7171
Belgium	32-2-778.37.71
Brazil	(11) 7297-8600
China	86 10 6261 3819
Denmark	45 99 12 88
Finland	358-10-855-2360
France	01.69.82.66.66
Germany	0180/524-6330
India	080-34 35788
Italy	+39 02 9212 2701
Ireland	01 615 8222
Japan	(81)-426-56-7832
Korea	82/2-3770-0400
Mexico	(5) 258-4826
Netherlands	020-547 6463
Norway	+47 22 73 57 59
Russia	+7-095-797-3930
Spain	(34/91) 631 1213
Sweden	08-5064 8700
Switzerland	(01) 735 7200
Taiwan	(886 2) 2-712-0404
United Kingdom	01 344 366666
United States and Canada	(800) 403-0801

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# General Information

This chapter of the Service Guide provides general information about the instrument. The following topics are covered here:

- Accessories
  - Options
  - Specifications and characteristics
  - Test equipment requirements
- 

## Accessories Supplied

- Three 3.5 mm female-to-female adapters, part number 5061-5311
  - SMA shorting caps, part number 0960-0055 (two with 54753A, one with 54754A)
  - SMA 50  $\Omega$  terminator, part number 1250-2153 (one with 54753A, two with 54754A)
  - Service Guide
  - TDR Demonstration Board, part number 54754-66503
  - Programmer's Guide
  - Programmer's Quick Reference
  - User's Guide
- 

## Accessories Available

- 54701A 2.5 GHz Active Probe with Option 001
  - 54006A 6 GHz resistive divider probe kit
  - 54007A accessory kit
  - 54008A 22 ns delay line
  - 54118A 18 GHz trigger
-

## Performance Specifications

The specifications are the performance standards against which the product is tested. Specifications are valid after a 60 minute warm-up period.

<b>Channels (Vertical)<sup>1</sup></b>	<b>18/20 GHz Bandwidth Mode</b>	<b>12.4 GHz Bandwidth Mode</b>
<b>Bandwidth<sup>2</sup></b> (-3dB)	54753A/54754A dc to 18 GHz TDR channel 54753A non-TDR channel dc to 20 GHz	dc to 12.4 GHz
<b>Transition time</b> (10% to 90%, calculated from Tr = .35/BW)	≤19.4 ps 54753A non-TDR channel ≤ 17.5 ps	≤28.2 ps
<b>Maximum noise (RMS)</b>	≤1 mV	≤0.5 mV
<b>Scale Factor</b>	(full scale is 8 divisions)	(full scale is 8 divisions)
miminum	1 mv/div	1 mV/div
maximum	100 mv/div	100 mV/div
<b>dc accuracy</b> single voltage marker <sup>3</sup>	±0.4% of full scale or marker reading (whichever is greater) ±2 mv ±1.2% of (reading - channel offset) <sup>5</sup>	±0.4% of full scale or marker reading (whichever is greater) ±2 mv ±0.6% of (reading - channel offset) <sup>5</sup>
<b>dc difference<sup>3</sup></b> (voltage accuracy using two voltage markers on the same channel)	±0.8% of full scale or delta marker reading (whichever is greater) ±1.2% of delta marker reading <sup>5</sup>	±0.8% of full scale or delta marker reading (whichever is greater) ±0.6% of delta marker reading <sup>5</sup>
<b>Programmable dc offset<sup>4</sup></b>	Channel offset ±500 mv	Channel offset ±500 mv
<b>Inputs</b>		
Number	two	
TDR Step Generators	1 54753A 2 54754A	
Dynamic range	±400 mv relative to channel offset	
Maximum safe input voltage	±2 Vdc + peak ac (+16 dBm)	
Nominal impedance	50 ohm	
Percent reflection	≤5% for 30 ps risetime	
Connectors	3.5 mm (m)	

<sup>1</sup> When operated within ±5°C (±9°F) of the temperature of the last plug-in calibration. See the Operating Characteristics for additional information on vertical software calibration.

<sup>2</sup> The input sampler are biased differently for increased bandwidth in the 18/20 GHz bandwidth mode.

<sup>3</sup> When driven from a 0 ohm source.

<sup>4</sup> An effective offset of ±900 mV can be achieved using the ±500 mV of channel offset and adding ±400 mV of offset with the waveform math offset scaling function.

<sup>5</sup> When operated within ±2°C (±3.6°F) of the temperature of the last plug-in calibration. When operated within ±5°C (±9°F) of the temperature of the last plug-in calibration, the final term in the dc accuracy specification is 2.5 times higher.

General Information  
**Performance Specifications**

**TDR System**

	<b>Combined Oscilloscope and TDR Performance</b>	<b>Normalized Characteristics<sup>1</sup></b>
<b>Rise time<sup>2</sup></b>	< 45 ps <sup>3</sup>	<b>Adjustable:</b> allowable values based on time base setting. <b>Minimum:</b> 10 ps or 0.08 x Time/div, whichever is greater <b>Maximum:</b> 5 x Time/div
<b>Flatness<sup>2</sup></b>	< ± 1% after 1 ns from edge; < +5%, -5% to 1 ns from edge	< 0.1%
<b>Levels:</b>		
Low	0.00 V ± 2 mV	0.00 V ± 2 mV
High	+200 mV ± 2 mV	+200 mV ± 2 mV

<sup>1</sup>Normalized information is a characteristic, not a specification. The information is presented here for comparison purposes only. Normalization characteristics are achieved only with the use of the normalization calibrations and firmware routines.

<sup>2</sup>Measured in the Averaged Display mode with best flatness on.

<sup>3</sup>The rise time of the generator is less than 35 ps, as calculated by:

$$T_{rSystem} = \sqrt{(T_{rGenerator})^2 + (T_{rScope})^2}$$



---

## Performance Characteristics

The characteristics are not specifications, but are included as additional information.

### Channels (Vertical)

**Scale Factors** Adjustable from 1 mV/div to 100 mV/div in a 1-2-5-10 sequence from the front panel knob or the INC/DEC keys. Also adjustable over the range in 0.1 mV increments from the numeric keypad.

**Attenuation Factors** Factors may be entered to scale the oscilloscope for external attenuators connected to the channel inputs. The range is from .0001:1 to 1,000,000:1.

**Noise** Averaging reduces noise by  $1/\sqrt{n}$ , where n is the number of averages, until a system limitation of approximately 25  $\mu$ V (low BW mode) or 50  $\mu$ V (high BW mode) is reached.

**Channel-to-channel isolation** 60 dB

**Bandwidth** The user may select between a high (18/20 GHz) or low (12.4 GHz) bandwidth mode. The sampler is biased differently for the two modes. Typically the low bandwidth mode has 300  $\mu$ Vrms noise and the high bandwidth mode has 600  $\mu$ Vrms noise.

### Reflection Measurements

**Source** Measurements are made using the Channel step source or a user supplied external source.

**Calibration** A reference plane is defined by calibrating the reflection channel with a short placed at the point where the device under test (DUT) will be connected. The short calibration is followed with a 50 ohm calibration. These calibrations derive the normalization filter.

**Cursor** Reads out the percent reflection, impedance, time, and distance from the reference plane to the cursor.

**Percent Reflection** Automatic measurements provided to calculate the maximum positive and negative percent reflections of the waveform shown on screen.

**Normalization Filter** Applies a firmware digital filter to the measured data. The rise time of the filter may be varied to allow the user to simulate the edge speeds which would be seen by the device under actual operating conditions. See TDR output specifications for allowable rise time values.

**Variable Bandwidth Limit** Changing the risetime of the normalization filter requires that a short and 50 ohm load be placed at the launch point. When this is not possible or differential TDR is utilized then a variable bandwidth limit filter can be used. The variable bandwidth limit function is located in the waveform math menu.

**Percent Reflection Measurements** Used to quantify reactive peaks and valleys of the TDR display. Impedance measurements are valid only for resistive, horizontal flat line TDR displays. Because the accuracy depends on the measurement being made, percent reflection and impedance accuracies are not specified. Percent reflection and impedance measurements are ratios of voltage measurements whose accuracies are specified.

$$\text{Percent Reflection (Rho)} = \frac{(V_{\text{cursor}} - V_{\text{top}})}{(V_{\text{top}} - V_{\text{base}})}$$

$$\text{Impedance (Z)} = 50 \text{ ohm} \times \frac{(1 + \text{Rho})}{(1 - \text{Rho})}$$

- Vcursor = voltage at the cursor
- Vtop = high level of incident step
- Vbase = low level of incident step and is determined during the reflection calibration

Distance measurements are subject to the accuracy of the velocity constant or dielectric constant entered by the user. Since the 54753A/ 54754A has no control over the accuracy of these numbers, distance accuracy is not specified. Distance is derived from time interval measurements whose accuracies are specified.

$$\text{Distance (d)} = \frac{1}{2} \times \Delta t \times \text{Velocity Constant}$$

Where  $\Delta t$  = time from the reference plane to the cursor

$$\text{Dielectric constant} = \frac{(3 \times 10^8 \text{ m/s})^2}{(\text{Velocity Constant})^2}$$

Where the user enters either a relative Dielectric Constant or a Velocity constant.

The TDR's ability to resolve the distance between two discontinuities is limited to  $\frac{1}{2}$  the system rise time. Without normalization, this is approximately  $\frac{1}{2} \times 45$  ps or 7 mm in air. For the distance resolution in your media, divide 7 mm by the square root of the effective dielectric constant of your media. With normalization, the system rise time can be 10 ps yielding 1.5 mm of resolution in air.

The maximum length the TDR can measure is subject to media loss. For a lossless vacuum, and using a 50 Hz TDR repetition rate, the system can measure 1500 km. Actual maximum lengths will generally be limited by the losses of the media under test.

**Excess L/C** Once a calibration plane is established, the excess L/C feature will compute the series L or shunt C equivalent to the area between cursors. The result is the equivalent L or C that causes a discontinuity with equal area to that measured.

**Scaling** The vertical scaling allows scaling in either percent reflection or ohms. Cursors will also read in voltage or ohms. A reference plane calibration must be performed to utilize these scales.

**Differential TDR** The differential and common stimulus are generated by staggered rising edges from 2 independent TDR step generators. Hardware setup remains fixed and therefore the skew for both differential and common measurements. The response to either differential or common mode stimulus may be viewed simultaneously as differential or common mode.

All waveform math functions are automatic. Both the differential and common mode responses are computed without user intervention.

**Differential TDR Timing Deskew** For accurate differential TDR measurements it is essential that the TDR steps are coincident at the reference plane and the reflected steps are coincident at the samplers. Ideally this is accomplished by using electrically matched launch cables. When this is not possible the TDR channels must be deskewed.

To accomplish this, it is necessary to have both TDR step time skew and channel skew capabilities. Each of the TDR steps may be moved  $\pm 400$  ps. When used in conjunction with the channel skew control then 1.6 ns of timing delta can be removed. Depending upon the cable, this equates to approximately 1 foot of cable length difference that can be electrically removed.

### **Transmission Measurements**

**Source** Measurements are made using the channel step source or a user-supplied external source.

**Calibration** A calibration with a straight-through path or through a user's standard device determines reference amplitude levels and reference time and distances of the signal path. These reference levels are used for gain and propagation delay measurements.

**Cursor** Reads out time referenced to the calibration edge and gain referenced to the transmission calibration results. (See Calculations below.)

**Propagation Delay and Gain** Automatically calculates the difference in time and distance between the calibration signal path the test signal path. Also calculates the ratio of the test signal amplitude to the calibration signal amplitude. (See Calculations below.)

**Normalization Filter** Applies a firmware digital filter to the measured data. The rise time of the filter may be varied to allow the user to simulate the edge speeds which would be seen by the device under actual operation. See TDR output specifications for allowable rise time values.

#### **Calculations**

$\Delta t = \text{Time of the cursor (50\%)} - \text{Time of reference edge (50\%)}$

$$\text{Gain} = \frac{(\text{V}_{\text{top}} - \text{V}_{\text{base}})_{\text{signal}}}{(\text{V}_{\text{top}} - \text{V}_{\text{base}})_{\text{reference}}}$$

$\text{Prop Delay} = \text{Time of test edge (50\%)} - \text{Time of reference edge (50\%)}$

$\text{Distance (d)} = \text{Prop delay} \times \text{Velocity Constant}$

$\text{V}_{\text{top}} = \text{High level of waveform}$

$\text{V}_{\text{base}} = \text{Low level of waveform}$

## Environmental Conditions

These environmental conditions apply to the 54753A/54754A:

The instrument meets environmental specifications (section 750) for class B-1 products with exceptions noted for temperature and condensation. Contact your field engineer for complete details.

### Temperature

operating	+10° C to +40° C
non-operating	-40° C to +70° C

### Humidity

operating	Up to 90% relative humidity (non–conducting) at +35° C
non-operating	Up to 90% relative humidity (non–condensing) at +65° C

### Altitude

operating	Up to 4,600 meters (15,000 ft)
non-operating	Up to 15, 300 meters (50,000 ft)

### Vibration

operating	Random vibration 5 to 500 Hz, 10 minutes per axis, 0.3 g(rms)
non-operating	Random vibration 5 to 500 Hz, 10 minutes per axis, 2.41 g(rms); resonant search, 5 to 500 Hz swept sine, 1 Octave/minute sweep rate, 0.75 g, 5 minute resonant dwell at 4 resonances/axis

### Power Requirements

Supplied by mainframe

### Model Number

54753A/54754A

### Weight

approx. net weight	1.6 kg (3.5 lbs)
approx. ship weight	2.7 kg (6.0 lbs)

## Recommended Test Equipment

The table shows a list of the test equipment required to test performance, calibrate, and troubleshoot this plug-in. The table indicates the critical specification of the test equipment and for which procedure the equipment is necessary. Equipment other than the recommended model may be used if it satisfies the critical specification listed in the table.

### Recommended Test Equipment

Equipment Required	Critical Specifications	Recommended Model	Use *
Oscilloscope Mainframe	No substitution	54750A or 83480A with sw option 54755A	P, C, T
Signal Generator	20 GHz, -25 dBc harmonics, +6 dBm output, 0.25 ppm/yr stability, 10 MHz reference output	8360/8340 series	P, C, T
Synthesizer/ Function Generator	10 MHz square wave, 120 mV output, 0.05 ppm/yr stability	3325B	P, C, T
RF Amplifier	22 dB gain at 10 MHz, 1.3 GHz bandwidth	8447D/E/F	P, C
Digital Multimeter	6 1/2 digit, 0.1 mV resolution, 0.05% dc accuracy, 0.01% resistance	34401A	P, T
Power Meter	20 GHz	437B	P
Power Sensor	20 GHz	8485A	P
TDR system	TDR, 30 ps and 200 ps normalized rise times	54121T system	P
Power Splitter	3.5 mm connectors	11667B	P, T
Attenuator	6 dB, 3.5 mm connectors	8490C/opt 6 or 33340C/opt 6	P
Attenuator	20 dB, 3.5 mm connectors	8490C/opt 20 or 33340C/opt 20	P
50 $\Omega$ load	3.5 mm (m)	909D	C, P
50 $\Omega$ load	3.5 mm (f)	909D/011	P
Calculator	Log base 10 function	20S	P
Oscilloscope	100 MHz bandwidth	54601B	T
Delay line	22 ns, 20 GHz	54008A	P
Adapter	N (m) to 3.5 mm (f)	1250-1743	P
Adapter	3.5 mm (m-m)	1250-1864	P
Adapter (2)	3.5 mm (m-f)	1250-1866	P, C, T
Adapter	N (m) to SMA (f)	1250-1250	P, C, T
Adapter	BNC (f) to SMA (m)	1250-1200	P, C, T
Adapter	3.5 mm (f-f) precise one end	5061-5311	P, C, T
Adapter	BNC (f) to dual banana (m)	1251-2277	P
Coaxial Short	3.5 mm (f)	1250-2127	P
BNC Tee	1 (m) end, 2 (f) ends	1250-0781	P, T
Cable	Precision SMA (f-m), 26.5 GHz	54007-61604	P
Cable (3)	SMA (m-m), 36 inch	8120-4948	P, T
Cable	BNC, 12 inch	8120-1838	C
Cable (2)	BNC, 48 inch	10503A	P, T

General Information

**Recommended Test Equipment**

Insulated Adjustment Screwdriver	0.01 inch thick, 0.04 inch long	N/A	C, T
Alignment Tool	Nonmetallic	N/A	C, T
Torque Wrench	5 in/lb, 5/16 inch	8710-1582	T
Torque Wrench	8 in/lb, 5/16 inch	8710-1765	T

\* P = Performance Tests, C = Calibration, T = Troubleshooting

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# Preparing for Use

This chapter shows you how to prepare the plug-in for use. It references the routines necessary to establish calibration levels.

The following areas are covered in this chapter.

- Inspection
- Setup
- Cleaning

When ordered as a system, the mainframe is shipped ready to use, with the plug-ins installed and calibrated. However, if you ordered additional plug-ins and you want to change the instrument configuration or you want to do your own calibration, this section will help you get the instrument ready to use.



---

## To inspect the instrument

- Inspect the shipping container for damage.

Keep a damaged shipping container or cushioning material until the contents of the shipment have been checked for completeness and the instrument has been checked mechanically and electrically.

- Check the accessories.

- Inspect the instrument.

---

## To install a plug-in

There are a few things to consider when using plug-ins:

- Plug-ins may be removed and installed without turning off instrument power.

---

### CAUTION

Do not remove or install a plug-in while the instrument is running calibration or testing routines. It may cause a situation that could require service of the instrument.

- 1 Install the plug-in in slots 1 and 2 or slots 3 and 4 of the mainframe.

If you install a plug-in in slots 2 and 3, the mainframe will give you an error message stating that it is an illegal configuration.

- 2 To check the plug-in data, press the Channel key, press the **Calibrate...** softkey, then set the **Cal status** softkey to on.

Read the display to check the plug-in model and serial numbers and plug-in calibration status. If the plug-in needs calibration, see "To calibrate the plug-ins" in chapter 4 of this service guide.

- 3 If you are using a probe or other attenuation device with your plug-in, you can perform the probe calibration.

Press the **Channel** key, press Calibrate, press the **Calibrate Probe...** softkey. Follow the instructions on the screen and press the **Continue** softkey.

### See Also

"Calibration Overview" in chapter 4 of the Service Guide provided with the mainframe for an overview of the frame, plug-in and probe calibrations.

## To clean the instrument

To clean the instrument, use a soft cloth, damp with a mild soap and water solution.

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# Testing Performance

Procedures in this chapter test the electrical performance of the instrument using Performance Specifications given in chapter 1 as performance standards.

## Testing Interval

The performance test procedures may be performed for incoming inspection of the instrument and should be performed periodically thereafter to ensure and maintain peak performance. The recommended test interval is yearly or every 2,000 hours of operation. Amount of use, environmental conditions, and your experience concerning need for testing will contribute to test requirements.

### See Also

Chapter 4, "Calibrating and Adjusting," for information about the calibration interval.

## Equipment Required

A complete list of equipment required for the performance tests is in the Recommended Test Equipment table in chapter 1, "General Information." Equipment required for individual tests is listed in the test. Any equipment satisfying the critical specifications listed may be substituted for the recommended model. The procedures are based on the model or part number recommended.

## Test Record

You may record the results of the performance tests in the Performance Test Record provided at the end of this chapter. The Performance Test Record lists the performance tests and provides an area to mark test results. You can use the results recorded at incoming inspection for later comparisons during periodic maintenance, troubleshooting, and after repairs or adjustments.

## Operating Hints

Some knowledge of operating the instrument is helpful; however, these procedures are written so that little experience is necessary. If you would like more help operating the instrument and you can refer to the User's Guide or the Getting Started Guide that were supplied with the oscilloscope. The following hints about clearing the display and averaging will speed progress of the testing.

### Clear Display

When using many averages, it often takes awhile for a waveform display to stabilize after a change. When a control on the instrument is changed, averaging automatically restarts. When just the input signal is changed, the instrument must average new data with the old so it takes a long time for the waveform to stabilize. Press the Clear Display key while changing input signals. The instrument will restart averaging and give a quick indication of the result of the change.

**Averaging**

Averaging is used to assure a stable signal for measurements. It is not necessary to wait for complete stability of the signal (averaging complete) as long as the measurement is well within the limits of the test.

**Keystroke Conventions**

To guide you while setting up the instrument, the following conventions are used to represent keystrokes and other interactions with the instrument.

When you need to press a front-panel key (also called a hardkey), you will be instructed to press a specific key. For example, press the Time Base key.

Bold text, such as **Display** or **Calibrate...**, represents text on the CRT screen and may be a softkey you should press or a selection you should make. For example, press the **Scale** softkey, and use the knob to set the scale to **1 ns/div**.

The blue key that has no writing on it is a shift key. It allows you access to the functions written in blue above some of the front-panel keys. For example, press the blue shift key, then press the Limit test key. When the shift key is pressed the green LED next to the key lights. This indicates the next keypress executes the blue shift function.

**Specifications**

The specifications that apply to a particular test are given at the test. The specification as given at the test may be abbreviated for clarity. In case of any questions, refer to the complete specifications and characteristics in chapter 1.

**Performance Test Procedures**

Performance test procedures start with the next paragraph. Procedures may be done individually and in any order.

**CAUTION**

Allow the instrument to warm up for at least 60 minutes prior to beginning performance tests. Failure to warm up the instrument may cause it to fail tests.

**Special Procedures**

- All connectors should be clean and undamaged to ensure accurate measurements. All 3.5 mm (f-f) adapters on the module should be mechanically and visually checked before inserting any calibration test tool into them. Damaged connectors or loose connectors may cause the performance verification tests to fail.
- The system should be allowed to warm up for at least 60 minutes.
- To avoid damage to module input connectors, use of the 3.5 mm (f-f) connector savers is encouraged. These connector savers are supplied with the module.
- Avoid sharp bends in 3.5 mm and SMA cables.
- When mating 3.5 mm connectors to 3.5 mm connectors or devices, torque all connections to 8 in/lbs. When mating 3.5 mm to SMA or SMA TO SMA, torque all connections to 5 in/lbs.

- If possible, minimize connector swapping during the procedures to avoid connector wear. All connectors on test tools and adapters should be inspected both visually and mechanically every few calibrations.
- Throughout the procedures, identical connectors are used in different ways. One way is precision at both ends. This means that both ends of the 3.5 mm connectors should be precise and should never have been connected to an SMA connector. The other way is precise at one end. This means that one of the 3.5 mm ends may be used with SMA connectors, but the other end should never have been connected to any SMA connectors. Unless otherwise stated, all 3.5 mm connectors should never be connected to SMA connectors.
- Allow the mainframe and plug-ins to warm up for at least 60 minutes prior to beginning performance tests.

---

**CAUTION**

The module inputs are very sensitive to static discharge. Failure to observe proper antistatic procedures may damage the gallium arsenide samplers. ESD damage is not covered under the warranty. All maintenance or operation should be performed with an antistatic mat and wrist strap.

---

**CAUTION**

Electrostatic discharge can seriously damage the test set's inputs. To eliminate any electrostatic build up from a cable you're connecting to the module, connect a female short to either end of the cable. Touch the short to an input connector hex nut on the module to discharge any static build up to ground. Remove the short. Use this procedure for all cables before connecting them to the module.

---

# To test voltage measurement accuracy

This test checks the offset accuracy, offset gain accuracy, and sampler gain accuracy of the module and mainframe. If this test fails, do the Module calibration. If the RMS noise test fails, the sampler is probably damaged due to ESD or over-voltage. Refer to the Troubleshooting chapter of this manual.

## Specifications:

**Single voltage marker** 12.4 GHz Bandwidth mode  $\pm 0.4\%$  of fullscale or marker reading (whichever is greater)  $\pm 2$  mV  $\pm 0.6\%$  of (reading - channel offset).<sup>1</sup>

18/20 GHz Bandwidth mode  $\pm 0.4\%$  of fullscale or marker reading (whichever is greater)  $\pm 2$  mV  $\pm 1.2\%$  of (reading - channel offset).<sup>1</sup>

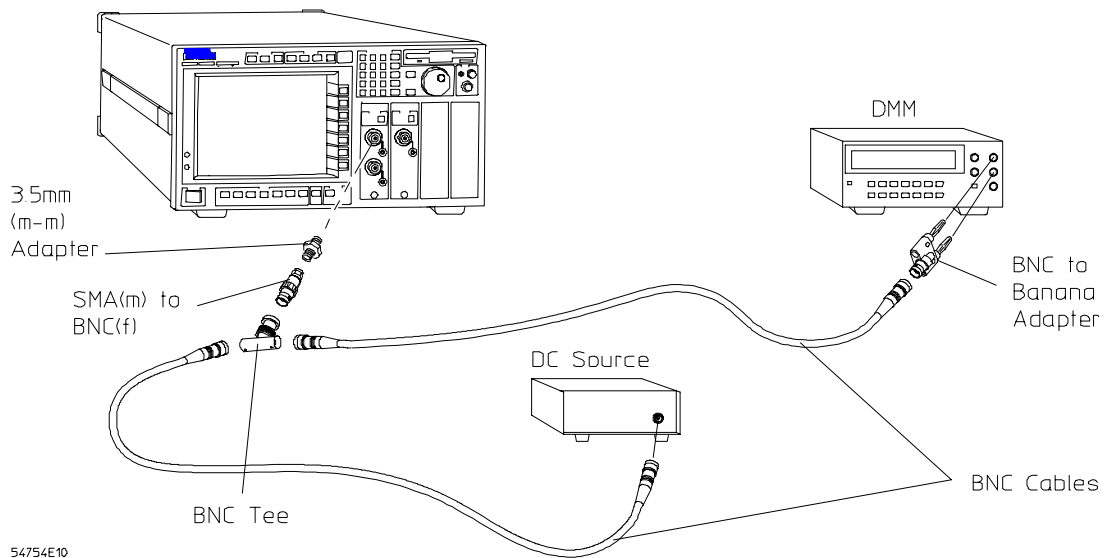
**Dual voltage marker** 12.4 GHz bandwidth mode  $\pm 0.8\%$  of fullscale or delta V reading (whichever is greater)  $\pm 0.6\%$  of delta marker reading.<sup>1</sup>

18/20 GHz bandwidth mode  $\pm 0.8\%$  of fullscale or delta V reading (whichever is greater)  $\pm 1.2\%$  of delta marker reading.<sup>1</sup>

<sup>1</sup>When operated within  $\pm 2^\circ\text{C}$  ( $\pm 3.6^\circ\text{F}$ ) of the temperature of the last plug-in calibration, the final term in the dc accuracy specification is as given. When operated within  $\pm 5^\circ\text{C}$  ( $\pm 9^\circ\text{F}$ ) of the temperature of the last plug-in calibration, the final term in the dc accuracy specification is 2.5 times higher.

## RMS noise (1 sigma RMS)

18/20 GHz bandwidth mode  $\leq 1$  mV, 12.4 GHz bandwidth mode  $\leq 0.5$  mV.



---

**Equipment required**

---

Equipment	Critical Specifications	Recommended Model/Part
Power Supply	$\pm 0.5$ V, 100 $\mu$ V resolution	3325B
Digital Multimeter	6 1/2 digit, 0.1mV resolution, dc accuracy 0.05%	34401A
Adapter	BNC tee	1250-0781
Adapters	BNC(f) to SMA(m)	1250-1200
Adapter	BNC to banana	1250-2277
Adapter	3.5 mm (f-f)	5061-5311 (supplied)

---

**CAUTION**

---

Exceeding  $\pm 2$  V on the power supply may damage the inputs of the Module!

**DC measurement accuracy procedure**

- 1 Press the mainframe Setup key, then press the **Default setup** softkey.
- 2 Press the Trigger key, set the **Sweep** softkey to **freerun**.
- 3 Press the Acquisition key, set the **Averaging** softkey to **on**, then set the **# of averages** softkey to **16**.
- 4 Press the Channel 2/4 Setup key, then set the **Display** softkey to **off**.
- 5 Press the Channel 1/3 Setup key, then set the **Scale** softkey to **5 mV/div**. Press the **Bandwidth** softkey to change to **12.4 GHz**.
- 6 Press the blue Shift key, press the More meas key, press the **General meas** softkey, select **vavg** from the drop-down menu, then press the **Enter** softkey. Set the source to the channel you are checking. Set the **Meas window** softkey to **display**, then press the **Enter** softkey.  
The Vavg(1) readout at the bottom of the screen should read  $0\text{ V} \pm 2.16\text{ mV}$ .
- 7 Press the Channel key, then set the **Bandwidth** softkey to **18 (20) GHz**.  
Vavg(1) should read  $0\text{ V} \pm 2.16\text{ mV}$ .
- 8 Change the **Bandwidth** softkey to **12.4 GHz** and the **Offset** softkey to **500 mV**.
- 9 Connect the BNC tee to the channel input and adjust the dc source until the DMM reads  $500\text{ mV} \pm 100\text{ }\mu\text{V}$ .  
Vavg(1) should read  $500\text{ mV} \pm 4\text{ mV}$ .
- 10 Change the **Offset** softkey to **-500 mV**.
- 11 Adjust the dc source until the DMM reads  $-500\text{ mV} \pm 100\text{ }\mu\text{V}$ .  
Vavg (1) should be  $-500\text{ mV} \pm 4\text{ mV}$ .
- 12 Adjust the dc source until DMM reads  $250\text{ mV} \pm 100\text{ }\mu\text{V}$ .



- 13 Change the **Scale** softkey to **100 mV/div** and the **Offset** softkey to **0 V**.
- 14 Press Math key, set the **Function** softkey to **f1**, press the **Define function** softkey, press the **Operator** softkey, select **Magnify** drop-down menu, then press the **Enter** softkey. Verify that the **Operand 1** softkey shows the channel you are testing, then press the **Done** softkey. Set the **Display** softkey to **on**, press the **Function scaling** softkey, set the **Vertical** softkey to **manual**, change the **Scale** softkey to **5 mV/div** and the **Offset** softkey to **250 mV**.
- 15 Press the Channel Setup key, then set the **Display** softkey to **off**.
- 16 Press the blue Shift key, press the More meas key, press the **General meas** softkey, select **vavg** from the drop-down menu, press the **Enter** softkey, set the **Source** softkey to **function 1**, then press the **Enter** softkey.  
Vavg(f1) should read  $250\text{ mV} \pm 6.7\text{ mV}$  ( $0.4\% \times 800\text{ mV} + 2\text{mV} + 0.6\% \times 250\text{ mV}$ ). Record the results in the Performance Test Record.
- 17 Press the Channel Setup key, then set the **Bandwidth** softkey to **18 (20) GHz**.  
Vavg(f1) should read  $250\text{ mV} \pm 8.2\text{ mV}$  ( $0.4\% \times 800\text{ mV} + 2\text{mV} + 1.2\% \times 250\text{ mV}$ ). Record the results in the Performance Test Record.
- 18 Press the Channel Setup key, then set the **Bandwidth** softkey back to **12.4 GHz**.
- 19 Adjust the dc source until the DMM reads  $-250\text{ mV} \pm 100\text{ }\mu\text{V}$ .
- 20 Press the Math key, press the **Function scaling** softkey, then set the **Offset** softkey to **-250 mV**.  
Vavg(f1) should read  $-250\text{ mV} \pm 6.7\text{ mV}$ . Record the results in the Performance Test Record.
- 21 Perform the following calculation: Vavg(f1)[from step 16] - Vavg(f1)[from step 20] should be  $500\text{ mV} \pm 9.4\text{ mV}$  ( $.8\% \times 800\text{ mV} + 0.6\% \times 500\text{ mV}$ ). Record the results in the Performance Test Record.
- 22 Press the Channel Setup key, then set the **Bandwidth** softkey to **18 (20) GHz**.  
Vavg(f1) should read  $-250\text{ mV} \pm 8.2\text{ mV}$ . Record the results in the Performance Test Record.
- 23 Perform the following calculation: Vavg(f1)[from step 17] - Vavg(f1)[from step 22] should be  $500\text{ mV} \pm 12.4\text{ mV}$  ( $.8\% \times 800\text{ mV} + 1.2\% \times 500\text{ mV}$ ). Record the results in the Performance Test Record.
- 24 Repeat steps 4 through 23 with channel 1/3 off and channel 2/4 on.

#### **RMS Noise Test**

- 25 Press the Setup key, press the **Default setup** softkey.
- 26 Press the Trigger key, then set the **Sweep** softkey to **freerun**.
- 27 Set both channels for 1 mV/div and 12.4 GHz bandwidth.

**To test voltage measurement accuracy**

- 28 Press the blue shift key, then press  $V_{rms}$ . Select source=ch1, Meas window=display, and RMS method=AC. Press Enter. This displays an RMS measurement of the noise on channel 1. The results should be  $\leq 0.5 \text{ mV}_{rms}$ . Record the results in the Performance Test Record.
- 29 Repeat step 28 for channel 2. The results should be  $\leq 0.5 \text{ mV}_{rms}$ . Record the results in the Performance Test Record.
- 30 Change both channels to 18 (20) GHz.
- 31 Repeat step 28 and 29. The results should be  $\leq 1.0 \text{ mV}_{rms}$ . Record the results in the Performance Test Record.

---

## To test bandwidth

This test checks the system bandwidth with the 54753A or 54754A TDR modules. The procedure calculates the bandwidth of the 54753A/54754A. A synthesized sweeper's sine wave output is leveled with a power meter. The sine wave's rms voltage is measured and converted to a power measurement to determine bandwidth. This is done for the two frequencies on both electrical inputs.

The 54753A channel 2/4 specification at 20 GHz is  $-3$  dB, however the sweeper's output may not be synchronized with its 10 MHz reference output at 20.000 GHz. Therefore, this test checks the output at 19.98 GHz where the specification is  $-2.99$  dB.

If this performance test fails, reinitialize the 54753A/54754A and perform the 54753A/54754A software calibration procedure, followed by the 54753A/54754A Feed-through compensation adjustments.

### Specifications

18/20 GHz bandwidth mode:  $-3$  dB at 18/20 GHz

12.4 GHz bandwidth mode:  $-3$  dB at 12.4 GHz. (The 54753A's channel 2/4 is specified at 20 GHz and 12.4 GHz.)

---

### Equipment required

Equipment	Critical Specifications	Recommended Model/Part
Synthesized sweeper	18/20 GHz, +6 dBm, 25 dBc subharmonics	83620A or 8341A/B Opt 003
R F Amplifier	Gain 22 dB at 10 MHz, flatness $\pm 1.5$ dB, harmonic distortion $-30$ dB for 0 dBm output, BW 100 kHz to 1.3 GHz	8447D/E/F
Power Meter	20 GHz	437B
Power sensor	20 GHz, 3.5 mm connector	8485A
Calculator	Log base 10 function	20S
20 dB attenuator	3.5 mm connections	8493C/020 or 33340C/020
Adapter (2)	BNC (f) to SMA(m)	1250-1200
Adapter	N (m) to 3.5 mm(m)	1250-1743
Adapter	3.5 mm (f-f), 26.5 GHz	5061-5311
Adapter	3.5 mm (m-f), precise male end	1250-1866
Adapters	3.5 mm (m-f), precise both ends	1250-1866
Cable	Precise SMA, 26.5 GHz	54007-61604
BNC Cable (2)	8 inches	10503A

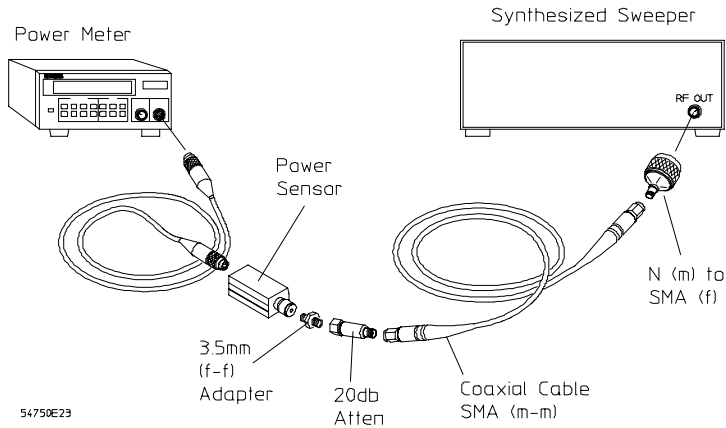
### Characterizing the sweep generator's output

The sweep generator's output will change slightly from one day to the next. That makes this part of the calibration procedure difficult to repeat. Improperly torqued connectors or using a different 20 dB pad is the most likely source of errors for regaining previously obtained values.

Testing Performance  
**To test bandwidth**

Type of Equipment	Model number	Serial number
Synthesized sweeper	_____	_____
Power meter	_____	_____
Power sensor	_____	_____

- 1 Calibrate and zero the power meter before connecting the sensor to the device under test. Use an N type (m) to 3.5 mm (f) adapter.
- 2 Connect the equipment as shown below.



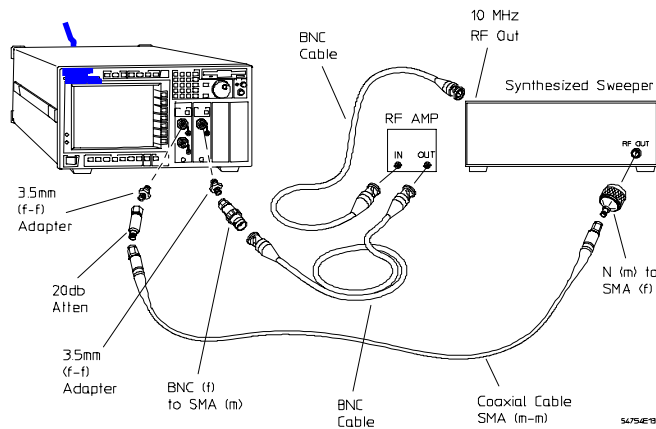
- 3 Set the sweep generator's frequency to 50 MHz.
- 4 Set the output power to +6 dBm.
- 5 Set power meter's cal factor to 100%. **DO NOT** change its setting during the following steps.

Record the reading of the power meter in  $\mu\text{W}$  in step 19 part 1.

- 6 Change the sweeper's frequency to 12.4 GHz and 18.0 GHz and record the power meter  $\mu\text{W}$  readings in step 20 part 1. If testing a 54753A, take the 19.98/20 GHz readings also

Record power sensor cal factors (CF) in step 20 part 2 (assume 100% for 50 MHz).

- 7 Connect the equipment as shown below.



- 8 Press the mainframe Setup key, then press the **Default setup** softkey.
- 9 Press the Acquisition key, set the **Averaging** softkey to **on**, set the **# of averages** softkey to **64**. Press the channel 2/4 Setup key, change the **Scale** softkey to

20 mV/div, and the **Bandwidth** softkey 12.4 GHz, then set the **Display** softkey off. Press the channel 1/3 key, change the **Scale** softkey to 20 mV/div and the **Bandwidth** softkey to 12.4 GHz. Press the Time base key, then set the **Scale** softkey to 5 ns/div.

- 10 Set the sweeper frequency to 50 MHz.
- 11 Press Clear Display key and wait for 64 averages to accumulate at the top left corner of the screen.
- 12 Press Shift (Blue) key, Vrms key, change the **Meas Window** softkey to **display**, set the **RMS method** softkey to **AC**, then press the **Enter** softkey.  
Note the VRMS reading on the bottom of the screen and record the value in step 20 part 3.
- 13 Change the sweep speed to 15 ps/div.
- 14 Change the sweeper frequency to 12.4 GHz and repeat steps 11 and 12.
- 15 Press the channel 1/3 Setup key, then set the **Bandwidth** softkey to 18 GHz.
- 16 Change the sweeper frequency to 18.00 GHz and repeat steps 11 and 12. (Use 19.98 GHz on the 54753A's second channel.)
- 17 Press the channel 1/3 Setup key, and turn display OFF.
- 18 Press the channel 2/4 Setup key and turn **Display on**. Then set the **Bandwidth** softkey to 12.4 GHz. Press the Time base key, then set the **Scale** softkey to 5 ns/div.
- 19 Repeat steps 10 through 16 for channel 2/4.
- 20 Calculate the bandwidth gains of the analyzer at 12.4 GHz and 18/20 GHz with the values and formula listed below.

Part 1		Part 2		Part 3		
Frequency	Sweeper output in $\mu\text{W}$	Frequency	Power sensor cal. factor	Frequency	Channel A	Channel B
50 MHz	_____ $\mu\text{W}$	50 MHz	_____	50 MHz	_____	_____
12.4 GHz	_____ $\mu\text{W}$	12.4 GHz	_____	12.4 GHz	_____	_____
18.0 GHz	_____ $\mu\text{W}$	18.0 GHz	_____	18.0 GHz	_____	_____
19.98 GHz	_____ $\mu\text{W}^*$	19.98 GHz	_____ *	19.98 GHz	_____	_____

\* 19.98 (20 GHz) information is only used with the 54753A's channel 2/4(B).

**Example**

Power meter reading at low frequency of 50 MHz = 38.8  $\mu\text{W}$   
 Power meter reading at high frequency of 20 GHz = 27.6  $\mu\text{W}$   
 VRMS of analyzer at low frequency of 50 MHz = 43.79  $\mu\text{V}$   
 VRMS of analyzer at high frequency of 19.98 GHz = 28.55  $\mu\text{V}$   
 CF of power meter at low frequency of 50 MHz = 100%  
 CF of power meter at high frequency of 19.98 GHz = 91.7%

$$\text{Gain} = 10 \log_{10} \left[ \frac{\text{Power Meter reading 50 MHz}}{\text{Power Meter reading high freq}} \right] \left[ \frac{\text{CF high freq}}{\text{CF 50 MHz}} \right] \left[ \frac{V_{\text{RMS high freq}}}{V_{\text{RMS 50 MHz}}} \right]^2$$

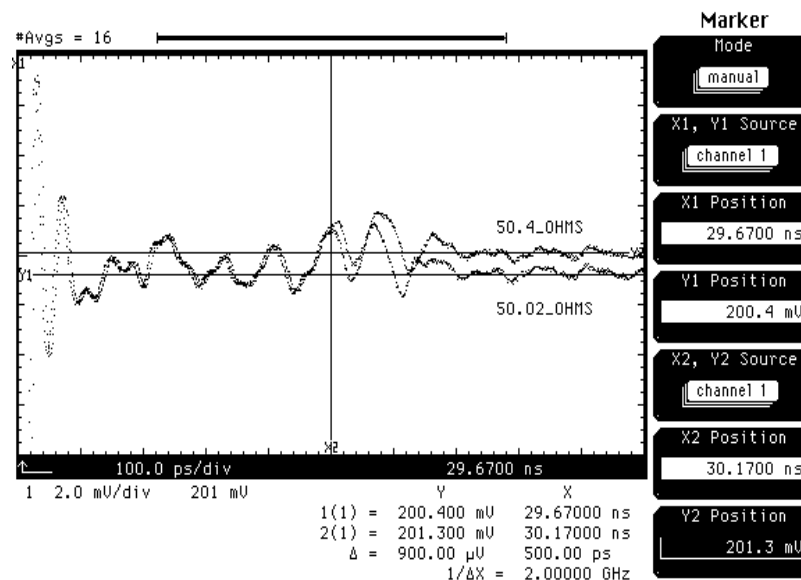
54120BDO

$$-2.6\text{dB} = 10 \log_{10} \left[ \frac{38.8 \mu\text{W}}{27.6 \mu\text{W}} \right] \left[ \frac{91.7\%}{100\%} \right] \left[ \frac{28.55 \mu\text{V}}{43.79 \mu\text{V}} \right]^2$$

## To test TDR system

This test verifies correct operation of the TDR system by checking the specifications of both the TDR system and the oscilloscope. The final value's of the TDR step generator's amplitude is controlled by the dc value of the 50 ohm termination. Since all of the flatness specifications depend on the final value measured in this test, the effects of using a non-perfect 50 ohm termination are accounted for during the procedure.

The dc resistance of a non-perfect 50 ohm termination will effect the on-screen final value. Figure below shows the first 1 ns after the incident step using two different 50 ohm terminations. Notice the two traces are incident for approximately the first 500 ps until the 50 ohm termination is encountered. The two traces finally settle with a constant level between them. The amount of the level shift is dependent on the dc resistance variation between the 50 ohm terminations used.



**Incident step with two different 50 ohm terminations, top trace dc resistance = 50.40 ohms , bottom trace dc resistance = 50.02 ohms.**

The final value recorded in the procedure is the value that a perfect 50 ohm termination would present. This number is calculated based on the actual dc resistance of the 50 ohm termination used.

There are two sets of flatness specifications, both are referenced to 1 ns after the incident step. One specification is before the 1 ns reference point. The other specification is after the 1 ns reference point.

For the tests (>1 ns after edge) a delta V measurement is made between the actual on-screen final value and the reflections from the 50 ohm termination. This delta V measurement will be independent of the dc resistance of the 50 ohm termination. This value is divided by the final value calculated for a 50 ohm termination's final value and multiplied by 100%.

For the +5%, -5% tests (<1 ns after edge) a different approach must be used. If the -5% reflection appears before the 50 ohm termination in time, then a delta V measurement using the on-screen final value of that reflection will be dependent on the dc resistance of the 50 ohm termination. This is not true if the reflection appears after the 50 ohm termination in time.

**Reflection appears before the termination.** The recorded final value is subtracted from the reflection's voltage value, then divided by the recorded final value and finally multiplied by 100%.

**Reflection appears after the termination.** The on-screen final value is subtracted from the reflection's voltage value, then divided by the recorded final value and multiplied by 100%.

The overshoot (+5% at <1 ns after edge) calculation is identical to the -5% test (reflection before the 50 ohm termination) since the overshoot appears before the termination in time. If the performance test fails, perform the TDR module's plug-in calibration.

#### SPECIFICATIONS:

- Combined oscilloscope and TDR risetime performance  $\leq 45 \text{ ps}^1$  (measured in 12.4 GHz bandwidth mode),
- Combined oscilloscope and TDR flatness performance (measured in 12.4 GHz bandwidth mode) +/- 1% after 1 ns from edge; + 5%, -5% to 1 ns from edge
- Combined oscilloscope and TDR levels performance;  
Low - 0 V +/- 2 mV; High - 200 mV +/- 2 mV

<sup>1</sup>The risetime of the generator is less than 35 ps as calculated by:  
 $(\text{Tr system})^2 = (\text{Tr generator})^2 + (\text{Tr oscilloscope})^2$

---

#### Equipment Required

Equipment	Critical Specifications	Recommended Model/Part
Termination	50 ohm, 3.5mm (m) connector	909D
DMM	6 1/2 digit, 0.01% resistance	34401A
Adapter	BNC (m-m)	1250-0216
Adapter	BNC (f) to banana (m)	1250-2277
Adapter	BNC (f) to SMA (m)	1250-1200
Coaxial short	3.5 mm (m)	1250-2128

**To test TDR system**

- 1 Assemble a fixture to measure the dc resistance of the 50 ohm termination to be used in this test by doing the following:
  - a Connect a banana to BNC (f) adapter to a BNC (m-m) adapter. Connect this to a BNC (f) to SMA (m) adapter. Connect this to an 3.5 mm (f-f) adapter. Connect the 3.5 mm (m) 50 ohm termination to the fixture. Record the resistance of the 50 ohm termination here \_\_\_\_\_ ohm. Example \_\_\_ 50.33 ohms
  - b Remove the 50 ohm termination and connect the 3.5 mm (m) short to the fixture. Record the dc resistance of the fixture here \_\_\_\_\_ ohm. Example \_\_\_ 0.11 ohm
  - c Subtract the fixture resistance (step b) for the termination resistance (step a).  
Step a \_\_\_\_\_ ohm - Step b \_\_\_\_\_ ohm = ZL \_\_\_\_\_ ohm Example 50.22 ohm
  - d Solve for Er using this formula (Er can be a negative number).  
 $Er = 200((ZL - 50)/(ZL + 50))$  (round to nearest 0.01 mV) Example 0.43 mV
  - e Install the 50 ohm termination on channel 1.

- 2 Press the mainframe Storage Setup key, then press the **Default setup** softkey.

- 3 Set 54750A or 83480A (with option 54755A) to the following settings:

Timebase <b>Scale</b>	<b>50 ps/div</b>
Trigger	<b>Freerun</b>
Acquisition	<b>Averaging on, Number of averages = 16 Best Flatness</b>
Channels	<b>Channel 1 Display on, other channels Display off, 5 mV/div, Offset 0, Bandwidth 12.4 GHz</b>

- 4 Measure the signal baseline before the TDR step occurs by the following method:

- Press the blue Shift key, More Meas key,
- Press **General Meas** softkey and toggle to highlight **V avg.**, press the **Enter** softkey.
- Set **Source** to **channel 1**, toggle the **Meas window** softkey to highlight **display**, and press the **Enter** softkey. **V avg(1)** should read **0 V +/- 2 mV**.
- Record **V avg(1)** here: Baseline = \_\_\_\_\_ mV. Example -146 uV

- 5 Press the Setup TDR key on the TDR module, press **Stimulus** softkey on the mainframe. Toggle the **Stimulus** softkey to highlight the TDR channel you are checking, for example, **1 only**, and press the **Enter** softkey. Press the **Preset TDR / TDT** softkey.

- 6 Press the Time base key and change the **Scale** to **1 ns/div**.

- 7 Press the blue shift key, then the Clr meas key to clear the cursor lines on screen.

- 8 Press the Marker key, press **Mode** softkey, toggle to **manual**, and press the **Enter** softkey.

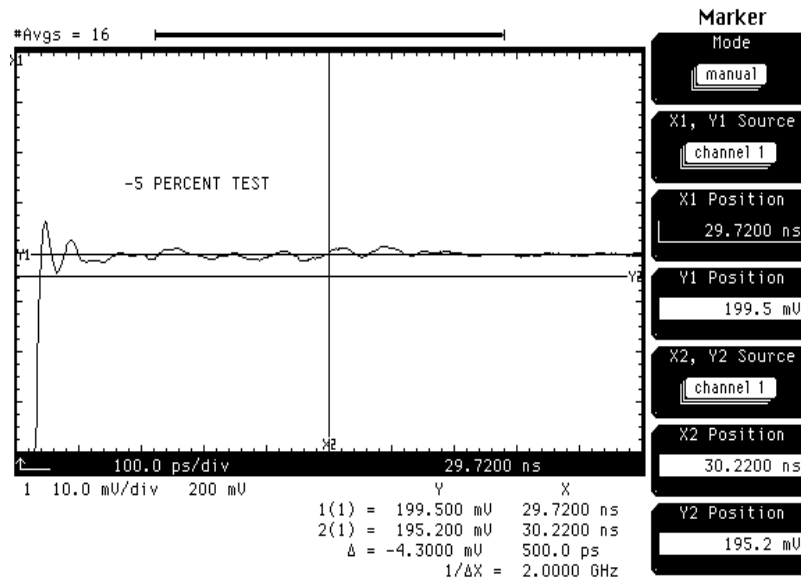
- 9 Move the **X1 Position** marker to the 50% point of the rising edge of the step.



- 10 Press the **X2 position** softkey and change the **X2 position** to the **X1 position's** value plus 1 ns.
- 11 Change the Timebase **Scale** to **100 ns/div**, **Position** to the value of the X2 marker, the channel **Scale** to **2 mV/div**, and the channel **offset** to **200mV**.
- 12 Press the Marker key and overlay the **Y1 Position** marker on the trace on the right edge of the screen.  
Record Y1, on-screen final value, here \_\_\_\_\_mV.                      Example 199.5 mV
- 13 Subtract the value of ER (from step 1-d) from Y1.  
High Level = Y1 \_\_\_\_\_ - Er \_\_\_\_\_ = \_\_\_\_\_ mV.                      Example 199.07 mV
- 14 Allow 16 averages to accumulate.  
Adjust **Y2 Position** marker to the highest point of the signal on screen.  
Divide the delta V reading by the final value obtained in step 13 and multiply by 100%.  
(delta V reading \_\_\_\_ / step 13 \_\_\_\_)\*100% = \_\_\_\_\_  
Example (600.0 uV / 199.07 mV)\*100% = 0.301%.  
The absolute value of this number should be less than 1% ( $\pm 1\%$  at  $>1$  ns after edge).
- 15 Adjust **Y2 Position** marker to the lowest point of the signal on the screen.
- 16 Press the Timebase key and select the **Scale** time/div softkey. Press the front-panel increment key to select the next faster sweep speed. If there is a point on screen lower than the previous position of marker Y2, readjust **Y2 Position** marker to that lowest point. Repeat this step until the time/div **Scale** of **1 ns/div** is reached.
- 17 Divide the absolute value of delta V by the final value obtained in step 13 and multiply to 100%.  
(delta V reading \_\_\_\_\_ / step 13 \_\_\_\_\_)\*100% = \_\_\_\_\_  
Example ( -1.40 mV / 199.07 mV)\*100% = - 0.703%.  
The absolute value of this number should be  $\leq 1\%$  ( $\pm 1\%$  at  $>1\%$  after edge).
- 18 Change the Timebase **Scale** to **200 ps/div**, and **Position** equal to the value of the **X1 Position** marker. Change the channel **Scale** to **100 mV/div**.
- 19 Position the step edge on screen by changing the timebase **Position** and verify that the X1 marker is at the mid-point of the step's rising edge. Move the **X1 Position** marker to the mid-point on the step's rising edge, if necessary.
- 20 Change the timebase **Position** to the value of marker X1. Adjust the **X2 Position** marker to the value of marker X1 plus 500 ps. Change the time base time/div **Scale** to **100 ps/div** and the Channel **Scale** to **5 mV/div**.
- 21 Press the Marker key and adjust **Y2 Position** marker to the lowest point of the signal on screen. DO NOT include the rising edge of the signal. If this point is to the left of the X2 **Position** marker, then subtract the final value obtained in step 13 from the value of marker Y2 and record that value in step 22.  
Refer to the following figure.  
Y2 marker value = \_\_\_\_\_ mV                      Example 195.20mV

If the lowest point on the screen is out of specification and is to the right of the X2 marker, change the 50 ohm termination. Out-of-tolerance connectors can cause out-of-specification perturbations from slightly left of the X2 marker and to the right of the X2 marker and continuing off screen. See Incident step with two different 50 ohm terminations, on page 3-12.

22 Example:  $195.20 \text{ mV} - 199.07 \text{ mV} = -3.87 \text{ mV}$  - 5% test \_\_\_\_\_ mV.



**-5% Test, The Reflection Appears Before the Termination.**

23 Divide the value obtained in step 22 by the final value obtained in step 13 and multiply by 100%.

(Step 22 \_\_\_\_\_ / Step 13 \_\_\_\_\_) \* 100% = \_\_\_\_\_.

Example  $(-3.87 \text{ mV} / 199.07 \text{ mV}) * 100\% = -1.94\%$

The absolute value of this number should be less than 5% (-5% at <1 ns after edge).

24 Adjust **Y2 Position** marker to the highest point of the signal on screen.

Record Y2 Position marker value here \_\_\_\_\_.

Example 205.40 mV

Subtract the final value obtained in step 13 from Y2 and record that value in step 25.

Example  $(205.40 \text{ mV} - 199.07 \text{ mV}) = 6.33 \text{ mV}$

25 +5% test \_\_\_\_\_ mV

Example 6.33 mV

26 Divide the value obtained in step 25 by the final value obtained in step 13 and multiply by 100%.

(step 25 \_\_\_\_\_ / step 13 \_\_\_\_\_) \* 100% = \_\_\_\_\_

Example  $(6.33 \text{ mV} / 199.07 \text{ mV}) * 100\% = 3.18\%$

The absolute value of this number should be less than 5% (+5% at <1 ns after edge).

27 Change the time base **Scale** to 50 ps/div. Toggle the time base **Reference** softkey until **Center** is highlighted.

- 28 Change the time base **Position** value to the value of **X1 Position** marker. Change the channel **Scale** to **30 mV/div** and the **Offset** to **100 mV**.
- 29 Press the blue shift key, press the Rise key, toggle the **channel (x)** softkey to highlight the proper channel and press the **Enter** softkey.
- 30 The measured rise time, **Risetime (x)**, should be  $\leq 45$  ps.  
Rise time = \_\_\_\_\_ ps
- 31 If this is a 54754A TDR plug-in, repeat steps 2 through 30 on the second TDR channel.

---

## To test the input reflection

This test uses an 54120 series TDR to measure the amount of reflection each channel reflects back to the test line when pulsed with a fast edge signal. A separate 54750A/54754A system can be substituted for the 54120 TDR system, but 54750 menu key presses must be used. The 54753A/54754A cannot be used to test its own trigger input, therefore, another TDR system is needed.

### Specifications

Percent reflection: For channels 1 - 2,  $\pm 5\%$  for 30 ps risetime. For external trigger,  $\leq 10\%$  for 200 ps risetime.

---

### Equipment required

Equipment	Critical Specifications	Recommended Model/Part
TDR system	30 ps risetime	54120A/B and 54121A
Termination	50 $\Omega$ , 3.5 mm (f)	909D/011
Adapter	3.5 mm(m-m), 26.5 GHz	1250-1864
Adapter	3.5 mm(f-f), 26.5 GHz	1250-1865
Coaxial short	3.5 mm(f)	1250-2127
Coaxial short	3.5 mm(m)	1250-2128
Cable	Precise SMA (f-m), 26.5 GHz	54007-61604

- 1 Perform a one-keydown power up on the 54120 system.  
Hold any key and cycle the power off and on. Continue to hold the key down until graticules are displayed on screen.
- 2 Change the oscilloscope settings for the 54753A/54754A so that channels 1 and 2 are OFF.
- 3 Set up the 54120 TDR equipment with the following settings:
  - a In the Display, set Mode to **Averaged**, **Number of Averages** to 16, and **Screen** to **Single**.
  - b In the time base, set **Time/Div** to 350 ps/div, **Delay** to 20.4 ns, and **Freerun rate** to 10 kHz.
  - c In Channels, set **Channel** to 1, **Display** to ON, **Volts/Div** to 80 mV/div, **Offset** to 200 mV, **Probe Atten** to 1, and set **channels 2 - 4 OFF**.
  - d In Network, set **Reflect/Trans/CAL** to **Reflect** and set **Step & Chan 1** to ON.
- 4 Connect the SMA cable to the 54121A channel 1 (TDR output). In the Time Base menu, adjust the **delay** so that the signal's second rising edge (representing an open circuit condition) is 4 divisions left of center. Change **channel 1** to 5 mV/div. Press the Network menu, and press the **Reflect/Trans/CAL** key until **Cal** is highlighted.

- 5 Press the **Reflect Cal** key. Connect a coaxial short with a 3.5 mm (f) connector to the cable. Press the **Reflect Cal** key again.
- 6 Remove the coaxial short from the cable and connect a 50  $\Omega$  termination 3.5 mm (f) to the cable. Press the **Reflect Cal** key again.
- 7 Remove the 50  $\Omega$  termination from the cable and connect the cable to the 54753A/54754A, 1/3 channel input. Press Clear Display key and wait for **16 averages** to accumulate.
- 8 Press the Network menu key. Press **Reflect/Trans/CAL** until **Reflect** is highlighted.
- 9 Set **normalized risetime** to **30 ps**. Press the **Normalize to mem 1** softkey.
- 10 When Normalizing is complete, press the Stop key, and press the Clear Display key.
- 11 Press the **Cursor** softkey until **mem 1** is highlighted.
- 12 Press the **Min & Max Reflect** key. The absolute value of **Rho minimum** and **Rho maximum** should be <5%. Record the results in the Performance Test Record.
- 13 Press the Run key.
- 14 Disconnect the cable from the channel 1/3 and connect it to the channel 2/4.
- 15 Press the Clear Display key.
- 16 Repeat steps 9 through 15 for the channel 2/4.
- 17 Repeat steps 3 through 13 for external input trigger, except change channel to **20 mV/div**, **Time/div** to **1 ns/div**, **normalize risetime** from **30 ps** to **200 ps**, and change the Rho limits from 5% to 10%. Record the results in the Performance Test Record.

## Performance Test Record

### Performance Test Record

	<b>54753A/54754A TDR Module</b>
Serial No. _____	Tested by _____
Recommended Test Interval - 1 Year/2000 hours	Work Order No. _____
Recommended next testing _____	Date _____
Mainframe Model No. _____	Temperature _____
Mainframe Serial No. _____	Plug-in delta Temperature _____

Test	Limits	Results			
		Minimum	Actual	Maximum	
Voltage Measurement Accuracy	Channel 1/3	12.4 GHz bandwidth 0 V offset	-2.16 mV	_____	2.16 mV
		18 GHz bandwidth 0 V offset	-2.16 mV	_____	2.16 mV
		+ offset gain 500 mV offset	496 mV	_____	504 mV
		- offset gain -500 mV offset	-504 mV	_____	-496 mV
		12.4 GHz + sampler gain 250 mV offset	243.3 mV	_____	256.7 mV
		18 GHz + sampler gain 250 mV offset	241.8 mV	_____	258.2 mV
		12.4 GHz - sampler gain -250 mV offset	-256.7 mV	_____	-243.3 mV
		12.4 GHz dual voltage marker	490.6 mV	_____	509.4 mV
		18 GHz - sampler gain -250 mV offset	-258.2 mV	_____	-241.8 mV
		18 GHz dual voltage marker	487.6 mV	_____	512.4 mV
	12.4 GHz Noise	_____	_____	0.5 mV rms	
	18 GHz Noise	_____	_____	1.0 mV rms	
	Channel 2/4	12.4 GHz bandwidth 0 V offset	-2.16 mV	_____	2.16 mV
		18 GHz bandwidth 0 V offset	-2.16 mV	_____	2.16 mV
		+ offset gain 500 mV offset	496 mV	_____	504 mV
		- offset gain -500 mV offset	-504 mV	_____	-496 mV
		12.4 GHz + sampler gain 250 mV offset	243.3 mV	_____	256.7 mV
		18 GHz + sampler gain 250 mV offset	241.8 mV	_____	258.2 mV
		12.4 GHz - sampler gain -250 mV offset	-256.7 mV	_____	-243.3 mV
		12.4 GHz dual voltage marker	490.6 mV	_____	509.4 mV
18 GHz - sampler gain -250 mV offset		-258.2 mV	_____	-241.8 mV	
18 GHz dual voltage marker		-487.6 mV	_____	512.4 mV	
12.4 GHz Noise	_____	_____	0.5 mV rms		
18 GHz Noise	_____	_____	1.0 mV rms		
Bandwidth	Channel 1/3	12.4 GHz	_____	_____	-3.00 dB
		18 GHz	_____	_____	-3.00 dB
	Channel 2/4	12.4 GHz	_____	_____	-3.00 dB
		18 GHz (19.98 GHz on 54753A)	_____	_____	-3.00 dB

Test	Limits	Results																					
Input Reflection	Channel 1/3      positive for 30 ps risetime negative for 30 ps risetime Channel 2/4      positive for 30 ps risetime negative for 30 ps risetime Trigger            positive for 200 ps risetime negative for 200 ps risetime	<table style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 30%;"></th> <th style="width: 30%; text-align: center;">Actual</th> <th style="width: 30%; text-align: center;">Maximum</th> </tr> </thead> <tbody> <tr> <td></td> <td style="text-align: center;">_____</td> <td style="text-align: center;">5%</td> </tr> <tr> <td></td> <td style="text-align: center;">_____</td> <td style="text-align: center;">5%</td> </tr> <tr> <td></td> <td style="text-align: center;">_____</td> <td style="text-align: center;">5%</td> </tr> <tr> <td></td> <td style="text-align: center;">_____</td> <td style="text-align: center;">5%</td> </tr> <tr> <td></td> <td style="text-align: center;">_____</td> <td style="text-align: center;">10%</td> </tr> <tr> <td></td> <td style="text-align: center;">_____</td> <td style="text-align: center;">10%</td> </tr> </tbody> </table>		Actual	Maximum		_____	5%		_____	5%		_____	5%		_____	5%		_____	10%		_____	10%
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TDR System Test Channel 1/3	Low level High level Flatness > 1 ns    +1% -1% < 1 ns                -5% +5% Risetime	<table style="width: 100%; border-collapse: collapse;"> <tbody> <tr> <td style="width: 30%;">-2 mV</td> <td style="width: 30%; text-align: center;">_____</td> <td style="width: 30%; text-align: center;">2 mV</td> </tr> <tr> <td>198 mV</td> <td style="text-align: center;">_____</td> <td style="text-align: center;">202 mV</td> </tr> <tr> <td></td> <td style="text-align: center;">_____</td> <td style="text-align: center;">+1%</td> </tr> <tr> <td></td> <td style="text-align: center;">_____</td> <td></td> </tr> <tr> <td></td> <td style="text-align: center;">_____</td> <td></td> </tr> <tr> <td></td> <td style="text-align: center;">_____</td> <td style="text-align: center;">+5%</td> </tr> <tr> <td></td> <td style="text-align: center;">_____</td> <td style="text-align: center;">45 ps</td> </tr> </tbody> </table>	-2 mV	_____	2 mV	198 mV	_____	202 mV		_____	+1%		_____			_____			_____	+5%		_____	45 ps
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TDR System Test Channel 2/4 (except 54753A)	Low level High level Flatness > 1 ns    +1% -1% < 1 ns                -5% +5% Risetime	<table style="width: 100%; border-collapse: collapse;"> <tbody> <tr> <td style="width: 30%;">-2 mV</td> <td style="width: 30%; text-align: center;">_____</td> <td style="width: 30%; text-align: center;">2 mV</td> </tr> <tr> <td>198 mV</td> <td style="text-align: center;">_____</td> <td style="text-align: center;">202 mV</td> </tr> <tr> <td></td> <td style="text-align: center;">_____</td> <td style="text-align: center;">+1%</td> </tr> <tr> <td></td> <td style="text-align: center;">_____</td> <td></td> </tr> <tr> <td></td> <td style="text-align: center;">_____</td> <td></td> </tr> <tr> <td></td> <td style="text-align: center;">_____</td> <td style="text-align: center;">+5%</td> </tr> <tr> <td></td> <td style="text-align: center;">_____</td> <td style="text-align: center;">45 ps</td> </tr> </tbody> </table>	-2 mV	_____	2 mV	198 mV	_____	202 mV		_____	+1%		_____			_____			_____	+5%		_____	45 ps
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Input Reflection Test	Channel 1/3 (30 ps) pos neg Channel 2/4 (30 ps) pos neg External Trigger    pos (200 ps) neg	<table style="width: 100%; border-collapse: collapse;"> <tbody> <tr> <td style="width: 30%;"></td> <td style="width: 30%; text-align: center;">_____</td> <td style="width: 30%; text-align: center;">5%</td> </tr> <tr> <td></td> <td style="text-align: center;">_____</td> <td style="text-align: center;">5%</td> </tr> <tr> <td></td> <td style="text-align: center;">_____</td> <td style="text-align: center;">5%</td> </tr> <tr> <td></td> <td style="text-align: center;">_____</td> <td style="text-align: center;">5%</td> </tr> <tr> <td></td> <td style="text-align: center;">_____</td> <td style="text-align: center;">10%</td> </tr> <tr> <td></td> <td style="text-align: center;">_____</td> <td style="text-align: center;">10%</td> </tr> </tbody> </table>		_____	5%		_____	5%		_____	5%		_____	5%		_____	10%		_____	10%			
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Calibration Interval 4-3  
Calibration Status Displays 4-4  
To calibrate the plug-ins 4-6  
To adjust feed-through compensation 4-9

---

# Calibrating and Adjusting

This chapter has procedures for calibrating the plug-in to the mainframe. To calibrate the mainframe, refer to the Service Guide supplied with the mainframe. Areas covered in this chapter include:

- Calibration interval
- Calibration status displays
- Plug-in calibration

## See also

"Calibration Overview" in chapter 4 of the Service Guide supplied with the mainframe for an overview of the frame, plug-in, and probe calibrations.

## Equipment Required

Equipment required for these procedures is listed in the Recommended Test Equipment table in chapter 1 of this manual. Any equipment that satisfies the critical specification listed in the table may be substituted for the recommended model. Equipment for individual procedures is listed at the procedure.

## Keystroke Conventions

To guide you while setting up the instrument, the following conventions are used to represent keystrokes and other interactions with the instrument.

When you need to press a front-panel key (also called a hardkey), you will be instructed to press a specific key. For example, press the Time base key.

Bold text, such as **Display** or **Calibrate...**, represents text on the CRT screen and may be a softkey you should press or a selection you should make. For example, press the **Scale** softkey, and use the knob to set the scale to **1 ns/div**.

The blue key that has no writing on it is a shift key. It allows you access to the functions written in blue above some of the front-panel keys. For example, press the blue shift key, then press the Limit test key. When the shift function is active, the green LED next to the blue shift key is on.

---

## Calibration Interval

Plug-in calibration allows the instrument to establish the vertical calibration factors for a particular plug-in in a particular mainframe slot that it is calibrated in. Plug-in vertical specifications only apply when the plug-in is used in the mainframe slot it was calibrated in.

For optimum measurement results, it is recommended that the instrument user perform the plug-in calibration regularly, especially if the operating temperature has changed over 2 deg C since the last plug-in cal. The plug-in calibration just takes about two minutes per channel.

A switch in the plug-in is used to enable or disable plug-in calibration. The plug-in side cover must be removed to gain access to the switch. Normally this switch is set in the unprotected (enabled) position so the instrument user can do the plug-in calibration periodically.

Mainframe and plug-in calibration should be done under any of the following conditions:

- Yearly or every 2,000 hours of operation.
- If the instrument temperature is more than 5 °C different than the temperature when the last calibration was done. Vertical dc accuracy has tighter specifications over the 2 dec C range. See the Performance Specifications section of chapter 1 for more information.
- If you are going to use the mainframe to calibrate plug-ins.

---

### **CAUTION**

Warm up the instrument for at least 60 minutes before starting these procedures. Failure to achieve a stable temperature before calibration may result in temperature shifts that void the calibration. For temperature and electrical stability, all calibrations must be done with the rear panel and all rear panel hardware installed.

---

## Calibration Status Displays

The calibration status displays show the current calibration status of the mainframe and plug-ins for normal accuracy and best accuracy. There are two displays, one through the Utility menu and one, specifically for each plug-in, through the channel setup menu. The status of Calibration Memory, and the Current Frame and plug-in  $\Delta$ Temp, update only when the Cal status display is entered.

### Frame Calibration Status

The following figure shows the display, and the table explains the features. This display also shows an abbreviated version of the plug-in status. To enter this display, press the Utility key, press the **Calibrate...** softkey, then set the **Cal status** softkey to on.

The screenshot shows the 'Calibrate' menu with the following softkeys: Calibrate plug-in..., Calibrate frame, Samplers (disabled/enabled), Cal status (off/on), Level (170.0 mU), and Exit.

The main display area shows the following text:

```

Current Frame  $\Delta$ Temp : -3°C
Frame
Calibration Status : Calibrated
Last Calibration  : 13 FEB 95 16:54
Calibration Memory : Unprotected

Other Calibration Status : Passed
Comments:
    
```

Below the text is a table titled 'Plug-ins':

Slot	Model	Memory	Date	Last Calibration Time	Accuracy	$\Delta$ Temp
1	54754A	Unprotected	24 FEB 95	10:54	Calibrated	0°C
2						
3	83483A	Unprotected	21 FEB 95	13:13	Calibrated	0°C
4						

### Frame Calibration Status

#### Frame

##### Current Frame

Displays the current internal temperature of the instrument compared to the temperature at which the frame was calibrated, in increments of one degree centigrade.

##### $\Delta$ Temp

##### Calibration Status

Displays Calibrated or Uncalibrated.

##### Last Calibration

Displays the date and time of the last frame calibration.

##### Calibration Memory

Shows the setting of the Frame cal memory protect switch.

##### Other Cal. Status

Displays Passed, Failed, or Calibrating

##### Comments

This area is for text that can be programmed See "Calibrate Subsystem" in the Programmer's Reference supplied with the mainframe.

#### Plug-ins

##### Slot

The front panel plug-in position.

##### Model

The model number of the plug-in currently in the slot. Unfilled slots register "empty." If the mainframe does not recognize the plug-in, "~known" is displayed instead of the model number. If "~known" or "?" is displayed, a non-compatible plug-in is installed, or the plug-in requires service. Initialize plug-in memory using the Utility key and the Service softkey.

##### Memory

Shows the status of the calibration switch in the plug-in.

When calibration is disabled, Protected is displayed.

When calibration is enabled, Unprotected is displayed.

##### Date

The date the plug-in was calibrated.

##### Time

The time the plug-in was calibrated.

##### Accuracy

This shows the plug-in calibration status, Calibrated or Uncalibrated

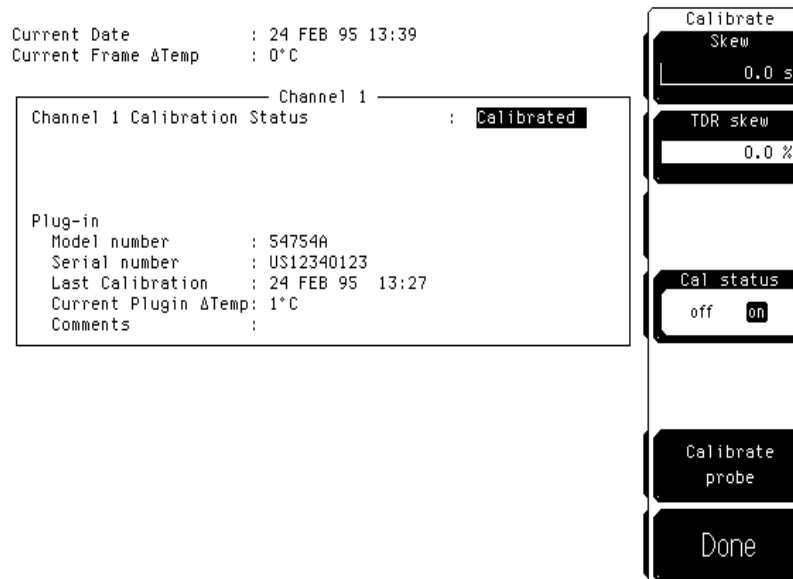
##### $\Delta$ Temp

The change in temperature since the plug-in was last calibrated.

### Plug-In Calibration Status

The following figure shows the plug-in calibration status display and the table explains the features.

To enter this display, press the Channel key, press the **Calibrate...** softkey, then set the **Cal status** softkey to on.



### Plug-In Calibration Status

<b>Current Date</b>	Date and time reflected by the internal clock.
<b>Current Frame ΔTemp</b>	The current internal temperature of the instrument compared to the temperature at which the frame was calibrated, in increments of one degree centigrade.
<b>Channel X Calibration Level</b>	Displays Uncalibrated or Calibrated
<b>Plug-in</b>	Shows other relevant plug-in data. The model number is derived from a hardware ID on the PC board. The serial number is set through the Utility Service menu. Last Calibration is the date and time of the last calibration level.

## To calibrate the plug-ins

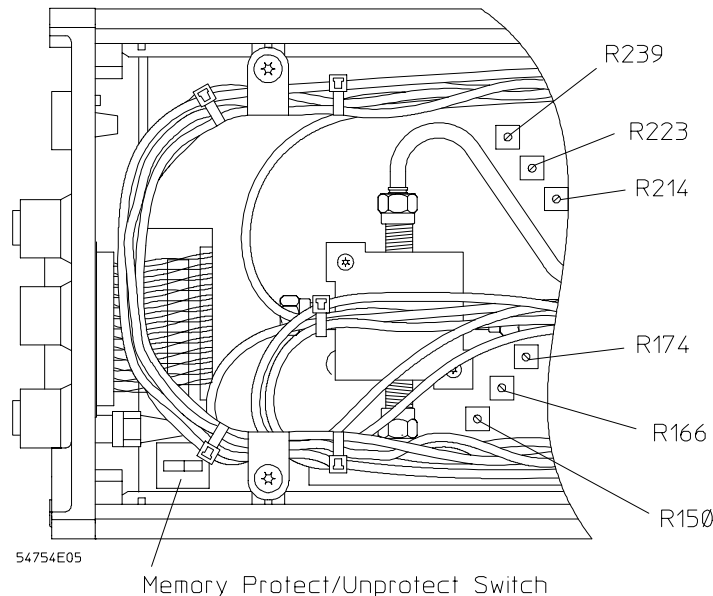
Plug-in software calibration allows the instrument to establish the vertical calibration factors for a particular plug-in in a particular mainframe slot that it is calibrated in. Plug-in specifications only apply when the plug-in is used in the mainframe slot it was calibrated in. The plug-in calibration takes about two minutes per channel.

For optimum measurements, the instrument user should perform the plug-in calibration regularly, especially if the operating temperature has changed over  $2^{\circ}\text{X}$  since the last plug-in cal. If the plug-in temperature has changed more than  $\pm 2^{\circ}\text{X}$  and less than  $\pm 5^{\circ}\text{X}$  since the last plug-in cal, the single and dual marker specifications increase slightly. See the specifications section in chapter 1 for more information.

A switch in the plug-in is used to enable or disable the plug-in calibration memory. The plug-in cover must be removed to gain access to the switch. Normally this switch is set in the unprotected (enabled) position so the instrument user can do the plug-in calibration periodically.

### Equipment Required

Equipment	Critical Specifications	Recommended Model/Part
DMM	6 1/2 digit, 0.01% resistance	34401A
50 ohm load	3.5mm (m) connector or SMA (m) connector (supplied with plug-in)	909D 1250-2153
Adapter (2)	3.5mm (f-f) (connector saver supplied with plug-in)	5061-5311
Adapter	BNC (m-m)	1250-0216
Adapter	BNC (f) to banana	1250-2277
Adapter	BNC (f) to SMA (m)	1250-1200
Coaxial short	SMA (m)	0960-0055
Cable	BNC, 12 inch	8120-1838



**Memory Protect/Unprotect switch location**

### Dc resistance of the 50 ohm termination measurement procedure

- 1 Measure the dc resistance of the 50 ohm termination. The measured value is used as the reference in the TDR portion of the plug-in calibration.
  - a Connect a banana to BNC (f) adapter to a BNC (m-m) adapter. Connect this to a BNC (f) to SMA (m) adapter. Connect this to an 3.5 mm (f-f) adapter. Connect the 50 ohm termination to the fixture.  
Record the resistance of the 50 ohm termination \_\_\_\_\_ ohm. Ex. 50.33 ohm
  - b Remove the 50 ohm termination and connect the SMA (m) short to the fixture.  
Record the dc resistance of the fixture \_\_\_\_\_ ohm. Ex. 0.11 ohm
  - c Subtract the fixture resistance (step b) from the termination resistance (step a).  
Record this number as ZL.  
(step a) \_\_\_\_\_ ohm - (step b) \_\_\_\_\_ ohm = ZL \_\_\_\_\_ ohm. Ex. 50.22 ohm
  - d Solve for Er using the following formula (Er can be a negative number):  
 $Er = 200 ((ZL - 50)/(ZL + 50))$ . Round to the nearest 0.01 mV. Ex. .43 mV  
Er = \_\_\_\_\_ mV

---

### CAUTION

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Warm up the instrument for at least 60 minutes before starting these procedures. Failure to achieve a stable temperature before calibration may result in temperature shifts that void the calibration. For temperature and electrical stability, all calibration must be done with the rear panel and all rear panel hardware installed.

### Plug-in calibration procedure

- 2 If the plug-in memory is protected, enable plug-in calibration by doing steps a through d. If the plug-in memory is in unprotected mode, go to step 3.
  - a Remove the plug-in from the mainframe.
  - b With a small flat tool, remove the leftside plug-in cover by prying gently at the rear corners, lifting, and sliding it back.
  - c Set the calibration switch to the ENABLE (unprotected) position.
  - d Replace the cover and put the plug-in back into the mainframe.
- 3 Determine if plug-in memory initialization is required.
  - a Press the Utility key, then press the System configuration... softkey.
  - b Look at the plug-in's window at the bottom of the system configuration screen. If the plug-in's model number does not display 54753A or 54754A, initialize the plug-in memory in the following steps, otherwise go to step 4.
  - c Press the **Utility** key, the **Service...** softkey, then the **Plug-in** softkey.
  - d Toggle the **Plug-in...** softkey to the plug-in slot in question, then press the **Initialize plug-in memory...** softkey. The initialization should take about one minute.
- 4 Press the **Utility** key, then press the **Calibrate...** softkey.
- 5 Press the **Calibrate plug-in...** softkey.
- 6 Toggle the **Plug-in...** softkey to select the plug-in to be calibrated.
- 7 Press the **Start cal** softkey, then follow the instructions on the screen:
  - a Disconnect everything. Press **Continue** softkey when ready. (Skip steps b through d if the plug-in's memory is not initialized.)
  - b Connect mainframe CAL signal to channel 1. Continue.
  - c Connect mainframe CAL signal to channel 2. Continue.
  - d Disconnect everything from the front panel. Continue.

- e** Ensure that only connector savers (3.5 mm (f-f) adapters) are on channels 1 and 2. Continue.
  - f** Connect 50 ohm load to channel 1. Continue.
  - g** Enter load resistance. Continue.
  - h** Connect the 50 ohm load to channel 2. Continue. (Skip this step for the 54753A.)
  - i** Enter load resistance. Continue. (Skip this step for the 54753A.)
  - j** Disconnect everything from the plug-in. Continue.
- 8 Calibration completed.** If the calibration fails, refer to the Troubleshooting section of the mainframe service manual to determine if the fault is in the mainframe or the plug-in.



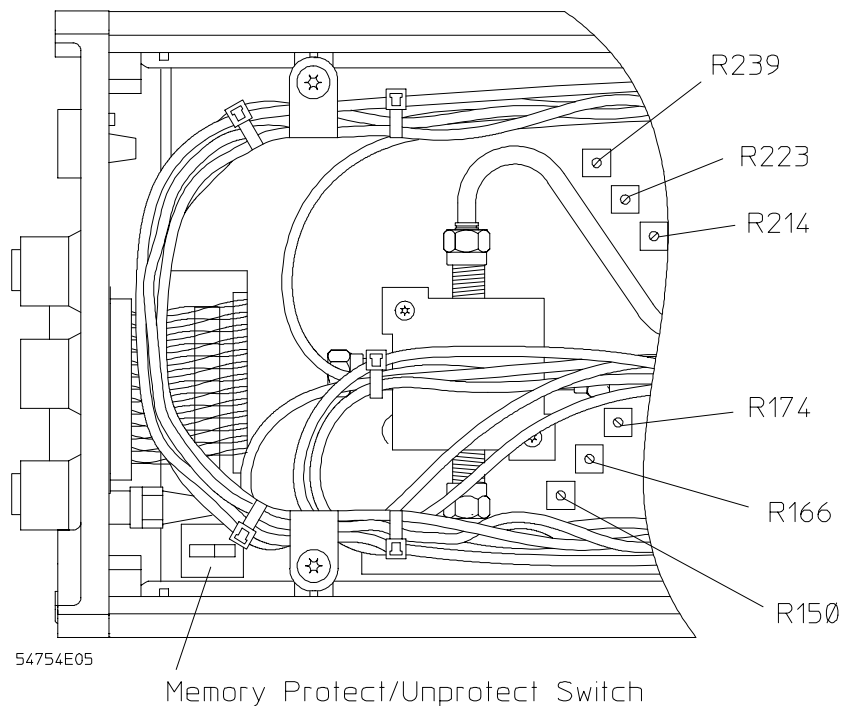
## To adjust feed-through compensation

This procedure adjusts the feed-through compensation on the plug-in. When the samplers are turned off, there is a small amount of parasitic (unwanted) feedthrough of signals through the samplers. This is caused by parasitic capacitance and resistive coupling through the samplers. In this procedure, the samplers are turned off and three pots on each channel are adjusted for minimum feedthrough.

### Equipment Required

Equipment	Critical Specifications	Recommended Model/Part
Pulse/Function Generator	500 mVp-p, 15 kHz square wave	8116A or 3325B
Cable (2)	BNC, 48 inch	10503A
Adapter	BNC(f) to SMA(m)	1250-1200

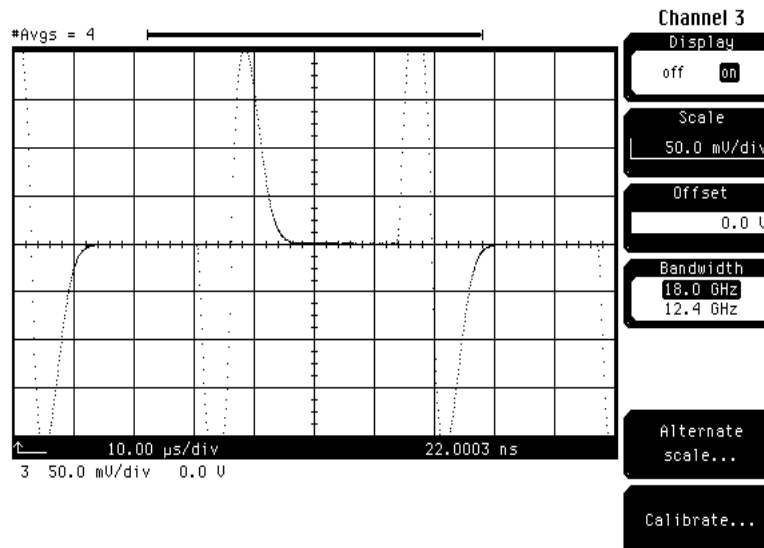
- 1 Remove the 54753A/54754A plug-in from the mainframe.
  - a Remove the left-side cover from the plug-in by prying the rear corners up until the cover releases from the top and bottom rails.
  - b Find the six pots on the sampler/IF board and preset these full counter-clockwise.
- 2 Place the plug-in into mainframe slots 3 and 4, and allow to warmup for at least 60 minutes.



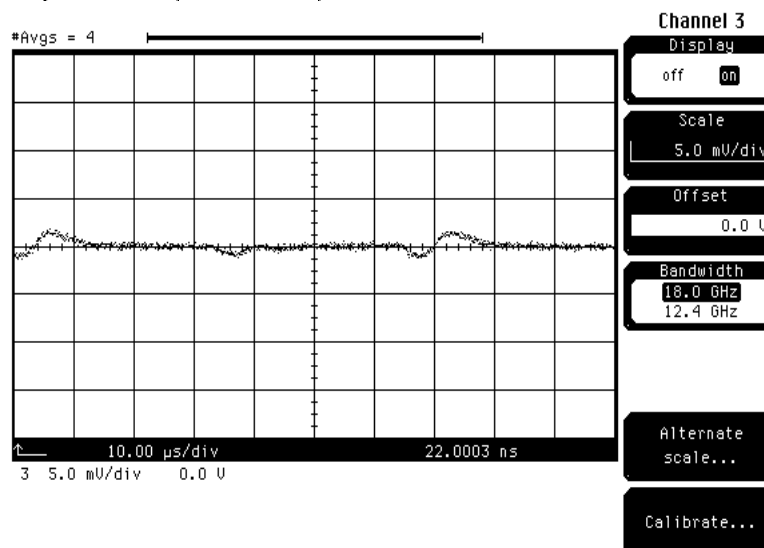
- 3 Using an 3325B or equivalent pulse/function generator, connect a 500 mV, 15 kHz square wave to channel 3.
- 4 Connect the trigger out of the pulse generator to Trigger input on the plug-in.
- 5 Press the Setup key, then press **Default setup** softkey.
- 6 Press the Time base key, then change Scale to 10  $\mu$ s/div, Position to 22 ns, and Reference Left.
- 7 Press the Trigger key, then change Level to 500 mV and Slope to +.
- 8 Press the Acquisition, set the **Averaging** softkey to **On**, and the **# of Averages** softkey to **4**. Toggle the Best key to highlight **throughput**.
- 9 Press the Setup Channel key on channel 3, then change Scale to 50 mV/div.
- 10 Press Setup Channel key on channel 4, then change Scale to 50 mV/div. Set Display to **OFF**.
- 11 Press the Utility key, press the **Calibrate...** softkey, then set the **Sampler** softkey to **Disabled**.

This disables the samplers from firing which allows only the feedthrough signal to be seen on screen.

- 12 The waveform should look like this picture, single cycles of a sine wave separated by a flat line.

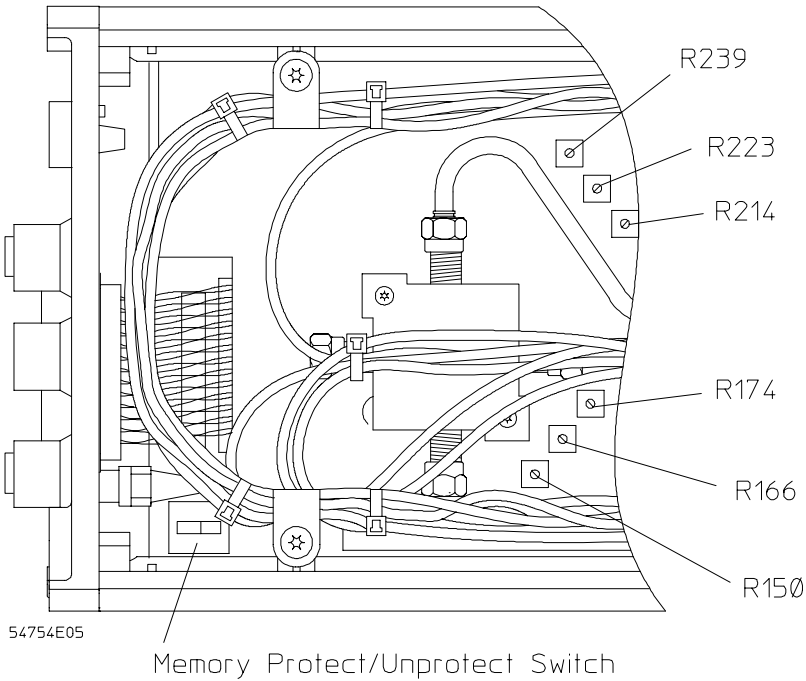


- 13 Adjust R239 (top pot) counter clockwise to reduce the amplitude of this waveform. When the approximate minimum amplitude is reached, the waveform should look approximately like single pulses separated by a flat line.
- 14 Adjust R2114 (bottom pot) to minimize the amplitude on the resultant waveform. Adjust R223 (middle pot) for best flatness.



- 15 Change to 5 mV/div and repeat the last two steps.
- 16 Some interaction between R239 and R214 and R223 may require readjusting these three pots to minimize the bumps to achieve the flattest possible line.
- 16 Connect the 15 kHz square wave to channel 4. Turn off channel 3 and turn on channel 4.
- 17 Repeat the above steps for channel 4 using R174, R150, and R166 instead of R239, R214, and R223.
- 18 Enable the samplers, press the Utility key, press the **Calibrate...** softkey, then set the **Sampler** softkey to **Enabled**.

Calibrating and Adjusting  
**To adjust feed-through compensation**



**Feedthrough compensation adjustment locations**

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# Troubleshooting

This section provides troubleshooting information for the plug-in. The service strategy of this instrument is replacement of defective assemblies, so the troubleshooting is designed to isolate a failed PC assembly, sampler, pulse filter, or cable. Trouble isolation of the plug-in requires checking the plug-in in a working mainframe.

## ESD Precautions

When using any of the procedures in this chapter, you should use proper ESD precautions. As a minimum, if you are working with the plug-in on an extender cable, you should place the instrument on a properly grounded ESD mat and wear a properly grounded ESD wrist strap.

## Equipment Required

A complete list of equipment needed for testing this instrument is in the Recommended Test Equipment table in chapter 1, "General Information." You need the tools normally used when troubleshooting electronic equipment. If you need to remove and replace parts and assemblies, you will need some of the hand tools listed in chapter 6, "Replacing Assemblies."

You can use an extender cable to operate the plug-in on the bus interface outside of the mainframe. You need a 25-conductor cable with a 25-pin, female, D-subminiature connector on one end, and a 25-pin, male, D-subminiature connector on the other. The cable should be about 2 feet long.

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### CAUTION

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The plug-in must be properly grounded. Failure to ground the plug-in before connecting the extender cable can cause circuit failures on the mainframe CPU board. The grounding when using the extender is not the same as when the plug-in is installed in the mainframe.

You must first do the following before you extend a plug-in:

- Turn the instrument to Standby when connecting and disconnecting the plug-in.
- Ground the plug-in to the mainframe with a separate wire before you connect the extender cable to the plug-in.

You can use an RS-232-type cable with all 25 pins wired pin-for-pin, or you can build a cable using the connectors below and some hookup wire. However, these cables will not connect the sampler strobe and trigger signals to the mainframe.

	<b>Female Connector</b>	<b>Male Connector</b>
<b>ITT Part No.</b>	DBM 25S	DBM 25P
<b>Part No.</b>	1251-0064	1251-0063

### OSP (Blindmate) extender cable

To isolate problems in the plug-in, it may be necessary to connect the strobe pulse with the OSP (Blindmate) extender cable. This cable consists of the following cables and adapters.

Part No. E2602-61601	Coaxial cable OSP (m) to SMA (m)
Part No. 83481-60006	Coaxial cable OSP (f) to SMA (m)
Part No. 1252-1158	Adapter SMA (f-f)

### Keystroke Conventions

To guide you while setting up the oscilloscope, the following conventions are used to represent keystrokes and other interactions with the instrument:

When you need to press a front-panel key (also called a hardkey), you will be instructed to press a specific key. For example, press the Time base key.

Bold text, such as **Display** or **Calibrate...**, represents text on the CRT screen and may be a softkey you should press or a selection you should make. For example, press the **Scale** softkey, and use the knob to set the scale to **1 ns/div**.

The blue key that has no writing on it is a shift key. It allows you access to the functions written in blue above some of the front-panel keys. For example, press the blue shift key, then press the Limit test key.

### Trouble Isolation

The trouble isolation information is provided to help you isolate a problem to a faulty assembly. When the faulty assembly has been located, the disassembly/assembly procedures in chapter 6, "Replacing Assemblies" help direct replacement of the assembly.

The primary procedural tool in this section is the flowchart. This chart contains the entire troubleshooting path from a failed instrument to a working one, and will direct you in an orderly manner through the failure symptoms. Reference letters on the flowchart point to sections of text that supplement the brief prompts in the chart. Do not try to troubleshoot by following only the supplemental text because the text is not in the correct order for troubleshooting. Instead, simply follow the flowchart.

- If you are uncertain that the plug-in is the cause of a failure, go to "Primary Trouble Isolation."
- If the plug-in does not respond in the mainframe or has failed calibration, go to "Functional Failures."

## Quick Checks

If you are familiar with this instrument family, you can use the following optional checks to quickly isolate some major failures to be fairly certain the plug-in works.

**1 Be sure the plug-in is at fault.**

Install plug-ins in slots 1 and 2 or slots 3 and 4. The mainframe will not recognize a plug-in installed in slots 2 and 3.

**2. If the plug-in is not recognized by the 54750A/83480A mainframe, initialize the plug-in:**

- a. Press the Utility key, then the **Service...** softkey.
- b. Press the **Plug-in...** softkey and toggle the **Plug-in...** softkey to the plug-in in question.
- c. Press the **Initialize plug-in memory...** softkey. The plug-in memory initialization takes about one minute to complete.

**3. If the initialization does not work, one of the following is the problem:**

- The mainframe slot is incorrect; try another mainframe slot.
- If the mainframe is the 83480A, verify that software option 54755A is installed.
- The 54753A/54754A interface board may have a failure or the select switches are not set properly. Refer to the Digital Interface Board in the Replacing Assemblies section of this manual for switch setting information.

When you have any problem involving a plug-in, put the suspect plug-in the other pair of slots where you know another plug-in performs properly and check for the failure. If the problem follows the plug-in, repair the plug-in. If the plug-in works, repair the mainframe.

**4 Check the digital interface.**

Press the Channel key. You should see the channel menu for the plug-in.

- If the response is correct, most of the digital interface in the plug-in is operating.
- If the instrument does not respond, the problem could be the keyboard, digital interface cable, or PC board.
  - a. Simulate a key closure by using a piece of wire to short the brown and black wires at the keyboard connector. If the instrument responds, remove the keyboard and check for contamination or other problems.
  - b. Check the bus interface cable using a digital multimeter to check cable continuity.
  - c. If the keyboard and bus cable are working, replace the PC board.



**5 Check channel menus**

Press the Channel key, then press the **Scale** softkey. Use the knob and arrow keys to change the scale. Failure to respond is likely caused by the digital interface board.

**6 Check autoscaling.**

Apply a 0.5 V, 10 MHz sine wave to the channel and trigger inputs, then press the Autoscale key. If Autoscale operates, the instrument has found the signal and a trigger.

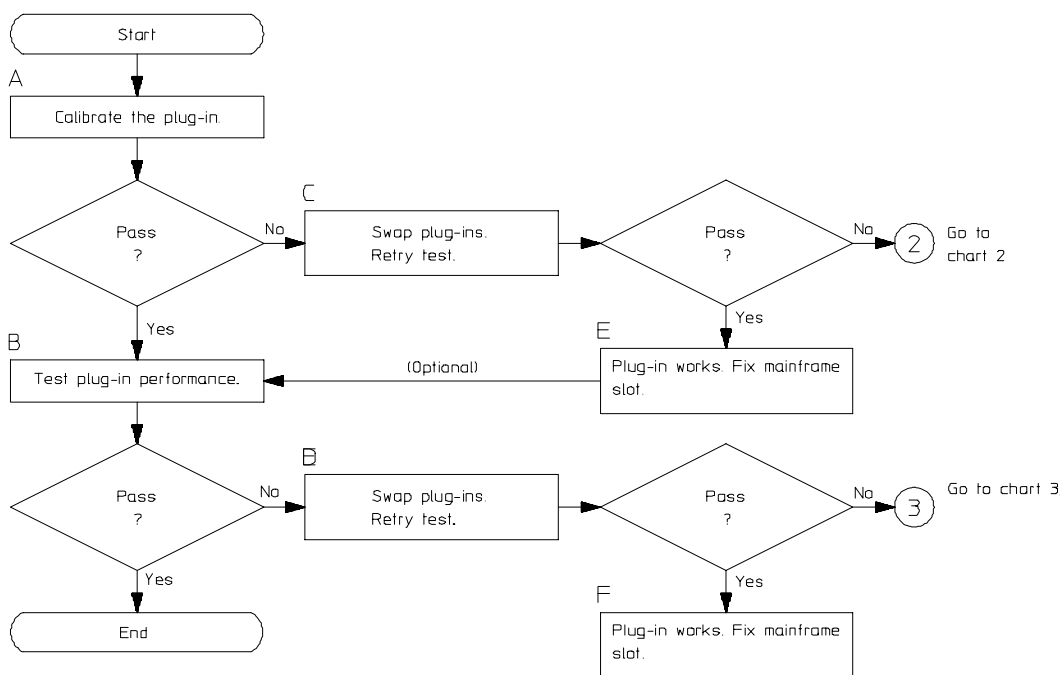
**7 Check triggering.**

Adjust the trigger level and check for changes.

**8 Try calibration.**

If the plug-in passes the plug-in calibration, any failure is most likely connected with performance tests and specifications.

**9 If you are uncertain about the plug-in at this point, use the trouble isolation procedures to find the failure. The flowchart block descriptions are located on the next page.**



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**Primary Trouble Isolation, Chart 1**

## Primary Trouble Isolation

Use the following text to supplement the steps in the flowchart on the previous page.

**A** Calibrate the plug-in.

- 1** Press the Utility key, press the **Calibrate...** softkey, then press the **Calibrate plug-in...** softkey.
- 2** Press the **Plug-in** softkey to select the plug-in to be calibrated.
- 3** Press the **Start cal** softkey, then follow the instructions on the display.
- 4** After the instructions have been followed, press the **Continue** softkey.

The status bar will show the progress of calibration.

When calibration is complete, the display will show **Calibration completed**.

**B** Test plug-in performance.

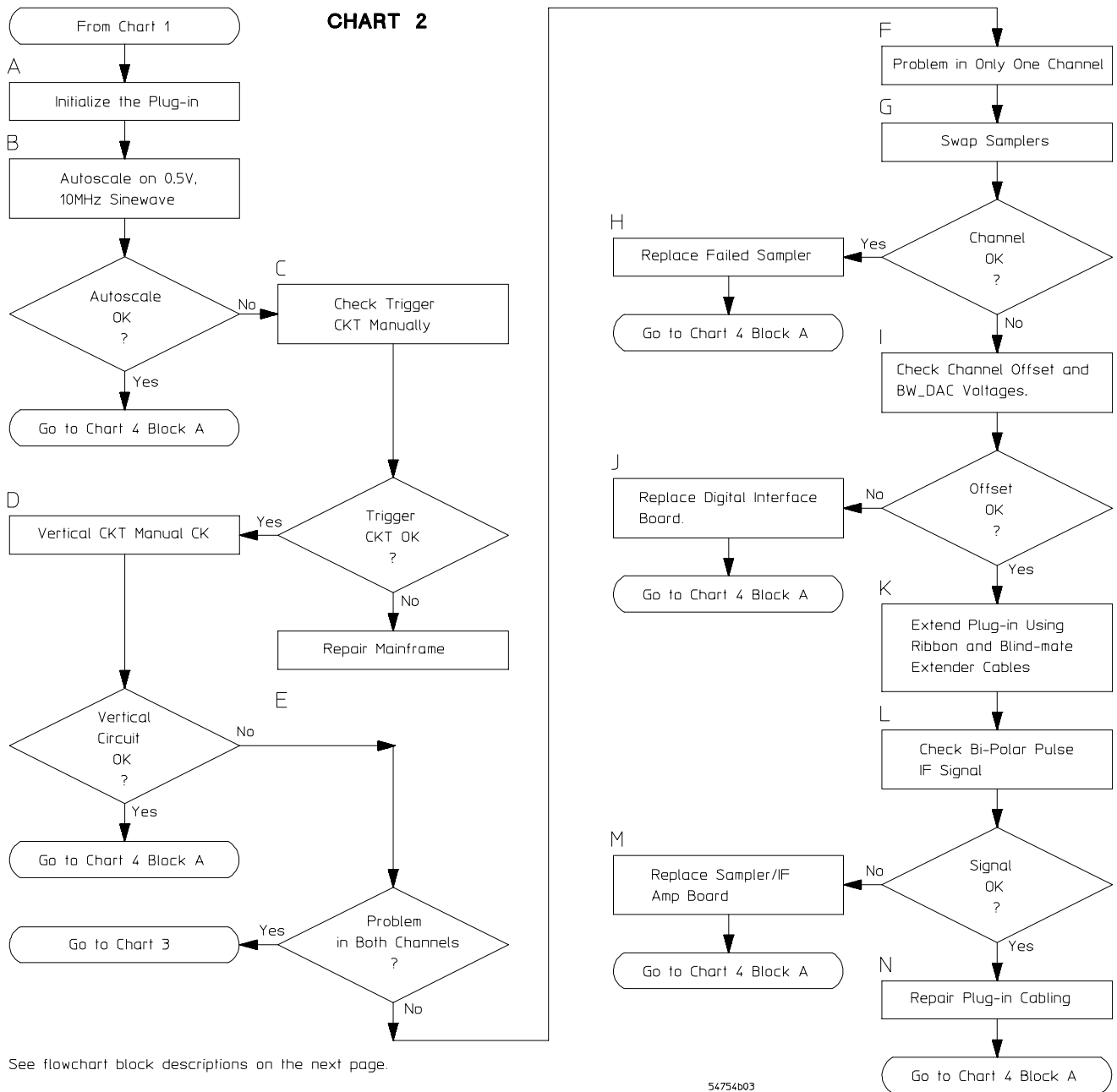
Do the performance tests in chapter 3 of this Service Guide.

**C/D** Swap plug-ins and retry the test.

Swap the plug-in into the other two slots and retry the failed calibration or performance test.

**E/F** The plug-in works. Troubleshoot the mainframe.

Since the plug-in operates in the other two slots, apparently the mainframe is at fault. Go to the mainframe troubleshooting procedures in chapter 5 of the Service Guide for the mainframe.



**Functional Failure Isolation, Chart 2**

## Functional Failure Isolation

Use the following steps to supplement the steps in the chart 2 on page 5-7.

A basic function of the plug-in has failed. Use the following tests to find the failure. To avoid having to make plug-in choices in menus, remove the plug-in that is not being tested.

### A Initialize the plug-in.

1 Press the Utility key, press the **Service** softkey, then press the **Plug-in** softkey.

If you did not remove the other plug-in, you will have to press **Plug-in** again to select the desired plug-in.

2 Press the **Initialize plug-in memory** softkey.

3 If you are not able to initialize the plug-in's memory, check the plug-in's cabling from the 25-pin rear panel connector to the digital interface board. If the cabling is good, the digital interface board may have failed.

### B Autoscale on a known signal.

1 Connect 0.5 V<sub>p-p</sub>, 10 MHz sine wave to channel A and trigger inputs by using a power splitter, adapters, and cables.

2 Press the Autoscale key.

### C Is the trigger functioning OK?

If the Autoscale failed, set up the system manually.

1 Disconnect the signal from the Channel and Trigger inputs.

2 Press the Setup key, then press the **Default setup** softkey.

3 Press the Time base key, then set the Scale to 20 ns/div.

4 On both plug-in channels, change the Scale to 50 mV/div and the bandwidth to 12.4 GHz.

5 Press the Trigger key, then set the **Sweep** softkey to **freerun**.

Each channel's traces should appear on the screen. The traces may be overlapped. The mainframe's freerun trigger circuit is functioning if the traces go across the screen. If the channel is damaged, the traces may be pegged at the top or bottom of the screen. But, that the traces appear somewhere on the screen shows that the freerun trigger circuit is functioning.

If the traces do not appear, the problem is in the mainframe. The mainframe's time base/acquisition assembly is the most likely cause.

6 Toggle the **Sweep** softkey to the **triggered**, then press the Clear Display key.

The traces on the screen should be cleared.

7 Reconnect the 0.5 volt, 10 MHz signal to the Trigger input.

If the channel traces reappear on screen, the trigger circuit is functioning. The Triggered LED on the mainframe should also light.

a If the traces do not appear, try adjusting the Trigger Level.

The input signal may have an offset. If so, adjust the trigger level to compensate for any signal offset.

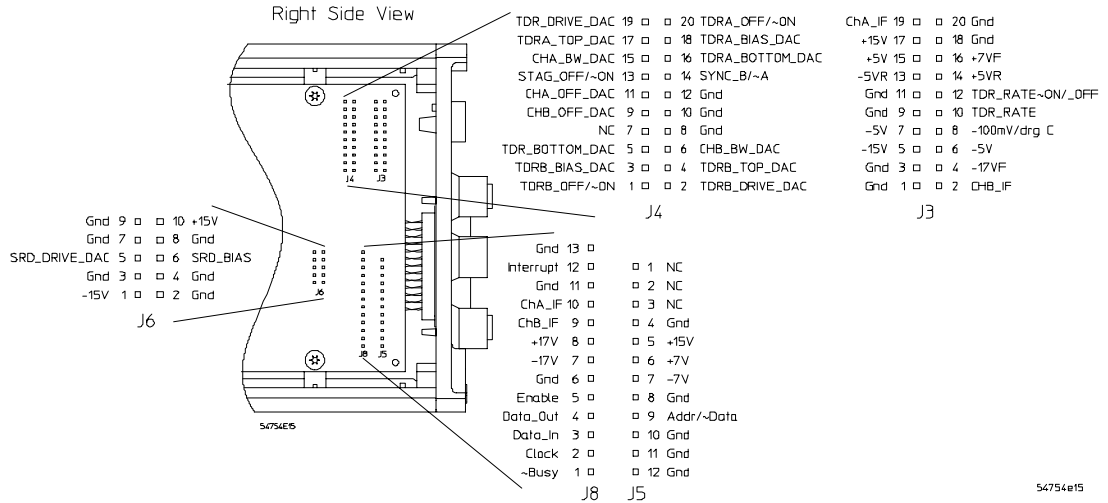
- b** If the traces still do not appear, check the trigger path cabling in the plug-in. Ohm out the trigger path between the Trigger input and the upper 'Blind-mate' connector on the rear panel of the plug-in.
- c** If the traces still do not appear, the trigger circuit in the mainframe's time base/acquisition assembly has a failure.

**D Channel signals OK?**

If the trigger circuit is functioning, connect the 0.5 volt peak-to-peak, 10 MHz sine wave to a channel input and the Trigger input through a power splitter. The signal should vary with the Scale V/div setting and move up and down with the channel offset. (When the plug-in is uncalibrated, the trace will likely move erratically when the offset is varied.) Move the signal to the other channel input and check that the signal varies with V/div scale and offset.

If the signals are not correct, the channel or channels are bad. Troubleshoot the respective channel.

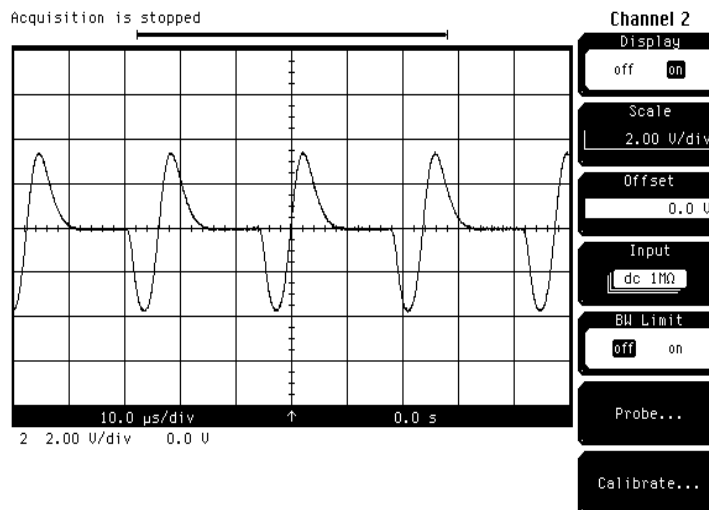
- E** Continue on this chart if only one channel has a problem. Go to Chart 3 if both channels have the same problem. If both channels have problems, but not the same problem, continue on this chart and troubleshoot one channel at a time.
- F** Follow this leg for trouble isolation if only one channel has the problem passing a correct signal, or if both channels have a different type of failure. For example, one channel has no offset control, and the other channel passes no signal.
- G** If one channel is working, but the other channel has failed, a sampler and/or TDR step generator may be blown due to overvoltage or ESD. Swap the samplers and TDR step generators between the working and non-working channels. If the problem stays with the sampler and TDR step generator, replace these. If the problem stays with the channel, try swapping the Teflon boards between channels also.
  - 1** Using good ESD methods, remove the the plug-in side covers, and top rail. Remove the samplers and TDR step generators from the sampling/IF board. Re-install the samplers and TDR step generators in the other channel.
  - 2** Check the plug-in operation in the mainframe. Did the problem stay with the suspect sampler and/or TDR step generator? If so, replace the suspect sampler and/or TDR step generator. If the problem stayed with the channel, remove the samplers again and swap the A2A1, A2A2 low-leakage Teflon boards. Since these are low-leakage boards, use finger cots to keep finger oils off the boards. The Teflon boards can be pressed out of the sampler/IF board by using a small non-metallic tweeker to reach through the sampler-pin holes.
  - 3** If the problem still stays with the channel, go on with the following step where the channel offset is checked. If the problem stays with the Teflon board replace the Teflon board.
- H** If the original problem stayed with the suspect sampler, replace the failed sampler and/or TDR step generator and go back to the beginning of chart 1.
- I** If the problem stayed with the channel, the problem can be caused by the following: No offset voltage coming from offset DAC on digital interface board, the sampler/IF amplifier board may have a problem, or the associated cabling may be open.
  - 1** Turn off the power to the mainframe and extend the plug-in using a 25-pin extender cable. See "Troubleshooting" page 5-2 for information about how to make up this extender cable.



**Measurement points on the Digital Interface assembly A1**

- 2 Press the Setup key, then press **Default setup** softkey. Press the Trigger key, then set the **Sweep** softkey to **Freerun**. Change the respective channel scales to 100 mV/div. Set the respective channel Bandwidths to 12.4 GHz. Using a DMM or scope, monitor the sampler offset voltage on their respective pins on J4. See the Figure on the following page for the measurement points on the Digital Interface assembly. The respective ChX\_Offset\_DAC lines should vary about  $\pm 5$  V as the channel Offset is varied to its positive and negative extremes. On a working channel on a plug-in that is uncalibrated (initialized), the trace should move up and down about 2.5 divisions from center screen.
  - 3 If the ChX\_OFF\_DAC vary correctly and the trace still does not move, the problem is in either the Sampler/IF Amplifier board or the connecting cabling.
  - 4 Using a DMM or an oscilloscope, monitor the bandwidth DAC voltages on their respective pins on P1. The respective ChX\_BW\_DAC voltage is typically approximately 350 mV in 18 GHz mode and approximately 290 mV in 12.4 GHz mode. Toggle the Channel Bandwidth between 18 GHz and 12.4 GHz. The respective ChX\_BW\_DAC voltage should switch between the above mentioned levels. If the voltages do not switch properly, replace the plug-in's Digital Interface board.
- J** If the ChX\_OFF\_DAC line or lines do not vary correctly, replace the Digital Interface Assembly. Go to Chart 1, Block A after replacing this board assembly.
- K** If the ChX\_OFF\_DAC lines vary correctly with the offset controls, the bad channel problem may be caused by the following: Ribbon cabling in the plug-in, the Sampler/IF Amplifier board, or the 25-pin interface connector between the plug-in and the mainframe. First verify if the Bi-polar pulse IF signals are present.
- 1 Turn off the power to the mainframe and extend the plug-in using.

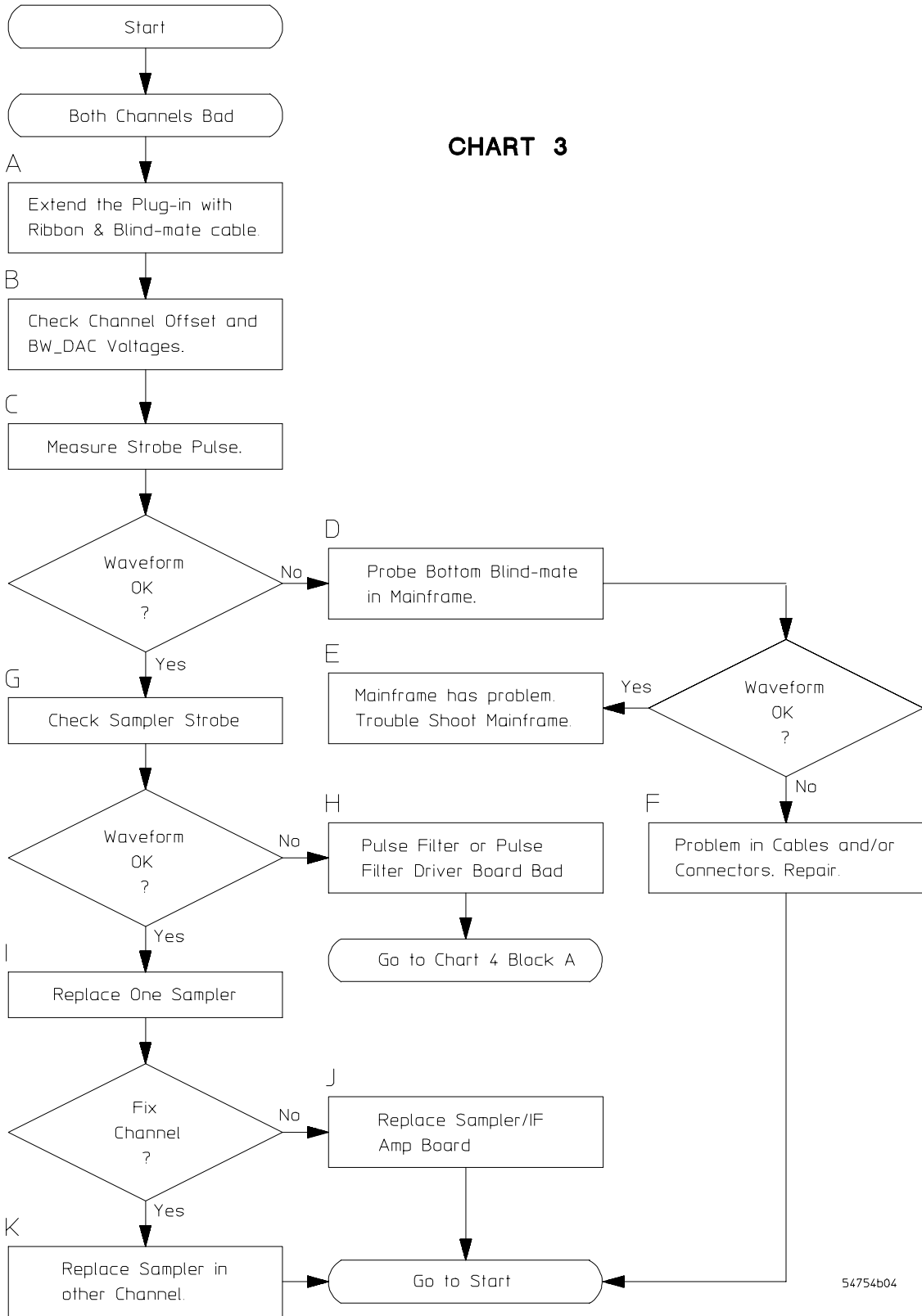
- a The 25-pin ribbon cable described on page 5-2.
  - b The Blind-mate extender cable. Carefully connect one end of the Blind-mate extender to the lower blind-mate connector in the plug-in cage and carefully connect the other end of the cable to the plug-in's lower blind-mate connector.
- 2 Turn on the mainframe power. Press the Setup key, then press the **Default** setup softkey. Press the Trigger key, then set the **Sweep** softkey to **freerun**. Set the respective Channel Scales to 100 mV/div, Bandwidth to 18 GHz, and Offset to 300 mV.
- L Probe the respective channel's ChX\_IF signal. See the previous figure, "Measurement points on the Digital Interface assembly" for the pin location to probe. The ChX\_IF bi-polar pulse signal should look like figure below "Bi-polar pulse IF signal." The amplitude and polarity of the signal should change as the channel offset is varied and the whether the offset is positive or negative. If the signal is not correct, replace the Sampler/ IF Amplifier assembly.
- M If the Bi-polar Pulse IF Signal is bad, replace the Sampler/IF Amplifier board, and go back to Chart 1, Block A.
- N If the Bi-polar Pulse IF Signal is good, the cabling carrying the signal back through the plug-in and into the mainframe must be bad. (This is assuming that the mainframe is working.) Repair the cabling and return to Chart 1, Block A.



**Bi-Polar Pulse IF Signal**

Troubleshooting  
**Functional Failure Isolation**

**CHART 3**



54754b04

**Troubleshooting chart 3**



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## Functional Failure Isolation 2

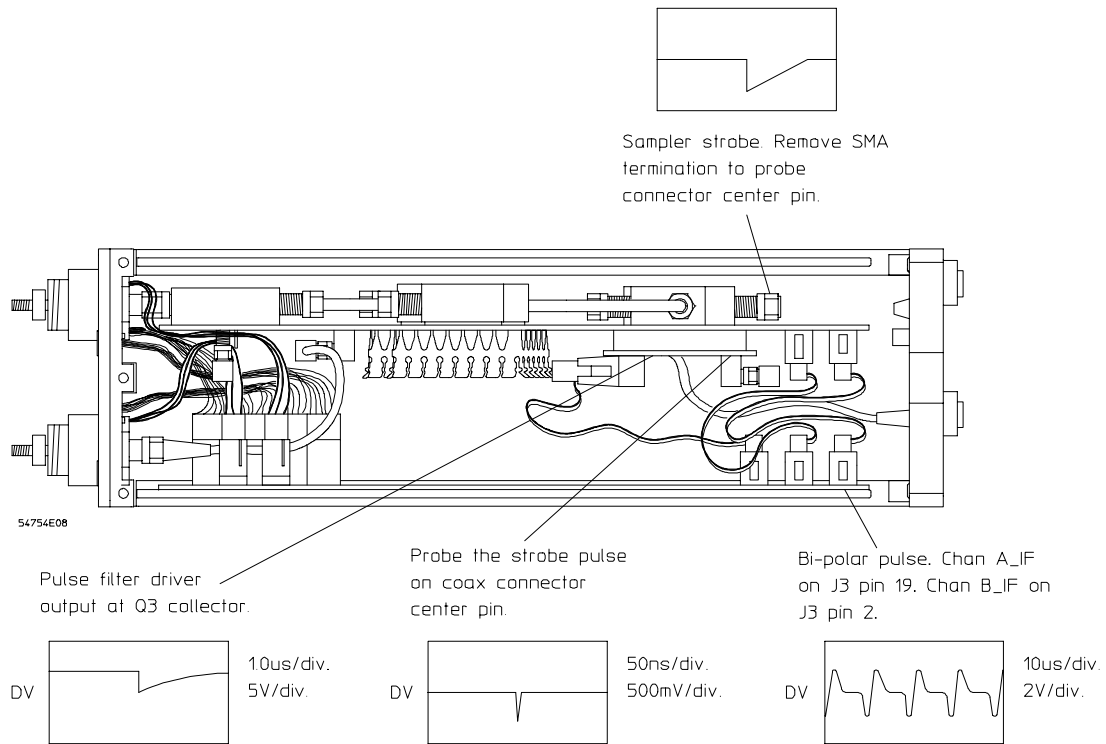
Use the following text to supplement the steps in chart 3 on page 5-12.

Both channels in the plug-in have the same or similar problems. This is a continuation of functional failure isolation procedure of flowchart 2. To avoid having to make plug-in choices in menus, remove the plug-in that is not being tested.

- A** Turn off the power to the mainframe and extend the plug-in using the the 25-pin ribbon cable and the blind-mate extender cable described on pages 5-2 and 5-3. Carefully connect one end of the blind-mate extender cable to the lower blind-mate connector in the mainframe's plug-in cage. Connect the other end of the blind-mate extender cable to the plug-in's lower connector.
- B** Check the Channel Offset, ChX\_OFF\_DAC, and the ChX\_BW\_DAC voltages.
  - 1** Press the Setup key, then press **Default setup** softkey. Press the Trigger key, then set the **Sweep** softkey to **Freerun**. Change the respective channel bandwidths to 12.4 GHz. Using a DMM or oscilloscope, monitor the sampler offset voltage on their respective pins on J4. See figure on page 5-10 for measurement points on the Digital Interface board assembly. The respective ChX\_OFF\_DAC should vary  $\pm 5$  V as the respective channel Offset is varied to its positive and negative extremes. On a working channel on a plug-in that is uncalibrated (Initialized), the trace should move up and down about 2.5 divisions from center screen.
  - 2** If the ChX\_OFF\_DAC vary correctly and the trace still does not move, the problem is in either the Sampler/IF Amplifier board or the connecting cable.
  - 3** Using the DMM or oscilloscope, monitor the bandwidth DAC voltages (ChX\_BW\_DAC) on their respective pins on J4. The respective ChX\_BW\_DAC voltage is typically approximately 350 mV when in 18 GHz mode and approximately 290 mV in 12.4 GHz mode. Toggle the **Channel Bandwidth** softkey between 12.4 GHz and 18 GHz. The voltage levels should switch between the above mentioned levels. If the voltage levels are not correct, try to Initialize the plug-in to correct this problem. If the levels are still incorrect, replace the plug-in's Digital Interface board assembly.

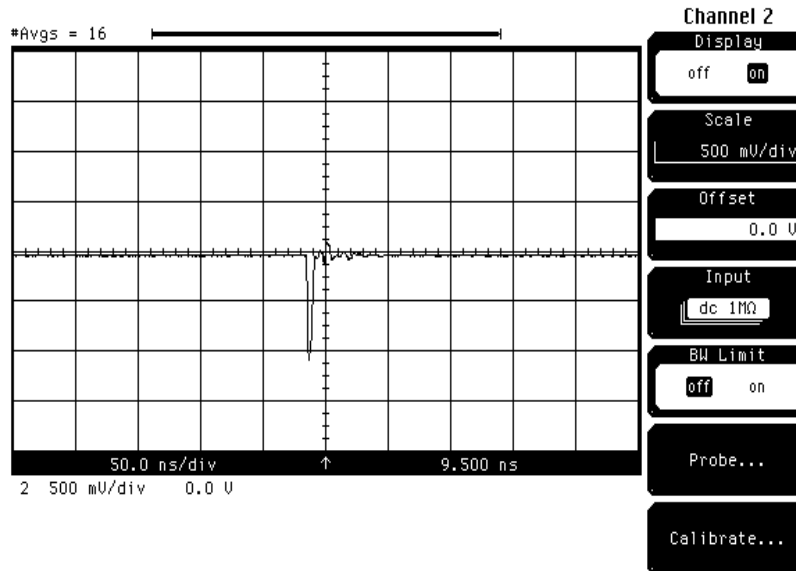
**C** Measure the Strobe Pulse. The Strobe Pulse comes from the mainframe into the plug-in through the lower Blind-mate connector. This strobe pulse fires the drive circuitry on the Pulse Filter Driver board. This in turn dumps current into the pulse filter to fire the samplers to sample the incoming waveform.

- 1 Turn on the power to the mainframe with the plug-in extended.
- 2 Press the Setup key, then press the **Default setup** softkey.
- 3 Press the Trigger key, then set the **Sweep** softkey to **Freerun**.
- 4 Remove the plug-in's top rail and measure the Strobe Pulse where the signal comes onto the Pulse Filter Driver board through the SMA to board adapter. Refer to the Figure below "Plug-in View With Top Rail Removed."



**Plug-in View With Top Rail Removed**

5 The waveform on the monitor display should look like the waveform below.



**Strobe Pulse**

- 6 If the waveform is not present coming onto the Pulse Filter Driver board, verify that the mainframe is putting out the Strobe Pulse. If the Strobe Pulse is coming onto the Pulse Filter Driver board, verify that the Pulse Filter is outputting the Sampler Strobe.
- D If the Strobe Pulse is not getting to the Pulse Filter Driver board, check that the mainframe is putting out the Strobe Pulse.

- 1 Disconnect the Blind-mate extender cable from the mainframe and probe the Blind-mate connector in the mainframe.

The waveform should be about the same as above Figure "Strobe Pulse." If the Strobe Pulse is coming out of the mainframe, the mainframe is OK. Troubleshoot the cabling that goes to this connector. If the Strobe Pulse is NOT coming out of the mainframe, the mainframe has a problem, or the mainframe was not setup correctly.

- 2 Verify the mainframe Trigger is set to Freerun. Also verify that the samplers have not been disabled.

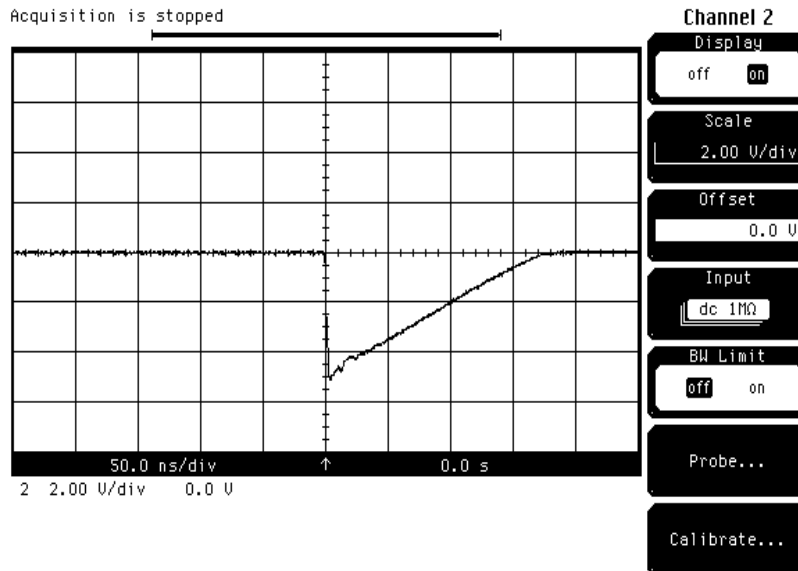
Press the Utility key, press the Calibration softkey, then verify that the Samplers softkey is set to **enabled**.

- E If the Strobe Pulse is not present, do the following five steps.

- 1 Press the Utility key, then press the **Declassify frame memory** softkey.
- 2 Turn the instrument off and back on.
- 3 Press the Setup key, then press the **Default setup** softkey.
- 4 Press the Trigger key, then set the **Sweep** softkey to **Freerun**.
- 5 Then check if the Strobe Pulse is present at the bottom blind-mate connectors in the mainframes plug-in cage.

If the Strobe Pulse is still not present at the lower blind-mate connectors, the mainframe has a problem. Replace the mainframe's Time base/Acquisition board assembly. (The mainframe must have a plug-in installed or attached to the extender ribbon cable to generate the the Strobe Pulses.)

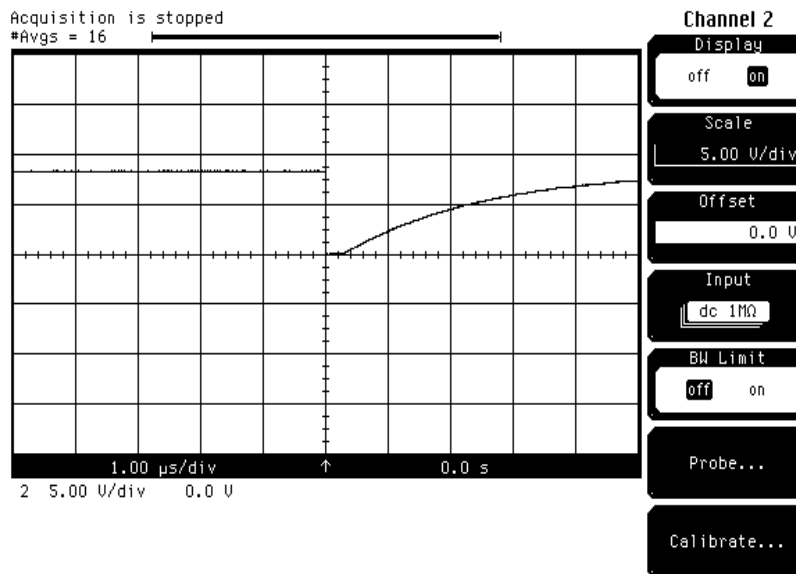
- F** If the Strobe Pulse is present at the bottom blind-mate connectors in the mainframe's plug-in cage, the mainframe is functioning and the problem is in the cable/connectors in the plug-in. Check the cables and connectors for the opens, shorts, and interfacing.
- G** If the Plug-in is receiving the Strobe Pulse, check an output of the Pulse Filter to see if the Pulse Filter Driver board and the Pulse Filter are functioning. The Pulse Filter has four output ports of which the plug-in uses only two. Remove the termination from the rear pulse filter port and carefully probe the port's center conductor. The waveform should be similar to waveform below. If the waveform is missing or significantly different, the Pulse Filter Driver board or the Pulse Filter are at fault.



**Sampler Strobe Waveform**

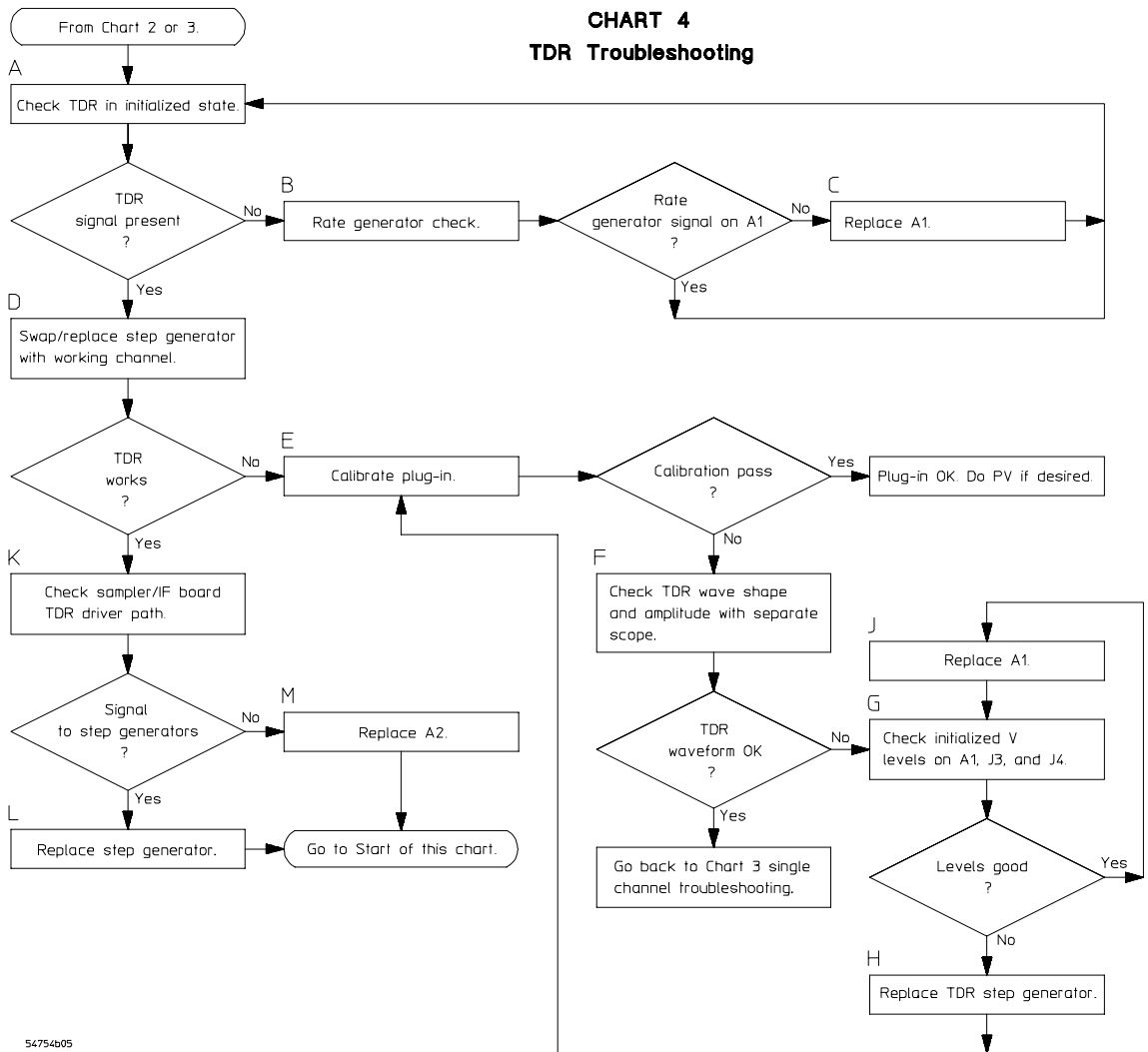
**H** If the Pulse Filter port output is bad, either the Pulse Filter Driver board or the Pulse Filter can be the problem. To isolate the problem to either the Pulse Filter Driver board or the Pulse Filter, check the Pulse Filter Driver board's output.

- 1 Turn off the power to the mainframe.
- 2 Remove the plug-in's top rail. To do this, remove the three screws at the top of the digital interface board, the two screws at the top of the sampling/IF amplifier board, and the six screws holding the top rail to the plug-in's front and rear panels.
- 3 Loosen the three screws that secure the bottom of the digital interface board to the bottom rail. Carefully tilt the digital board out. It is helpful to disconnect the two plug-in keyboard cables from the top-front of the board.
- 4 With the plug-in extended with the two extender cables, power up the mainframe. Probe the microwave transistor's collector lead. The collector is the lead that points toward the board fastening screws. The waveform should resemble waveform below.



**Pulse Filter Driver Output Waveform**

- 5 If the waveform is not correct, replace the Pulse Filter Driver. If the waveform is correct, the Pulse Filter Driver is working and the problem is in the Pulse Filter itself. Replace the failed item and return to Chart 1, Block A.
- I** If both samplers have been damaged by overvoltage, both channels may show the same failure much as a failure in a circuit common to both channels. Since the Pulse Filter is outputting a good Sampler Strobe pulse, the samplers may both have been damaged. If the new sampler fixes the channel, that confirms that both samplers have been damaged. If replacing the sampler does not fix the failed channel, problem is likely the Sampler/IF Amplifier board.
- J** If replacing the sampler in the failed channel does not fix the bad channel, replace the Sampler/IF Amplifier board assembly in the plug-in. After replacement, go to Chart 1, Block A.
- K** If replacing the first sampler fixes the first channel, it is likely that the second channel has a blown sampler also. Replace the sampler in the second channel and check the operation. Go back to Chart 1, Block A and check operation.



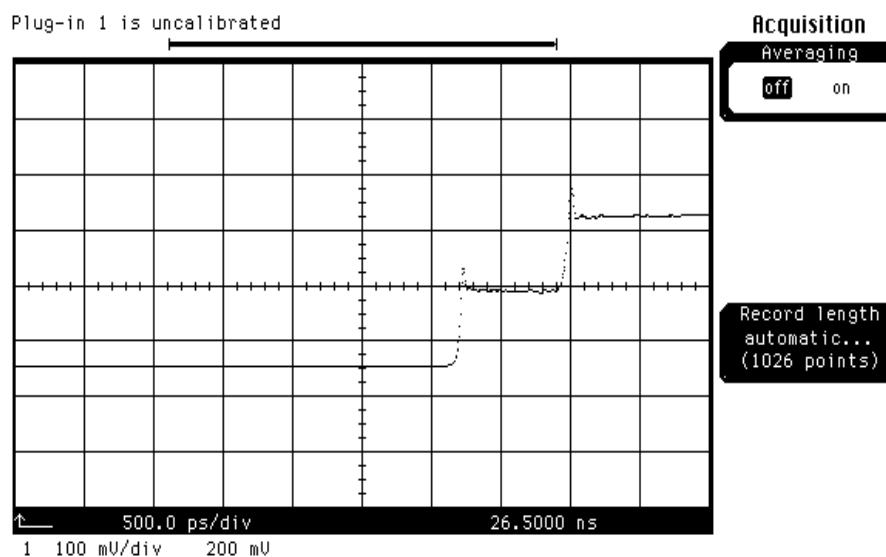
**TDR Troubleshooting Chart 4**

## Functional Failure Isolation 3

Use the following text to supplement the steps in chart 4. Refer to the block diagram in the Theory of Operations section to see signal flow.

### A Check the TDR when module is in the initialized state

- 1 If the TDR module is not in the initialized state, press the **Utility** key, the **Service** softkey, and the **Plug-in** softkey. Select the plug-in to be initialized, and press the **Initialize plug-in memory** softkey. The initializing takes about a minute.
- 2 Press the **TDR** key on the module and turn on the first or only TDR channel depending on which module you are troubleshooting. Press the **Preset TDR/TDT** softkey. Next press the **Acquisition** softkey and set Averaging to "off."
- 3 The waveform should look similar to the following figure.



### TDR waveform when the plug-in memory is initialized and Averaging is set to "off"

- 4 If the TDR module is a 54754A, check the second TDR channel also.
- B** If one or both of the TDR channel signals come on screen the rate generator on the digital interface board and the associated TDR rate buffer circuitry on the sampling/IF board is working, extend the plug-in using only the ribbon cable and check if the rate generator signal is present at A1J3 pin 10. This should be a 250 kHz pulse. One of the TDR channels must be turned on for this signal to be present.
- C** Replace the digital interface board A1 if the rate generator signal is not present. Re-initialize the plug-in after the digital interface board is replaced.
- D** If one TDR channel is functioning and the other channel is not functioning, swap the TDR step generators between the working and non-working channels. If the problem follows the TDR step generator, replace the defective TDR step generator. If both TDR channels are now functioning, try calibrating the plug-in. If the plug-in calibration is successful the plug-in is working.

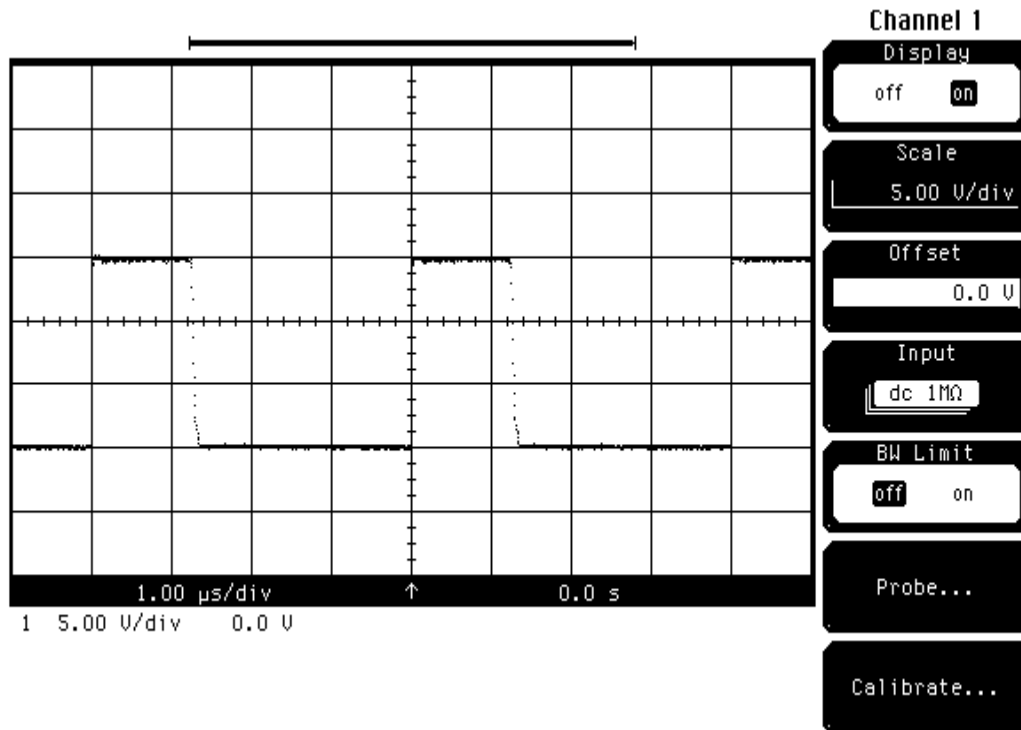
- E** Try to calibrate the TDR plug-in. Press the **Utility** key, the **Calibrate** softkey, the **Calibrate plug-in ...** softkey, and the **Start cal** softkey. Follow the instruction on the screen. If the calibration passes, and the unit is working, go to the Testing Performance section of this manual to check the performance to specifications. If the plug-in calibration fails, go to step F.
- F** Check the TDR waveshape, amplitude, and rise time. The waveshape is a step from 0 volts to 200 mV into 50 ohms. The rise time should be less than 45 ps. Check the TDR waveshape on a known good scope channel if necessary. If the TDR waveshape is good on a known good scope channel, but bad on the current channel, go back to Chart 3 and troubleshoot a single scope channel problem. If the TDR waveform is bad, go to step G.
- G** Check the initialized DAC voltage levels on A1J3 and J4. See the following table for the DAC voltage levels. The measurement points drawing on page 5-10 may also be helpful in locating the connector pins. If the levels are good go to step H. If the DAC voltage levels are not correct go to step J.

	pin number	signal name	V levels
<b>J4 levels</b>	1	tdrb_off~on	5V off/0V on
	2	tdrb_drive	-3V off/-3V on
	3	tdrb_bias_dac	2V off/2V on
	4	tdrb_top_dac	0V off/13.5V on
	5	tdrb_bottom_dat	0.8V off/-14V on
	6	chb_bw_dac	0.5V low BW/0.6V high BW
	7	nc	
	8	grd	
	9	chb_off_dac	0.9V off/0.9V on
	10	gnd	
	11	cha_off_dac	0.9V off/0.9V on
	12	gnd	
	13	stag_off~on	0V in tdr diff & common mode
	14	sync_b/~a	sq wave in diff & common mode
	15	cha_bw_dac	0.5V low BW/0.6V high BW
	16	tdra_bottom_dac	0.8V off/-14V on
	17	tdrA_top_dac	0V off/13.5V on
	18	tdra_bias_dac	2V off/2V on
	19	tdr_drive_dac	-3V off/-3V on
	20	tdra_off~on	5V off/0V on
<b>J3 levels</b>	8	-100mV/degreeC	approx -2.5V
	10	tdr_rate	250kHz sq wave when TDR is on
	12	tdr_rate~on/_off	0V off/5V on
<b>J6 levels</b>	5	srd_drive_dac	9V
	6	srd_bias	0.8V

**Approximate voltage levels on J1J3, J4, and J6 after plug-in memory is initialized**



- H** If the initialized DAC voltage levels are correct but the TDR waveform is distorted, replace the marginal TDR step generator. After replacing the step generator, go back to step E and try the plug-in calibration.
- J** If the initialized DAC voltage levels are not correct, replace the Digital Interface assembly A1. Re-initialize the plug-in memory and go back to step G to verify that the DAC voltage levels are now correct.
- K** Check the Sampler/IF board TDR driver signal path.
  - 1** Refer to the mechanical view of the TDR plug-in on page 7-4 and find W10 connected to J16 on the Sampler/IF board. Remove W10 from J16 and extend the plug-in using the ribbon cable and the Blindmate (OSP) extender cables, connect the Blindmante extender between the upper connector on the plug-in and the upper connector in the mainframe.
  - 2** Press the **Setup** key, the **Default setup** softkey, and the plug-in's **Setup TDR** key. Press the **Stimulus** softkey until "1 only" is highlighted and then press Enter.
  - 3** Connect an oscilloscope probe to J16. The waveform should look like the following screen shot.



**TDR Driver Waveform at J16**

- L** Replace the questionable TDR step generator. Then go to the beginning of this troubleshooting chart.
- M** If the signal is not present, replace the questionable parts, either the cabling or the Sampler/IF board. Then go to the beginning of this chart.



To return the instrument ██████ for service 6-4

To remove and replace

Covers 6-4

Front panel 6-5

Digital Interface Board 6-6

Sampler board and samplers/pulse filter/TDR step generators 6-6

Coaxial Interface Cables 6-8

Bus cable 6-9

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# Replacing Assemblies

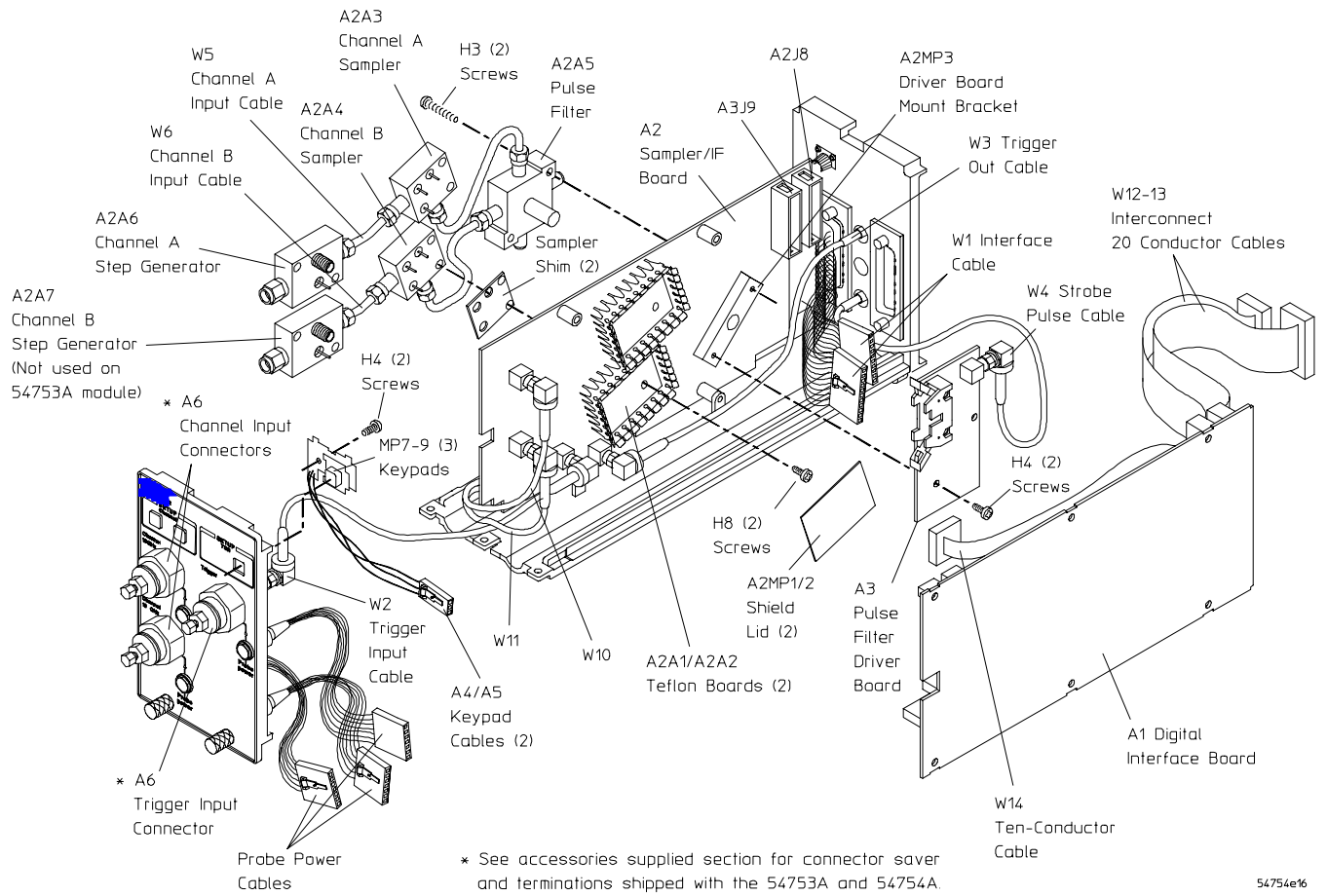
Use the procedures in this chapter when removing and replacing assemblies and parts in the plug-in.

## **ESD Precautions**

Use proper ESD precautions when using any of the procedures in this chapter. As a minimum, place the instrument on a properly grounded ESD mat and wear a properly grounded ESD wrist strap. Failure to take ESD precautions can cause immediate or potential failures in the instrument.

## **Tools Required**

- Torx driver: T10
- Open-end wrench: 10 mm
- Open-end wrench: 7/32 inch
- Socket wrench: 5/8 inch
- Pozidrive screwdriver: #1
- Connector removal tool AMP Tool No. 305141-4—for output connectors
- Torque wrench: 5 in/lb, 5/16 inch
- Torque wrench: 8 in/lb, 5/16 inch
- 1/4 inch open-end wrench
- 6 mm open-end wrench
- Finger cots



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**Plug-in Part Locations**

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## To return the instrument for service

- 1** Write the following information on a tag and attach it to the instrument.
  - Name and address of owner
  - Instrument model numbers
  - Instrument serial numbers
  - Description of the service required or failure indications
- 2** Remove all accessories from the instrument.

Accessories include all cables. Do not include accessories unless they are associated with the failure symptoms.
- 3** Protect the instrument by wrapping it in plastic or heavy paper.
- 4** Pack the instrument in foam or other shock absorbing material and place it in a strong shipping container.

You can use the original shipping materials or order materials from an sales office. If neither is available, place 3 to 4 inches of shock-absorbing material around the instrument and place it in a box that does not allow movement during shipping.
- 5** Seal the shipping container securely.
- 6** Mark the shipping container as FRAGILE.

In any correspondence, refer to the instrument by model number and full serial number.

---

## To remove and replace the covers

A cover comes off more easily when it is released one edge at a time.

- 1** With a small screwdriver, pry up at one of the rear corners of the cover.
- 2** Once a corner is free, lift the cover so that nearly one entire edge is loose.
- 3** Starting at the other rear corner, lift the other side of the cover.
- 4** When both edges of the cover are loose, remove the front edge of the cover from under the edge of the front panel.
- 5** To replace the cover, reverse the procedure.

---

## To remove and replace the front panel

You must remove the front panel to replace the keyboard.

### Front Panel

- 1 Remove the side covers.
- 2 Remove the top rail by removing the 6 screws that secure it to the front and rear castings. Remove the 2 screws that secure the top of the digital interface and sampler IF board assemblies.
- 3 Disconnect the 2 step generators or semi-rigid cable from the bulk-head connectors.
- 4 Disconnect the trigger input SMA cable from the bulk-head connector.
- 5 Remove the 2 screws that secure the front panel to the bottom rail.
- 6 Disconnect the probe and auxiliary power cables and setup channel keys from the digital board.
- 7 To replace the front panel reverse the procedure, taking note of the following:
  - Auxiliary power cable connects to J7
  - (A) channel probe power connects to J9
  - (B) channel probe power connects to J10
  - (A) keyboard cable connects to J1
  - (B) (TDR) keyboard cable connects to J2

### Input Connectors

Use a 5/8-in open-end wrench to remove the rear nut and lockwasher that hold each APC 3.5 bulk head connector to the front panel.

### Keyboard

Remove the keyboard screw and lift the keyboard off the keypad.

---

**CAUTION**

---

Be careful not to contaminate the key side of the PC board or the keypads. Dust or fingerprints on these parts may cause intermittent key operation.

## To remove and replace the digital interface board

- 1 Remove the side covers.
  - 2 Remove the top rail.
    - a Remove the 3 screws that secure the digital board to the top rail.
    - b Remove the 2 screws that secure the sampler/IF board to the top rail.
    - c Remove the 5 screws that secure the top rail to the front and rear frames.
  - 3 Remove the three screws that secure the digital board to the bottom rail.
  - 4 Swing the digital board out and disconnect the various cables:
    - a Disconnect the 2 three-conductor keyboard cables.
    - b Disconnect the 3 probe power cables.
    - c Disconnect the ten-conductor ribbon cable going from the digital board to the pulse filter driver board.
    - d Disconnect the two ribbon cables going to the sampler board.
    - e Disconnect the two connectors that go to the interface cable.
  - 5 Set the module ID switches and the temp comp switches to proper settings. See the Digital Interface Board switch settings diagram on page 6-7 for more information.
  - 6 To reassemble the plug-in, reverse the above procedure.
- 

## To remove and replace the sampler board and samplers/pulse filter/TDR step generators

- 1 Remove the side covers.
- 2 Remove the top rail as described in step 2 above.
- 3 Remove the digital board as described in steps 3 and 4 above.
- 4 Disconnect the channel 1 and 2 TDR step generators or semi-rigid cable from the samplers and input connectors.
- 5 Disconnect the strobe pulse cable from the pulse filter driver board.
- 6 Remove the 2 screws that secure the bottom of the sampler/IF board to the bottom casting.
- 7 Swap the step generators, samplers, Teflon boards, and pulse filter to the new sampler/IF board.
  - a Remove the step generators.
  - b Remove the 2 semi-rigid cables between the pulse filter and the samplers.

---

### CAUTION

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The samplers are very susceptible to ESD damage. Use ESD precautions while disassembling the sampling assembly. Also the Teflon sub-boards inside the shields are special low-leakage assemblies, therefore use finger cots when handling these assemblies to keep finger oils off boards. Contamination will cause leakage paths.

- c Remove the shield covers and remove the 2 screws that secure each of the samplers to the board.
  - d Remove the the Teflon sub-boards A2A1 and A2A2. Use a non-metallic tweaker to reach through the sampler-pin holes to press out the Teflon sub-boards.
  - e Remove the 2 screws that secure the pulse filter driver board to the pulse filter spacer.
-



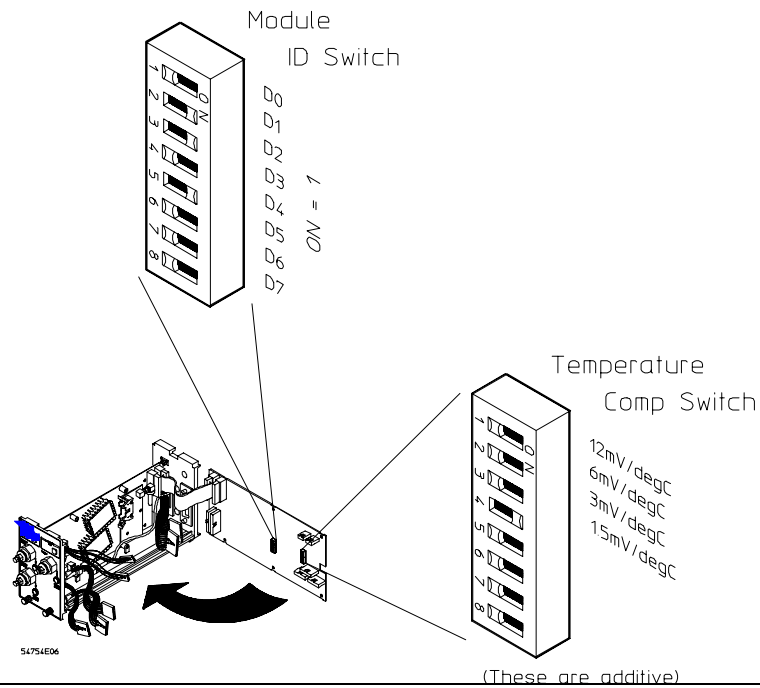
**To remove and replace the sampler board and samplers/pulse filter/TDR step generators**

- f Remove the 2 screws securing the pulse filter to the sampler/IF board and pulse filter spacer.
- 8 To reinstall the sampler board follow the above instructions in reverse order.
- 9 Torque all SMA connectors to 5 inch/lbs.

**Digital Interface Board switch settings**

Model	switch # decimal	d7 128	d6 64	d5 32	d4 16	d3 8	d2 4	d1 2	d0 1
54752A	24	0	0	0	1	1	0	0	0
54752B	25	0	0	0	1	1	0	0	1
54753A	20	0	0	0	1	0	1	0	0
54754A	22	0	0	0	1	0	1	1	0
83484A	26	0	0	0	1	1	0	1	0
83484B	27	0	0 </td <td>0</td> <td>1</td> <td>1</td> <td>0</td> <td>1</td> <td>1</td>	0	1	1	0	1	1

Set the Module ID switch settings to match the model number of the plug-in. On = 1.



**Temperature Compensation switch settings**

Fall time	12 mV/deg C	6 mV/deg C	3 mV/deg C	1.5 mV/deg C
< 41 ps	0	0	0	1
41 to 43.9 ps	0	0	1	0
44 to 46.9 ps	0	0	1	1
≥ 47 ps	0	1	0	0

Set the temperature compensation switches according to the table depending on the pulse filter fall time label. For example, the label may read 43/9.7, where 43 is the fall time and 9.7 is the amplitude. On = 1.

---

## To remove and replace the plug-in rear panel coaxial interface cables

You need a special tool to remove these cables from the rear panel.

- AMP Tool No. 305141-4

The coaxial interface cables are held in the rear panel by tapered snap rings that expand once they pass the shoulder in the mounting hole. The special tool compresses the snap ring and pushes the connector out of its mounting.

The connectors in the rear panel are spring loaded so they mate firmly with the connectors at the rear of the plug-in compartment.

### 1 Remove the side covers.

At the rear panel, there are two OSP (blindmate) coaxial cable connectors.

- a The lower coaxial cable is the strobe pulse cable that connects to the pulse filter driver board.
- b The upper coaxial cable is the trigger cable that connects to the trigger input connector on the front panel.

### 2 Remove the digital interface board using the instructions earlier in this chapter.

Disconnect both the trigger cable and the strobe pulse cable from their respective connectors.

### 3 Remove the 6 screws that secure the rear panel so the rear panel can be removed.

### 4 Remove and replace the rear-panel connector.

- a To remove, slide the special tool over the rear of the connector.
- b While pushing the tool on, rotate it slightly to slip it over the locking ring.
- c Push on the tool plunger to extract the connector.

Pushing the plunger first takes up the spring in the connector, then pushes the connector past the mounting hole shoulder. A very firm force is necessary to remove the connector.

- d To replace, set the connector into the rear panel hole.
- e Use a blunt tool to force the connector to lock in the rear panel.

Push on the connector, not on the cable. Pushing the cable could damage it and cause problems.

- f Make sure the connector is locked and won't fall out.

Use the handle end of a screw driver and push on the connector from the rear, enough to completely compress the spring tension on the connector.

### 5 Reverse steps 3 through 1 to reassemble the plug-in.

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**CAUTION**

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## To remove and replace the bus cable

Just a couple of pointers are needed.

- Use a #1 pozi-drive screwdriver to remove and replace this cable.
- The D-shell connector is designed to move freely on its mounting screws. The length of the screws is selected so they bottom in the mounting hole and allow the connector shell to float.

---

### **CAUTION**

If the bus connector does not float, it may interfere and cause damage when the plug-in is installed in the mainframe. When replacing the connector, use the same hardware you removed.

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Ordering Replaceable Parts 7-2  
  Listed Parts 7-2  
  Unlisted Parts 7-2  
  Direct Mail Order System 7-2  
  Exchange Assemblies 7-2  
Mechanical View 7-3  
Replaceable Parts List 7-5

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# Replaceable Parts

This chapter contains information for ordering parts. Service support for this instrument is replacement of parts to the assembly level. The replaceable parts include assemblies and chassis parts.

---

## Ordering Replaceable Parts

### Listed Parts

To order a part in the parts list, quote the part number, indicate the quantity desired, and address the order to the nearest Sales/Service Office.

### Unlisted Parts

To order a part not listed in the parts list, include the instrument part number, instrument serial number, a description of the part (including its function), and the number of parts required. Address the order to the nearest Sales/Service Office.

### Direct Mail Order System

- Direct ordering and shipment from the parts center in California, USA.
- No maximum or minimum on any mail order (there is a minimum amount for parts ordered through a local sales office when the orders require billing and invoicing).
- Prepaid transportation (there is a small handling charge for each order).
- No invoices.

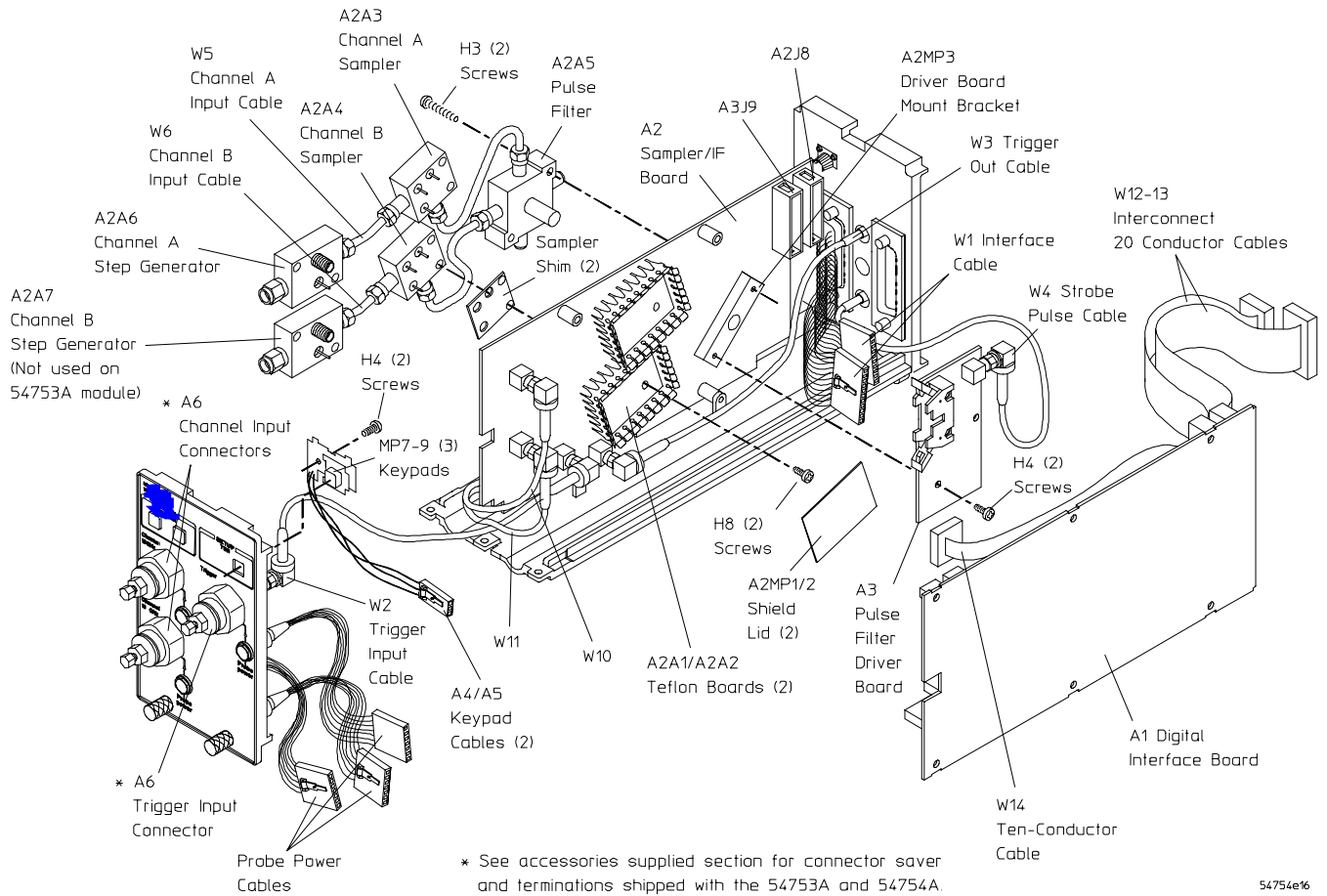
In order to provide these advantages, please send a check or money order with each order.

Mail order forms and specific ordering information are available through your local sales office. Addresses and telephone numbers are located in a separate document shipped with the manuals.

### Exchange Assemblies

Some parts used in this instrument have been set up for an exchange program. This program allows the customer to exchange a faulty assembly with one that has been repaired, calibrated, and performance-verified by the factory. The cost is significantly less than that of a new part. The exchange parts have a part number in the form XXXXX-695XX.

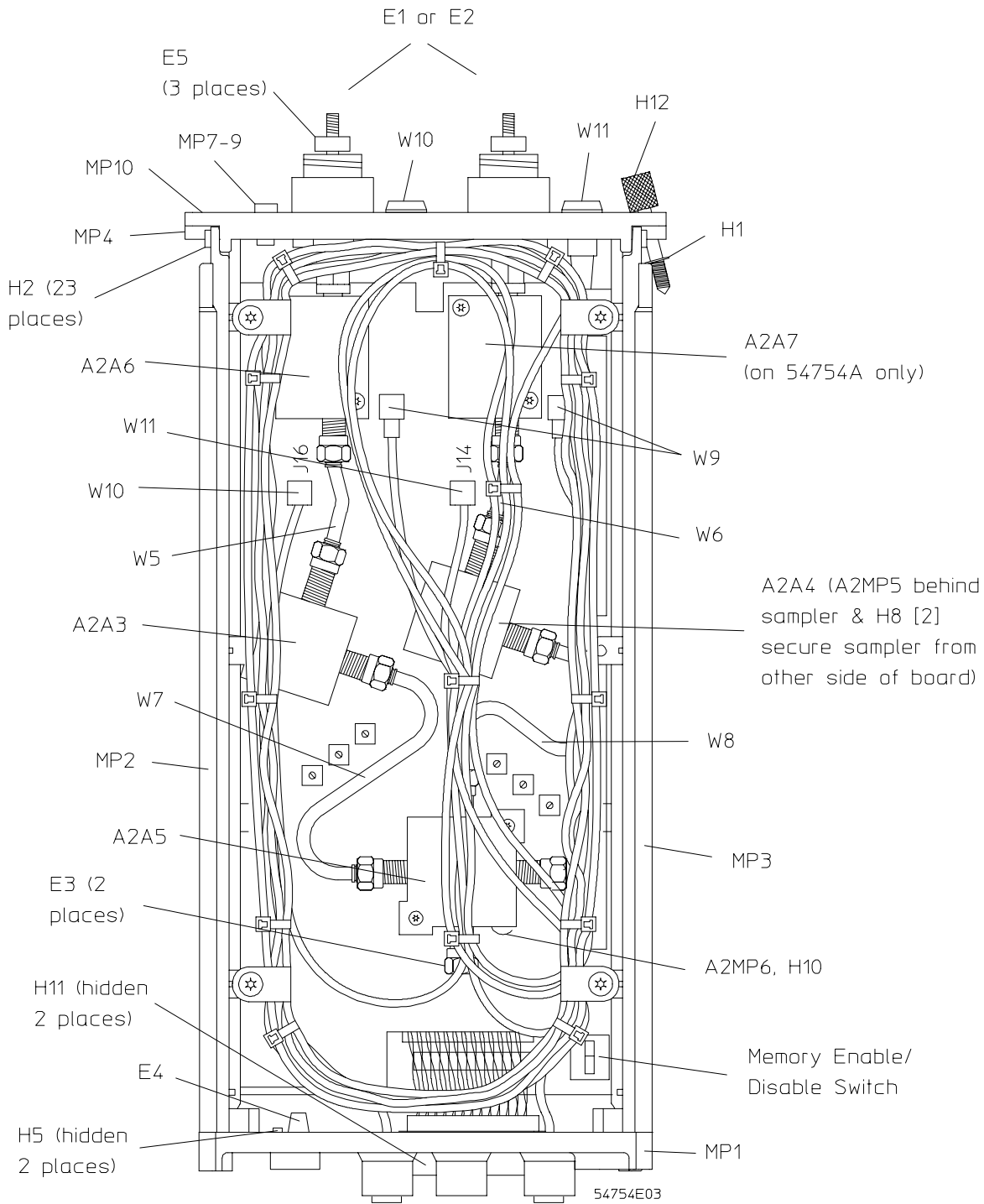
After receiving the repaired exchange part a United States customer has 30 days to return the faulty assembly. For orders not originating in the United States, contact the local service organization. If the faulty assembly is not returned within the warranty time limit, the customer will be charged an additional amount. The additional amount will be the difference in price between a new assembly and that of an exchange assembly.



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**Mechanical View**

Replaceable Parts  
**Ordering Replaceable Parts**



**Mechanical View**



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## Replaceable Parts List

The following table is a list of replaceable parts and is organized as follows:

- Exchange assemblies in alphanumerical order by reference designation.
- Electrical assemblies in alphanumerical order by reference designation.
- Chassis-mounted parts in alphanumerical order by reference designation.

The information given for each part consists of the following:

- Reference designation.
- part number.
- Total quantity (QTY) in instrument or on assembly. The total quantity is given once and at the first appearance of the part number in the list.
- Description of the part.

Replaceable Parts  
**Replaceable Parts List**

---

**Replaceable Parts**

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Ref. Des.	Part Number	QTY	Description
EXCHANGE ASSEMBLIES			
A2A3	5086-6699	1	REBUILT SAMPLER ASSEMBLY
A2A4	5086-6699	1	REBUILT SAMPLER ASSEMBLY
A2A6	5086-6471	1	REBUILT TDR STEP GENERATOR
A2A7	5086-6471	1	REBUILT TDR STEP GENERATOR (not present on 54753A)
ELECTRICAL ASSEMBLIES			
A1	54754-66501	1	BD ASSY-DIGITAL INTERFACE
A2	54754-66502	1	BD ASSY-SAMPLER/IF (Does not include Teflon boards A1A2, A2A2, samplers A2A3, A2A4, pulse filter A2A5, or TDR step generators A2A6, A2A7)
A3	83481-60003	1	BD ASSY-PULSE FILTER DRIVER
A4	54710-66512	1	MODULE KEYBOARD
A5	54710-66512	1	MODULE KEYBOARD
A6	5062-1247	3	CONNECTOR ASSEMBLY, CHANA, CHANB, TRIGGER
A2A1	54751-60022	1	BD ASSY-TEFLON BD
A2A2	54751-60022	1	BD ASSY-TEFLON BD
A2A3	5086-7699	1	SAMPLER
A2A4	5086-7699	1	SAMPLER
A2A5	5086-7461	1	PULSE FILTER
A2A6	5086-7471	1	TDR STEP GENERATOR
A2A7	5086-7471	1	TDR STEP GENERATOR (not present on 54753A)
A2MP1	83481-00001	1	SHIELD-LID
A2MP2	83481-00001	1	SHIELD-LID
A2MP3	83481-20006	1	MT BRKT-PULSE FILTER DRIVER BOARD
A2MP4	83481-20008	1	SHIM-SAMPLER
A2MP5	83481-20008	1	SHIM-SAMPLER
A2MP6	83481-20024	1	TEM-SENSOR CLAMP
A2MP7	54754-24701	1	Shim-TDR Step Generator
A2MP8	54754-24701	1	Shim-TDR Step Generator (deleted on 54753A)
CHASSIS PARTS			
E1	1250-2153	2	TERMINATION 50 OHM SMA (m)
E2	0960-0055	1	SMA SHORTS (m)
E3	1810-0118	2	TERM M SMA 50 OHM
E4	5001-5840	1	GROUNDING SPRING
E5	5061-5311	3	APC-3.5 (f) TO APC-3.5 (f)
H1	0510-0166	2	RETAINER RING
H2	0515-0372	23	MS M3 8MM-LG PAN-HD T10
H3	0515-0375	2	MS M3 X 0.5 16MM-LG
H4	0515-0430	4	MS M3 6MM-LG PAN-HD T10
H5	0515-0894	2	MS M2.5X0,45 6MM LG
H7	2190-0104	3	WSHR LK .439 ID
H8	2360-0526	4	SCREW-MACH 4-40 .312-IN-LG PAN
H9	2950-0132	3	HEX NUT 7/16 - 28
H10	2950-0216	1	NUT-HEX-DBL-CHAM 5/16
H11	5041-9448	2	SCR-TPG 2-56
H12	5062-7543	2	SCREW - MODULE RETAINING
MP1	5041-9424	1	FRAME (rear)

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**Replaceable Parts**

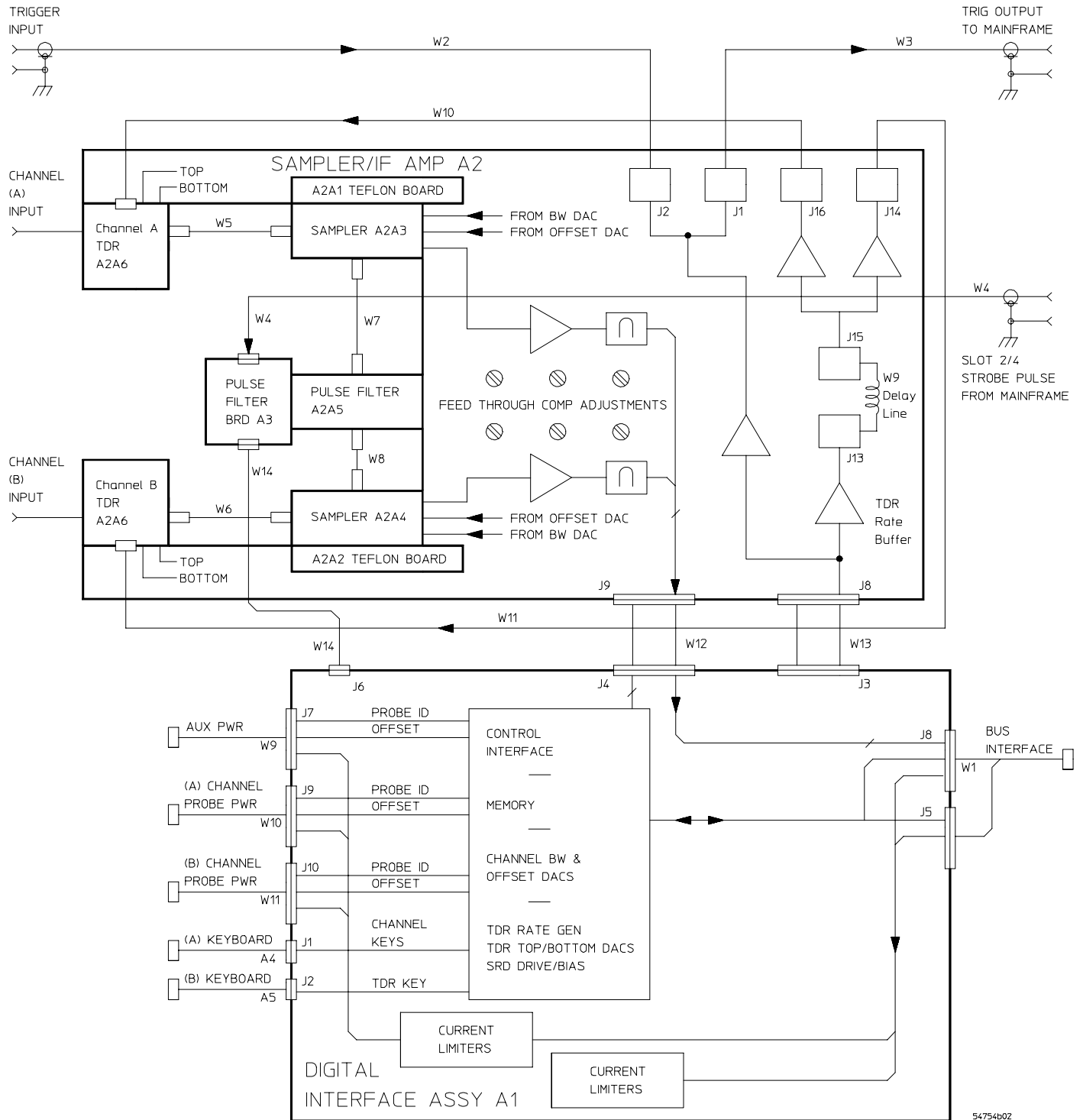
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MP2	5041-9425	1	RAIL DUAL (top)
MP3	5041-9425	1	RAIL (bottom)
MP4	5042-1002	1	FRONT FRAME
MP5	5062-7344	1	COVER - SIDE
MP6	5062-7344	1	COVER - SIDE
MP7	54714-41903	1	SINGLE KEYPAD
MP8	54714-41903	1	SINGLE KEYPAD
MP9	54714-41903	1	SINGLE KEYPAD
MP10	54754-94301	1	LABEL, FRT PANEL, "54754A"
MP10	54753-94301	1	LABEL, FRT PANEL, "54753A"
W1	5062-7322	1	D SHELL INTERFACE CABLE ASSEMBLY
W2	E1427-61606	1	CA ASSY-TRIGGER INPUT
W3	54717-61601	1	CABLE, COAX-TRIGGER OUTPUT
W4	83481-60007	1	CABLE, COAX - REAR PANEL TO PULSE FILTER BOARD
W5	54754-61605	1	CABLE-RF-CH1 INPUT
W6	54754-61606	1	CABLE-RF-CH2 INPUT 54754A only)
W6	54753-61601	1	CABLE-RF-CH2 INPUT 54753A only)
W7	54754-61607	1	CABLE-RF-CH1 SMPLR-PULSE FLTR 54754A only)
W7	54753-61602	1	CABLE-RF-CH1 SMPLR-PULSE FLTR 54753A only)
W8	54754-61608	1	CABLE-RF-CH2 SMPLR-PULSE FLTR
W9	54754-61609	1	CABLE-DELAY LINE (10 FEET)
W10	54754-61612	1	CABLE-DELAY LINE-3 FT
W11	54754-61612	1	CABLE-DELAY LINE-3 FT 54754A only)
W12/13	54754-61610	2	CABLE-RIBBON 20 CONDUCTOR
W14	54754-61602	1	CABLE-RIBBON 10 CONDUCTOR
W15	54710-61605	1	PROBE POWER CBL ASSY
W16	54710-61605	1	PROBE POWER CBL ASSY
W17	54710-61605	1	PROBE POWER CBL ASSY



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# Theory of Operation



## Block Diagram

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# Theory of Operation

The 54753A / 54754A TDR Modules are plug-in modules for use with the 54750A High Bandwidth Oscilloscope and the 83480A Digital Communications Analyzer mainframes.

The 83480A mainframe must have firmware option 54755A installed. These TDR plug-ins occupy two slots and have two oscilloscope channels that are selectable between 18 GHz and 12.4 GHz bandwidths. The 54753A's non-TDR channel's bandwidth is 20 GHz and 12.4 GHz. The plug-in is triggered by a 2.5 GHz external trigger. The plug-ins have an internal rate generator that clocks the internal TDR step generators in the TDR/TDT modes at selectable rates. The two channel inputs and the trigger input are 3.5 mm connectors.

Three additional connectors provide power/control and identification for using a 54701A active probe on the two channel inputs and the trigger input. Two front panel menu keys call up the setup menus for their respective input channels.

TDR (time domain reflectometry) sends a very fast edge down a transmission line to a test device and then measures the reflections from that device. The measured reflections are very useful in determining where discontinuities exist so modifications can be made.

TDT (time domain transmission) measurements are made by passing an edge through a test device. Parameters typically measured are gain and propagation delay.

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## Channel Signal Path

**Primary components** The primary signal path components in the plug-in are the samplers and sampler drive circuitry, the two charge amplifiers, and IF filters in the plug-in. The signal path components in the mainframe are the track and hold, the A/D, and the FIFO memory. In the TDR mode, the TDR step generator/s insert a 200 mV step in the scope channel/s. The mainframe is triggered by the rate generator in the plug-in.

**Sampler and Sampler Drive Circuitry** Sampler drive circuitry receives the strobe pulse from the mainframe via the lower blind-mate connector and cable. The strobe pulse is carried to the Pulse Filter board, A3, which drives Pulse Filter, A7, which drives the two samplers in the plug-in. When the sampler is strobed it outputs a charge that is proportional to the difference between the offset voltage and the input signal at that moment in time.

**Charge Amplifier and IF Filter** The difference charge from the sampler is amplified and converted into a bi-polar pulse by the charge amplifier and IF filters located in the plug-in. This bi-polar pulse is sent back into the mainframe where it goes to the track and hold circuits.

**Mainframe Track and Hold, A/D, and FIFO Memory** (See the mainframe theory of operation.) The mainframe track and hold circuits follow the amplitude of the bi-polar pulse. When the pulse reaches peak amplitude, the track and hold circuit holds the peak analog value. The A/D converters convert the track and hold's level to a 12-bit digital word. These 12-bit words are then put into a FIFO memory which are then processed by the CPU.

**High Frequency Trigger** The high frequency trigger provides a single trigger channel. The switch in the mainframe selects between the trigger input from the plug-in in slot 1-2 or the plug-in in slot 3-4. This trigger signal is carried to the mainframe by the upper blind-mate connector.

**TDR Circuitry** The TDR circuitry is made up of TDR step generators in the scope signal channel/s. In the TDR mode, the 200 mV step is inserted into the respective scope channel/s so the incident step and reflected signal can be viewed by the scope channel. In the TDT mode, the 200 mV step is output by the one channel and viewed by a second channel after passing through the device under test.

The repetition rate of the step generator is variable. The repetition rate is controlled by the rate generator on the digital interface board. The rate signal is connected to the sampler/IF board by interface cable W13. The rate buffer amps on the sampler/IF board feed the rate signal to 1) the delay line W9 and 2) the signal-launch located by connectors A2J1/J2. From the signal-launch, the rate signal is feed to the mainframe's trigger circuit, by the trigger output cable W3, to control the system acquisition cycle. The delayed rate signal from delay line W9 is buffered again before it feeds cables W10/W11, on the 54754A, or just W10 on the 54753A. These cable/s feed their respective step generator/s in the respective scope channel/s. Delaying the step signal allows the scope's acquisition system to begin acquiring data before the step occurs.

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## Digital Interface

The digital interface provides communication and control between the plug-in and the Module Interface Bus (MIB) in the mainframe. Along with other circuitry, the interface is located on the interface PC assembly. The digital interface provides the following functions.

**Interface Communication** The data interface with the MIB in the mainframe is serial. The digital interface converts serial data and address from the MIB to parallel for the plug-in and converts parallel data and address in the plug-in to serial for the MIB. In addition to the two data/address lines (one for input and one for output), the mainframe uses six other lines to communicate with the MIB.

**Digital-to-Analog Converters** A sixteen-bit DAC drives a current source as offset signals to the samplers. When a channel probe is installed, the output of the DAC drives a current source for the channel probe offset. The voltage output of the DAC is converted to a current for the probe.

**Memory** Plug-in memory is used for calibration factors, plug-in statistics (such as model and serial numbers), and calibration status (temperature, date, time, etc). The memory IC is an 8k by 8 EEPROM.

**Channel Key** Pressing the channel key sets a status bit and initiates an interrupt of the CPU in the mainframe.



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## Probe Power

There are two front panel connectors for probe power and control; one for each of the two channel probes. Each connector provides the six lines shown below, with a seventh line as a spare.

**Two probe identification lines** The probe pulls these lines low to inform the system of the attenuation factor of the probe. The state of each line is latched in the control interface. A change in the state of a line initiates an interrupt.

Since the circuitry senses the presence and type of probe, each probe power connector is associated with a given plug-in and function (channel or trigger). Probes must be connected to the proper probe power connector and not switched. Switched probe power cables may cause improper setup of the channel or trigger paths.

**An offset line** A DAC, followed by a voltage-to-current converter, provides a variable current for offset in active probes.

**Two power supply lines** These are  $\pm 17$  V supplies for active probes. The current is limited to approximately 400 mA maximum for each supply pin on each connector.

**Ground** This is ground for the probe power lines. Probe signal ground is through the signal coaxial cable.

In addition, there is an Aux power connector that supplies only the two power supply lines and ground.

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## Power Supplies

The mainframe supplies are  $\pm 17$  V, +15 V, and  $\pm 7$  V. The other supplies are regulated into  $\pm 15$  V,  $\pm 7$  V, and +5 V<sub>ref</sub>. The  $\pm 17$  V supplies are also current limited and fed to the probe power connectors.

