

User Manual



80E07, 80E08, 80E09, and 80E10 Electrical Sampling Remote Modules

071-2038-01

This document applies to firmware version 2.5X
and above.

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General Safety Summary

Review the following safety precautions to avoid injury and prevent damage to this product or any products connected to it.

To avoid potential hazards, use this product only as specified.

Only qualified personnel should perform service procedures.

While using this product, you may need to access other parts of a larger system. Read the safety sections of the other component manuals for warnings and cautions related to operating the system.

To Avoid Fire or Personal Injury

Connect and Disconnect Properly. Do not connect or disconnect probes or test leads while they are connected to a voltage source.

Ground the Product. This product is indirectly grounded through the grounding conductor of the mainframe power cord. To avoid electric shock, the grounding conductor must be connected to earth ground. Before making connections to the input or output terminals of the product, ensure that the product is properly grounded.

Observe All Terminal Ratings. To avoid fire or shock hazard, observe all ratings and markings on the product. Consult the product manual for further ratings information before making connections to the product.

Do not apply a potential to any terminal, including the common terminal, that exceeds the maximum rating of that terminal.

Do Not Operate Without Covers. Do not operate this product with covers or panels removed.

Do Not Operate With Suspected Failures. If you suspect there is damage to this product, have it inspected by qualified service personnel.

Avoid Exposed Circuitry. Do not touch exposed connections and components when power is present.

Wear Eye Protection. Wear eye protection if exposure to high-intensity rays or laser radiation exists.

Do Not Operate in Wet/Damp Conditions.

Do Not Operate in an Explosive Atmosphere.

Keep Product Surfaces Clean and Dry.

Terms in this Manual

These terms may appear in this manual:



WARNING. *Warning statements identify conditions or practices that could result in injury or loss of life.*



CAUTION. *Caution statements identify conditions or practices that could result in damage to this product or other property.*

Symbols and Terms on the Product

These terms may appear on the product:

- DANGER indicates an injury hazard immediately accessible as you read the marking.
- WARNING indicates an injury hazard not immediately accessible as you read the marking.
- CAUTION indicates a hazard to property including the product.

The following symbol(s) may appear on the product:

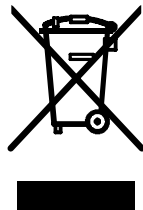


Environmental Considerations

This section provides information about the environmental impact of the product.

Observe the following guidelines when recycling an instrument or component:

Equipment Recycling. Production of this equipment required the extraction and use of natural resources. The equipment may contain substances that could be harmful to the environment or human health if improperly handled at the product's end of life. In order to avoid release of such substances into the environment and to reduce the use of natural resources, we encourage you to recycle this product in an appropriate system that will ensure that most of the materials are reused or recycled appropriately.



The symbol shown to the left indicates that this product complies with the European Union's requirements according to Directive 2002/96/EC on waste electrical and electronic equipment (WEEE). For information about recycling options, check the Support/Service section of the Tektronix Web site (www.tektronix.com).

Restriction of Hazardous Substances

This product has been classified as Monitoring and Control equipment, and is outside the scope of the 2002/95/EC RoHS Directive. This product is known to contain lead, cadmium, and hexavalent chromium.

Preface

This is the user manual for the 80E07, 80E08, 80E09, and 80E10 remote sampling modules. It covers the following information:

- Description of the capabilities of the sampling modules and how to install them
- Explanation of how to operate the sampling modules: how to control acquisition, processing, and input/output of information
- List of the specifications of the sampling modules

You may want to visit the Tektronix Website at <http://www.tektronix.com> for the latest revision of the user documentation. Select the Manuals link, then enter the part number or product name to locate the document.

A printed version of this manual is also orderable (see *Optional Accessories* on page 4).

NOTE. Using the 80E07, 80E08, 80E09, or 80E10 modules in a main instrument that is not using product software version 2.5 or greater may cause the application to fail to start.

To display the version installed, select *About* from the Help menu of the main instrument.

Manual Structure

This manual is composed of the following chapters:

- *Getting Started* shows you how to configure and install your sampling module.
- *Operating Basics* describes controlling the sampling module using the front panel and the instrument user interface.
- *Reference* provides additional TDR information.
- *Specifications* provide a list of guaranteed and typical specifications.

Related Manuals

For information of the main instrument in which the sampling module is used, refer to the documents and online help provided with your main instrument. The programming commands for these modules are listed in the programmer guide for the main instrument.

Getting Started

The Tektronix 80E07, 80E08, 80E09, and 80E10 remote sampling modules are high-performance sampling modules that can be installed in the following instruments:

- DSA8200 Digital Serial Analyzer
- CSA8000, CSA800B, and CSA8200 Communications Signal Analyzers
- TDS8000, TDS8000B, and TDS8200 Digital Sampling Oscilloscopes

Proper operation of the electrical sampling modules requires that product software version 2.5 or greater be installed on the main instrument.

NOTE. *The main instrument may not boot properly if an 80E07, 80E08, 80E09, or 80E10 module is installed into a main instrument that is using product software version 2.4 or earlier.*

To display the version installed, select *About* from the Help menu of the main instrument.



CAUTION. *To prevent electrostatic damage to the instrument and sampling modules, follow the precautions described in this manual and the manuals accompanying your instrument. (See Electrostatic Discharge on page 8.)*

Product Description

The electrical sampling modules are high-bandwidth sampling acquisition modules or sampling TDR modules suitable for use in a variety of test and measurement applications and systems.

Key features include:

- Two channels of mid-to-high bandwidth sampling acquisition.
- Remote channel modules are attached to the main unit through cables, allowing placement of the sampler or sampler/TDR closer to the unit under test.
- User-selectable bandwidth.
- Independent channel delay.
- Differential and common-mode TDR with independently controllable polarity and step deskew on each channel (80E08 and 80E10 modules only).
- Fast TDR step speeds (80E08 and 80E10 modules only).

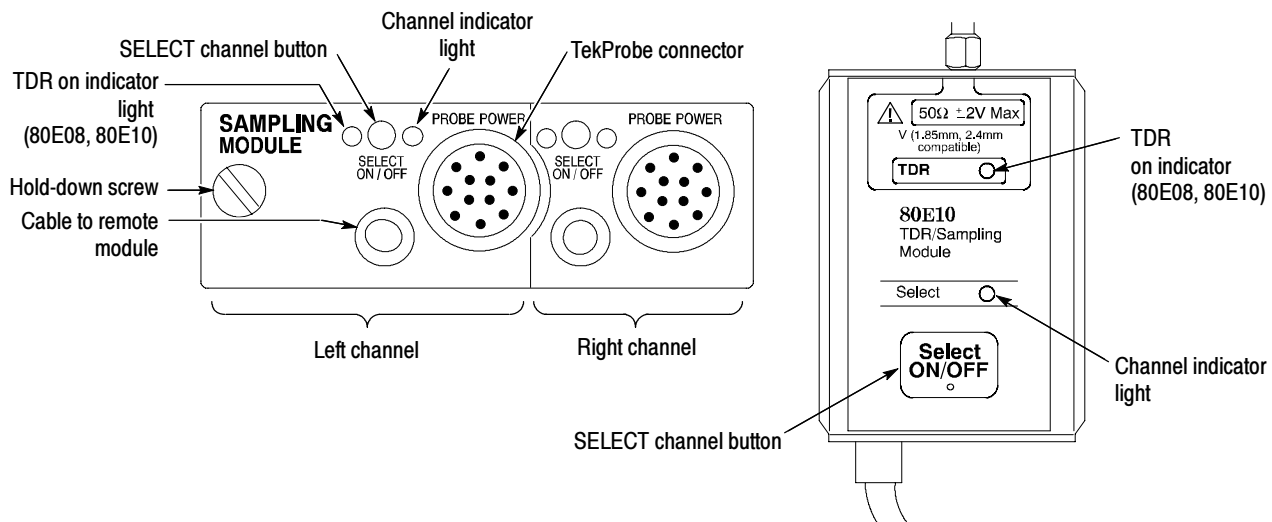


Figure 1: Sampling main module and remote module, 80E10 shown

The sampling modules provide the features shown in Table 1.

Table 1: Sampling module features

Feature	80E07	80E08	80E09	80E10
Number of independent channels	2	2	2	2
Number of TDR channels	N.A.	2	N.A.	2
Bandwidth ¹	30 GHz	30 GHz	60 GHz	50 GHz
Selectable bandwidths	20 GHz, 30 GHz	20 GHz, 30 GHz	40 GHz, 30 GHz, 60 GHz	40 GHz, 30 GHz, 50 GHz
Vertical sensitivity, full scale	1 mV per div (min) 100 mV per div (max)	1 mV per div (min) 100 mV per div (max)	1 mV per div (min) 100 mV per div (max)	1 mV per div (min) 100 mV per div (max)
Signal connectors	2.92 mm (K) female	2.92 mm (K) female	1.85 mm (V) female	1.85 mm (V) female

¹ Refer to the specification section for complete details on risetime, bandwidth, and noise.

The 80E07, 80E08, 80E09, and 80E10 remote sampling modules have two independent channels, each with its own acquisition circuitry.

The strobe drive signal from the instrument controls the timing of the strobe assertion to each acquisition system. This guarantees sampling coincidence between the two channels of a sampling module.

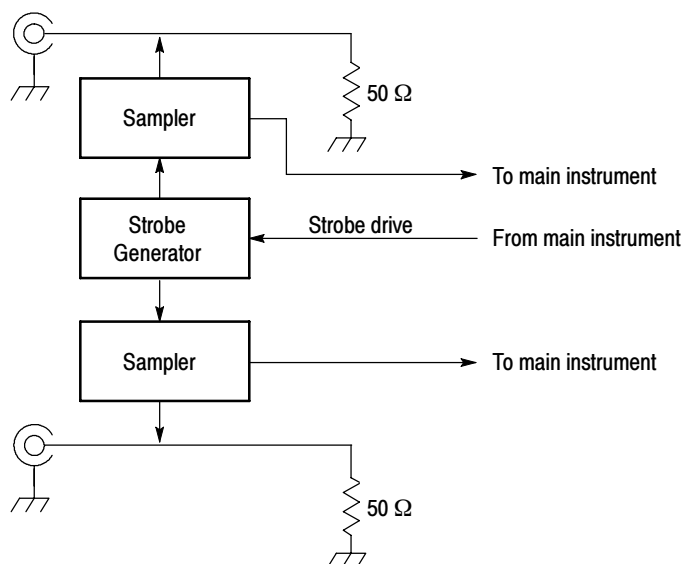


Figure 2: Sampling module block diagram

Accessories and Options

This section lists the standard and optional accessories available for the sampling modules, as well as the product options.

Standard Accessories

The accessories in Table 2 are shipped with the module. Visit the Tektronix web site or a current Tektronix catalog for additions, changes, and details.

Table 2: Standard accessories

Item	Part number
Certificate of Traceable Calibration for product at initial shipment	Not Orderable
SMA male 50 Ω termination with beaded chain (2, one per channel)	011-0176-xx
Guide rail kit (2 guide rails, 4 flathead 4-40 screws)	650-4986-xx
2.4 mm/1.85 mm S male to 2.92 mm K female adapters (2) (80E09 and 80E10 only)	011-0157-xx
Transit case with anti-static foam	024-0053-xx (MaxTek part number)
Product documentation CD-ROM (includes cd, instructions, cable markers)	020-2543-xx

Optional Accessories

The accessories in Table 3 are orderable for use with the sampling module at the time this manual was originally published. Visit the Tektronix Web site or a current Tektronix catalog for additions, changes, and details.

Table 3: Optional accessories

Item	Part number
2X attenuator (SMA male-to-female)	015-1001-xx
5X attenuator (male-to-female)	015-1002-xx
Power divider	015-0565-xx
SMA accessory kit	020-1693-xx
3.5 male to 3.5 female SMA	015-0552-xx
Slip-on SMA connector	015-0553-xx
3.5 mm 50 Ω connector (SMA male-to-female)	015-0549-xx
BNC female 75 Ω to 50 Ω type N minimum loss attenuator	131-0112-xx
Terminator, ECL	015-0558-xx

Table 3: Optional accessories (cont.)

Item	Part number
Connector saver, 3.5 mm SMA	015-0549-xx
80E07, 80E08, 80E09, and 80E10 Remote Sampling Module User Manual (printed)	071-2038-xx

Options

The following options can be ordered for the module:

- Option C3: Three years of calibration services
- Option C5: Five years of calibration services
- Option D3: Test Data for calibration services in Option C3
- Option D5: Test Data for calibration services in Option C5
- Option R3: Repair warranty extended to cover three years
- Option R5: Repair warranty extended to cover five years

Installation

The sampling modules fit into the front panel of any of the main instruments listed Getting Started on page 1.

To install a module, first turn off the instrument using the front-panel On/Stand-by switch. Then place the module in a compartment and slowly push it in with firm pressure. Once seated, turn the hold-down screw to tighten the module into place. See Figure 3.



CAUTION. To prevent damage to the module or instrument, never install or remove a module when the instrument is on or when input connectors are unprotected.

NOTE. When removing your sampling module, first loosen the hold-down screw, and then use the module ejector on the main instrument to eject the module.

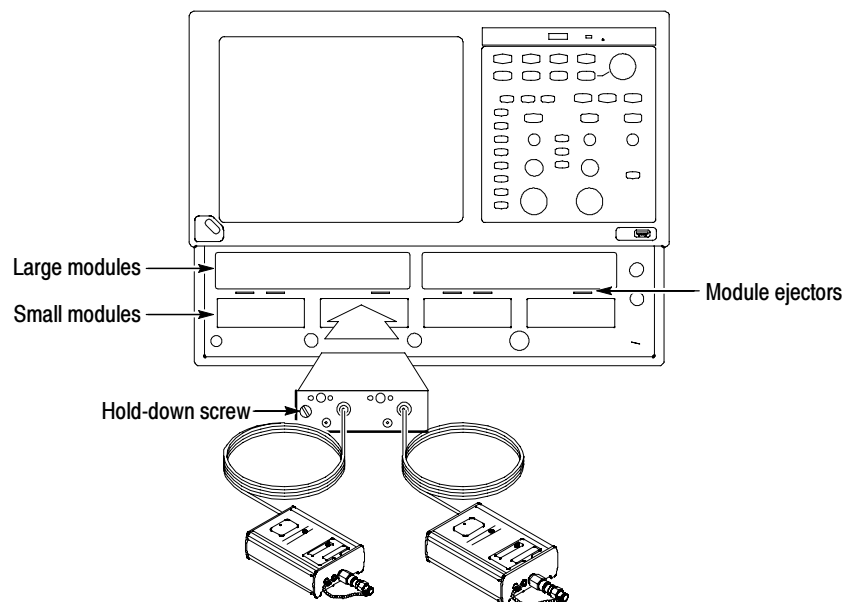


Figure 3: Sampling module compartments

At least one sampling module must be installed in an instrument to sample signals.

NOTE. Refer to the *Quick Start User manual* for your instrument about the interaction between large and small module compartments.

Using the Guide Rails

The guide rails allows you to create a stable environment for the remote modules. One guide rail is provided for each remote module.

Attach the guide rail to a fixture (or desktop) using the two mounting screws (provided). The holes in the fixture must have 4-40 threaded holes spaced 1.25 inches (31.8 mm) apart (measured from center of hole).

Once you've secured the guide rail to a surface, slide the remote module onto the rail, engaging the tracks on the bottom of the remote module.

NOTE. The tracks on the remote module and guide rails must be properly mated to ensure a firm attachment. One track on the module is larger than the other. The larger track must engage the ball plungers on the guide rail. See the detail in Figure 4.

Using the End Plate Mounting Holes

The end plate mounting holes also allow you to create a stable environment for the remote modules. There is one hole in each module end plate: one in the front end plate and one in the rear end plate. You will need to provide the mounting apparatus to use with these mounting holes.

The front and rear end plate spacing is 2.95 inches (75.0 mm) and the mounting holes are located co-axially in line as shown in Figure 4. Each mounting hole is threaded for a 4-40 machine screw to a depth of 0.38 inches (9.5 mm). The bottom of the mounting holes are closed in order to prevent accidental damage to the internal circuits of the remote module from the machine screws.



CAUTION. Do not use machine screws in the end plate mounting holes that can protrude deeper than 0.38 inches (9.5 mm). Such screws may bottom out in the closed mounting holes and damage the screw threads or break off.

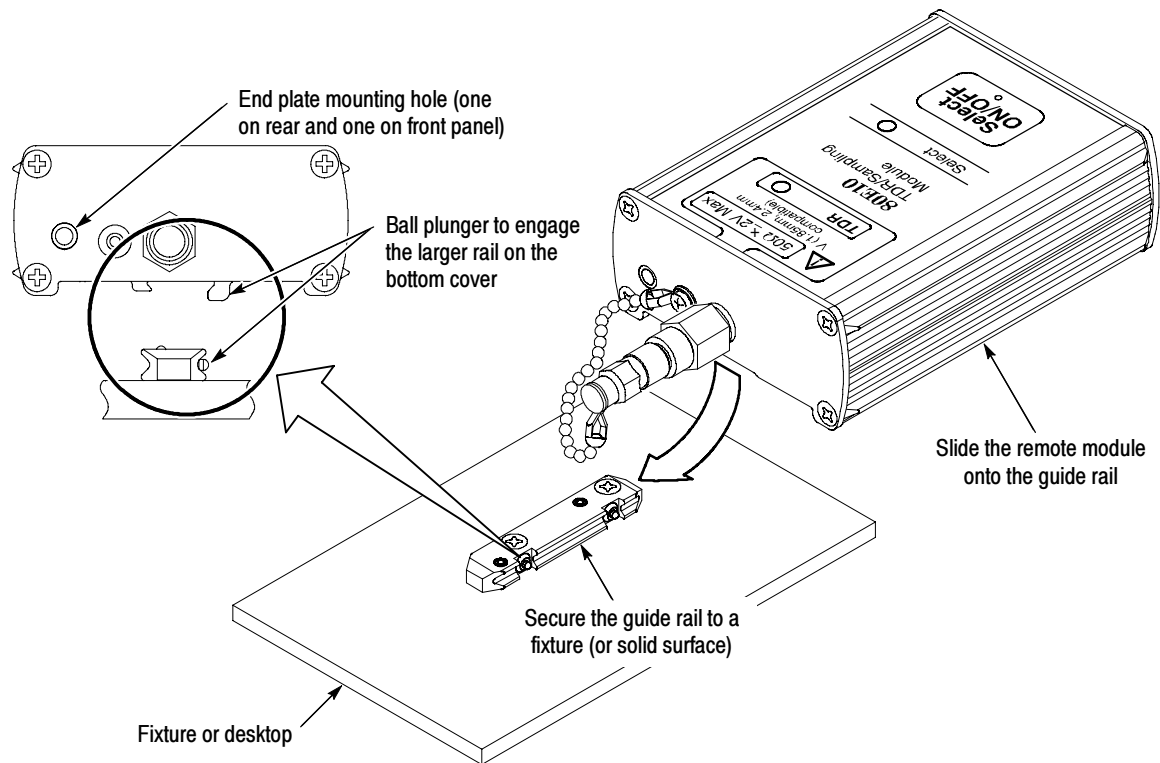


Figure 4: Guide rail and mounting holes

Electrostatic Discharge

To prevent electrostatic damage to your mainframe and sampling modules, follow the precautions described in this manual.

Circuitry in the sampling module is very susceptible to damage from electrostatic discharge or from overdrive signals. Be sure to only operate the sampling module in a static-controlled environment. Be sure to discharge to ground any electrostatic charge that may be present on the center and outer connectors of cables before attaching the cable to the sampling module.

Know your signal source. If it is capable of delivering overvoltages, it is safer to not depend on the signal source settings for protection, but instead use an external attenuator that protects the input from the worst-case conditions. For example, for a 20 V maximum source connected to a 3 V maximum sampling module, use a 10X attenuator. Where possible, connect your cables to the signal source first, and to the sampling module second.



CAUTION. To prevent damage from electrostatic discharge, install $50\ \Omega$ terminations on the sampling-module connectors before removing the sampling modules from an instrument or when it is not in use. Store the sampling module in a static-free container, such as the shipping container. Whenever you move the sampling module from one instrument to another, use a static-free container to transport the sampling module.

To prevent damage to the sampling module, discharge to ground any electrostatic charge that may be present on the center and outer conductors of cables before attaching the cable to the sampling module.

To prevent damage to the sampling module, do not create an ESD antenna by leaving cables attached to the sampling-module input with the other end of the cable open.

To prevent damage to the sampling module or instrument, never install or remove a sampling module when the instrument is on.

Always use a wrist strap (provided with your instrument) when handling sampling modules or making signal connections. Wear anti-static clothing and work in a static-free workstation when using sampling modules.

Use a Tektronix 80A02 EOS/ESD Protection Module if doing TDR work.



To prevent damage to the sampling module or instrument, do not apply a voltage greater than the Maximum Input Voltage (see page 49) for your sampling module.

Static Controlled Workstation

For information on creating a static-controlled workstation, consult the Electronic Industries Association document *EIA-625; Requirements for Handling Electrostatic-Discharge-Sensitive (ESDS) Devices*.

You can use a Tektronix 80A02 EOS/ESD Protection Module to protect the sampling module from damage due to static discharge from circuit boards and cables. Use the 80A02 in applications where large static charges can be stored on the device under test, such as when testing TDR circuit boards or cables.

Refer to the documentation supplied with the 80A02 module for proper installation and use.

Compensation

After installing a sampling module or after moving a sampling module from one compartment to another, you should run Compensation from the Utilities menu to ensure the instrument and modules meets their specifications.

For instructions on running a compensation, see *Optimizing Measurement Accuracy* in your main instrument Quick Start User manual or the online help.

Operating Basics

This chapter makes you familiar with the operation of your sampling module. It describes the controls and connectors, interaction of the sampling module with your instrument, programming the sampling module, and user adjustments.

Usage

Figure 5 shows the sampling module and remote modules and identifies the buttons, lights, and connectors.



CAUTION. *To prevent damage to your sampling module or instrument, do not apply a voltage greater than the Maximum Input Voltage (see page 49) for your sampling module.*

To prevent electrostatic damage to the instrument and sampling modules, follow the precautions described in this manual and the manuals accompanying your instrument. (See Electrostatic Discharge starting on page 8.)



Always use a wrist strap (provided with your instrument) when handling sampling modules or making signal connections.

The input circuitry in your sampling module is very susceptible to damage from overdrive signals and electrostatic discharge. Never apply a DC or peak voltage greater than the Maximum Input Voltage (see page 49) of your sampling module. Only operate the instrument and sampling module in a static-controlled environment.

Controls

Each sampling module contains two identical remote modules. This section describes module channel controls, connectors, and indicators.

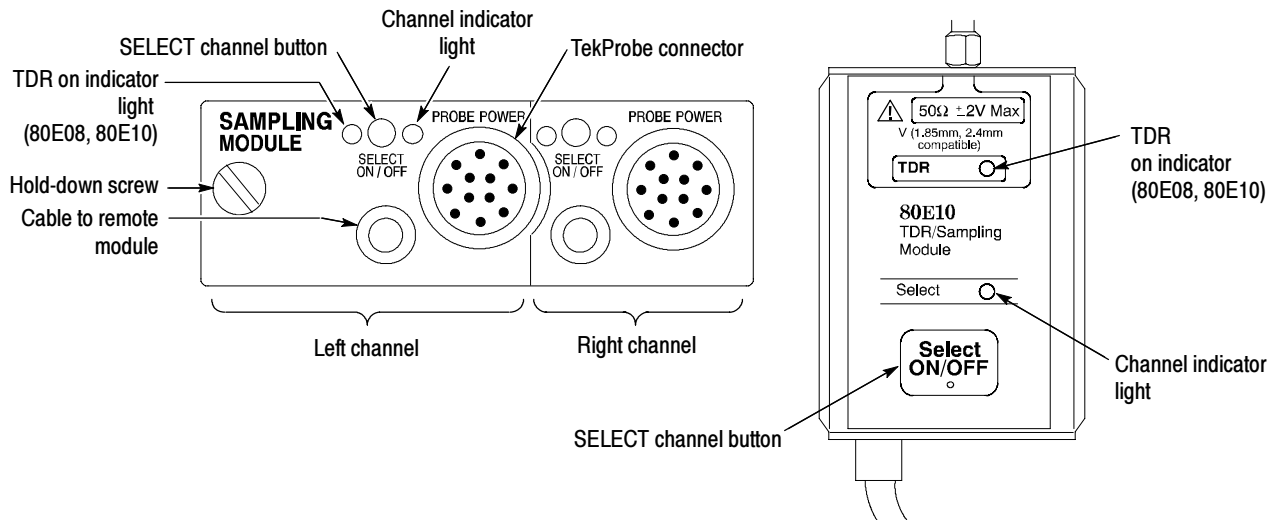


Figure 5: Sampling module, 80E10 shown

Signal Connector

The input signal connectors for each channel let you connect signals that you want to sample. To acquire a signal, connect the signal to the remote sampling module through the Signal Connector input. Signal connectors used on your sampling module are described in Table 1 on page 3.

Connector Care. Never attach a cable to a sampling-module connector if the cable has a worn or damaged connector because you may damage the sampling-module connector. Use extra care when attaching or removing a cable from the connectors. Turn only the nut, not the cable. When attaching a cable to a sampling-module connector, align the connectors carefully before turning the nut. Use light finger pressure to make this initial connection. Then tighten the nut lightly with a wrench. For more information, see *Connector and Adapter Care Requirements* on page 41. For the specific torque settings, see *Table 4* on page 45.

If the sampling-module connectors will receive heavy use, such as in a production environment, you should install adapters (such as a Tektronix part number 015-0549-xx for 3.5 mm connectors) on the sampling module to make connections to the device under test.

Channel Selection

Each channel has two locations to control the channel. The module (installed into the instrument) has a SELECT ON/OFF button and a channel light for each channel. This same function and indicator light is available on each remote module. The buttons and lights operates as follows:

- If the yellow channel light is on, the channel is acquiring a waveform.
- If you press the button and the channel is not currently being acquired (for any channel or math waveform), then the instrument activates (turns on) the channel.
- If you press the button and the channel is currently active as a channel waveform, then the instrument selects the channel waveform.
- If the channel waveform is already selected when you press the channel button, the instrument turns the channel off.

TekProbe Connector

A TekProbe connector is provided at the module for accessories requiring TekProbe SMA support at levels 1 and 2. The connector provides power and control to attached accessories, by the main instrument.

TDR On Indicator

On modules with TDR capability, a TDR ON light is included on the main module and remote modules to indicate whether the step generator is sending out a step through the signal connector. The main instrument turns this on or off.

System Interaction

Your sampling module is a part of a larger instrument system. Most of the sampling-module functions, such as vertical and horizontal scale, are controlled automatically by the main instrument. You do not directly control these parameters; they are controlled for you as you perform tasks on the main instrument.

You also control external channel attenuation from the main instrument. External attenuation enables you to enter a number representing external attenuation you have added to a channel.

Commands From the Main Instrument Front Panel

Vertical Setup The Vertical Setup dialog box accesses the sampling module controls. This dialog box is shown in Figure 6.

You first select the channel in the Waveform section of the dialog box. Then you select the Setup Scale, Position, Channel Offset, Deskew, Delay, Bandwidth, Units, or External Attenuation boxes to change those settings.

Detailed information on this dialog box can be found in the online help accessed from the main instrument.

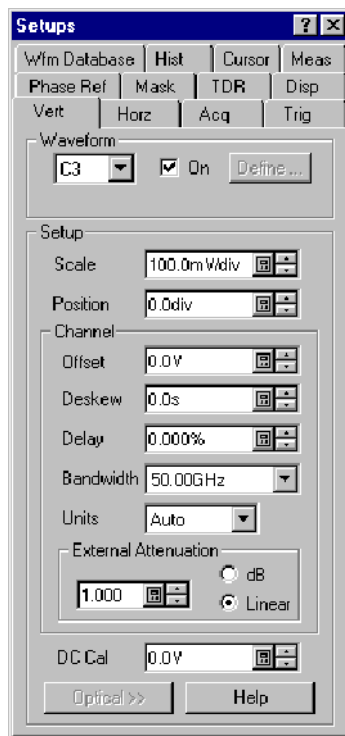


Figure 6: Vertical Setup dialog box

TDR Setup The TDR Setup dialog box accesses the controls for a TDR capable sampling module. This dialog box is shown in Figure 7.

The channels with TDR capability are active. Use the channel Preset to automatically display the incident step. Once a TDR step is active (and the channel selected), use TDR autosect to automatically find and display the first reflected edge.

Detailed information on this dialog box can be found in the online help accessed from the main instrument.

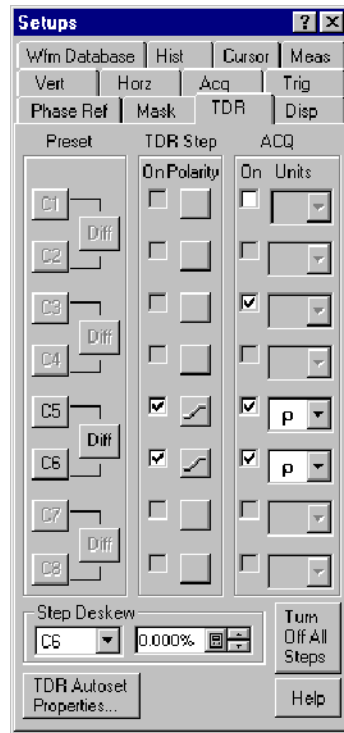


Figure 7: TDR Setup dialog box

Programmer Interface Commands

The remote-programming commands for all modules are documented in the online programmer guide.

User Adjustments

All sampling module setups, parameters, and adjustments are controlled by the main instrument. To save, recall, or change any module settings, use the instrument menus or front-panel controls or consult the online help accessed from the main instrument.

Cleaning

The module case keeps dust out and should not be opened. Cleaning the exterior of the main module is usually confined to the front panel. If you need to clean the case, remove the module from the main instrument but first read the entire *Installation* procedure starting on page 6 for proper handling of the module.



WARNING. *To prevent injury, power down the instrument and disconnect it from line voltage before performing any cleaning.*

Clean the exterior surfaces of the modules or cables with a dry lint-free cloth or a soft-bristle brush. If any dirt remains, use a damp cloth or swab dipped in a 75% isopropyl alcohol solution. Use a swab to clean narrow spaces around controls and connectors. Do not allow moisture inside the modules. Do not use abrasive compounds on any part of the cases or cables that may damage them.



CAUTION. *To prevent damage, avoid the use of chemical cleaning agents which might damage the plastics used in this instrument. Use a 75% isopropyl alcohol solution as a cleaner, and rinse with deionized water. Use only deionized water when cleaning the menu buttons or front-panel buttons. Before using any other type of cleaner, consult your Tektronix Service Center or representative.*

Do not open the case of the module or the remote modules. There are no user serviceable components and cleaning the interior is not required.

Reference

This chapter contains the following sections:

- *Taking TDR Measurements* describes how to use the 80E08 and 80E10 to perform time-domain-reflectometry (TDR) measurements.
- *TDR Measurements Background* contains information that describes the cause of reflections, measurement range, the velocity of propagation and measuring mismatches, measurement units, and considerations for making accurate measurements.
- *Taking Differential and Common-Mode TDR Measurements* describes how to use the TDR capable sampling module to perform differential and common-mode TDR measurements.
- *Connector and Adapter Care Requirements* describes proper care and use of the connectors and adapters, including protection against electrostatic discharge (ESD), cleaning connectors, and the assembly and torquing of connectors.
- *Detecting Blown Inputs* describes how to check for damage on a sampling module.
- *EOS (Electrical Overstress) Prevention* describes the causes and prevention of EOS, and how to check for EOS damage.

Taking TDR Measurements

This section describes how to use the 80E08 and 80E10 sampling modules to perform TDR measurements.

Why Use? To take TDR measurements on transmission lines. Using TDR you can measure the impedance along a transmission line and determine the distance to an impedance change.

What's Special? Vertical can be scaled in volts, rho, or ohms units.

Keys to Using Read the following topics; they provide details that can help you set up and take effective TDR measurements.

TDR Step Generation. Both channels in the 80E08 or 80E10 TDR/sampling module have a selectable polarity step generator which gives both channels

individual measurement capabilities. You can use the outputs of both generators to perform differential and common-mode TDR measurements.

The step generator circuitry fundamentally consists of a polarity-selectable current source and a diode switch. Initially, before the step, the diode switch is biased to conduct current to the output. When the diode switch opens, the step occurs. A DC current source assures that the baseline level stays close to zero volts. Figure 8, a simplified diagram, shows the switch and the current source.

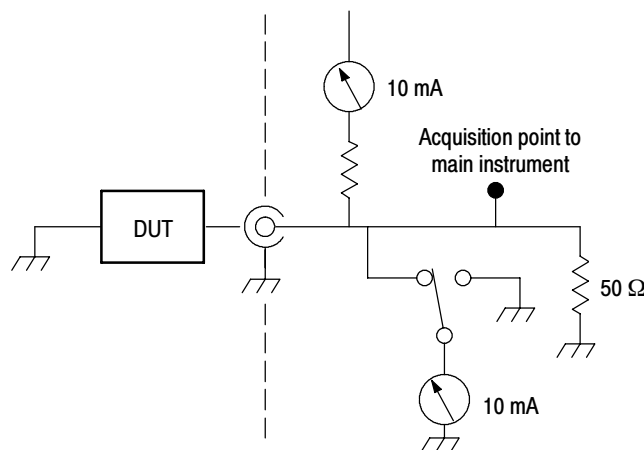


Figure 8: Simplified schematic diagram of step generator - positive polarity

The following sections and figures 9–11 describe the operation with a short circuit, an open circuit, and a $50\ \Omega$ load, with a positive step source.

Operation Into a Short. Initially, the diode switch is conducting $-10\ \text{mA}$. Since the step-generator output is initially shorted, the resistance to ground is $0\ \Omega$.

When the diode switch opens (reverse-biased), apparent resistance to ground at the acquisition point (and at the channel connector) is $25\ \Omega$ because the internal termination resistance is $50\ \Omega$ in parallel with the connector impedance of $50\ \Omega$. The voltage at the acquisition point rises to $+250\ \text{mV}$, the incident amplitude E_i .

The transition propagates to the short in the Device Under Test (DUT) and is negatively reflected back to the acquisition point, $E_r = -250\ \text{mV}$ reflected, causing the voltage at the acquisition point to drop back to $0\ \text{V}$. The time displayed from the first transition to the second transition is the round trip propagation time from the acquisition point to the short in the device under test and back. See Figure 9.

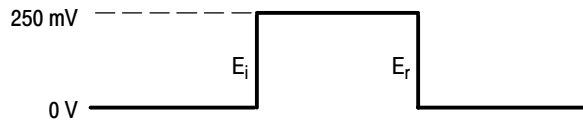


Figure 9: Step generator with a shorted output

Operation Into a 50 Ω Load. Initially, the diode switch is conducting -10 mA. Since the step-generator output is connected to a 50 Ω load, the resistance to ground at the acquisition point is 25 Ω (because of the internal 50 Ω impedance).

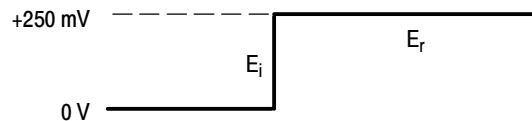


Figure 10: Step generation with a 50 Ω load

When the diode switch opens (reverse-biased), apparent resistance to ground at the acquisition point (and at the channel connector) is 25 Ω because the internal termination resistance is 50 Ω in parallel with the connector impedance of 50 Ω . The voltage at the acquisition point rises to +250 mV.

The transition propagates to the 50 Ω load and no reflection occurs.

Operation Into an Open. Initially, the diode switch is conducting -10 mA. Since the step-generator output is open, the resistance to ground at the acquisition point is 50 Ω (because of the internal 50 Ω impedance).

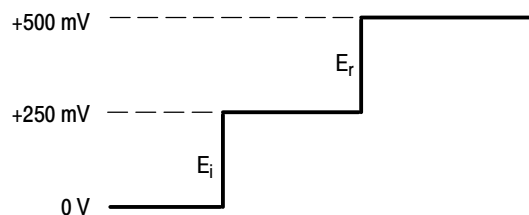


Figure 11: Step generation with an open circuit

When the diode switch opens (reverse-biased), apparent resistance to ground at the acquisition point (and at the channel connector) is 25 Ω because the internal termination resistance is 50 Ω in parallel with the connector impedance of 50 Ω . The voltage at the acquisition point rises to +250 mV.

The transition propagates to the open in the DUT and is positively reflected back to the acquisition point, causing the voltage at the acquisition point to rise to +500 mV. At the acquisition point, the time displayed from the first step to the second step is the round trip propagation time from the acquisition point to the open in the DUT and back. See Figure 11.

Baseline Correction. The baseline of a current-source based step generator normally shifts its DC level with loading. The use of a DC current source to cancel the step source current maintains the baseline level close to 0 V (see Figure 8 on page 18).

Shape of Reflections. The shape of a reflection reveals the nature and magnitude of the load impedance, mismatch, or fault, even when the load impedance is not a short, $50\ \Omega$, or open. Figure 12 shows typical TDR displays and the load that generated the reflection.

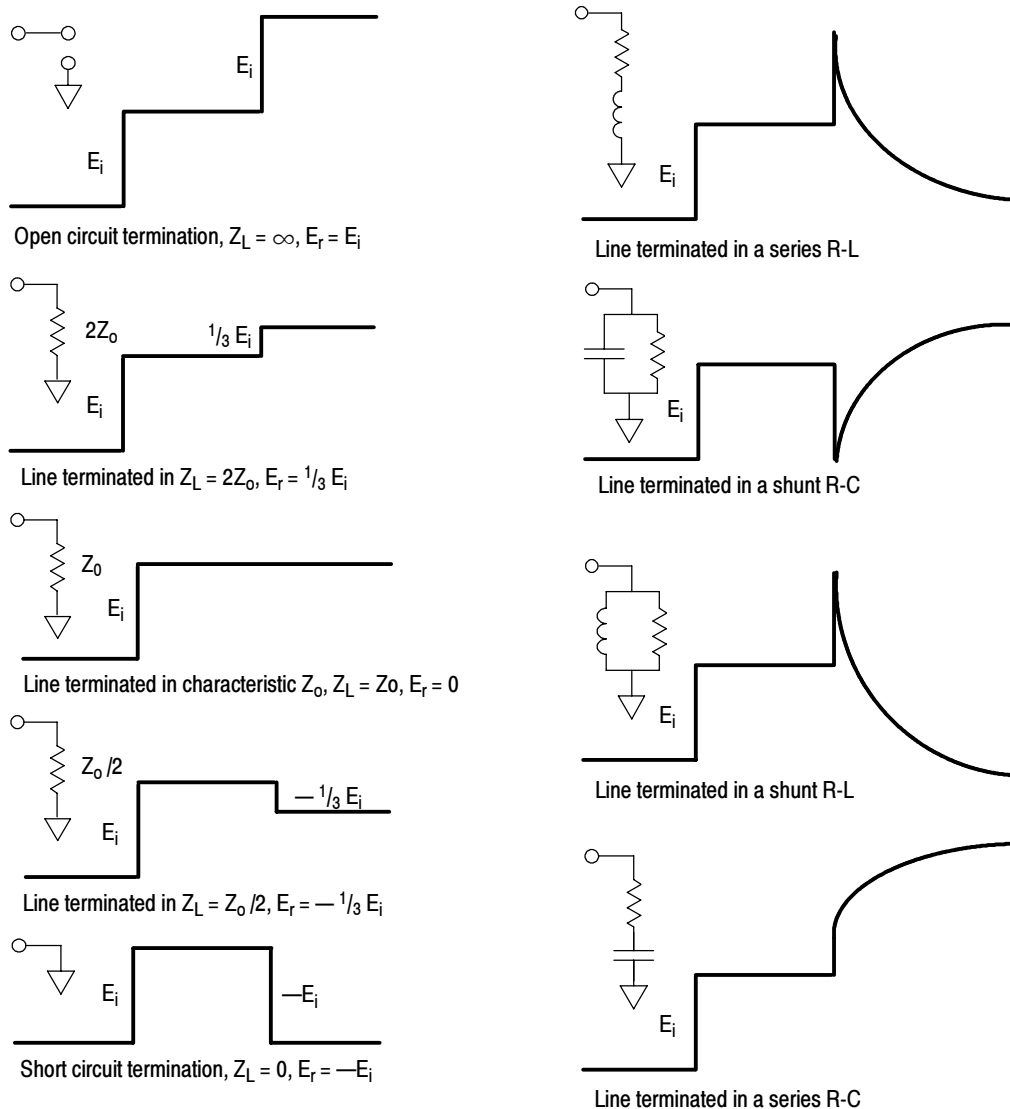
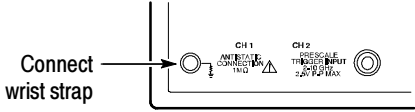
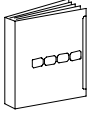
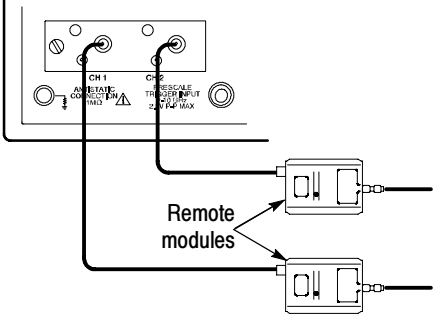
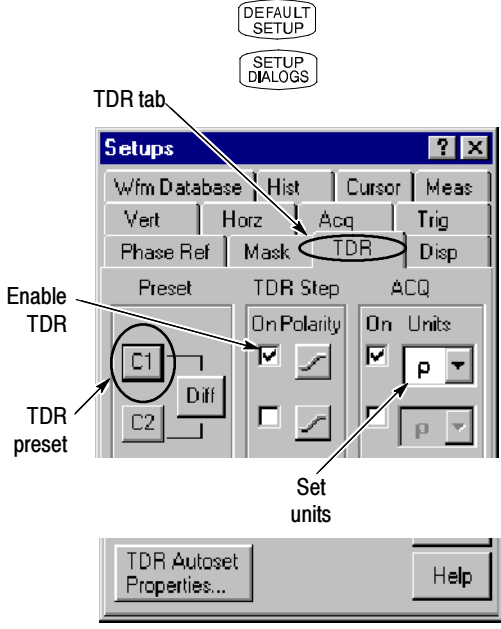


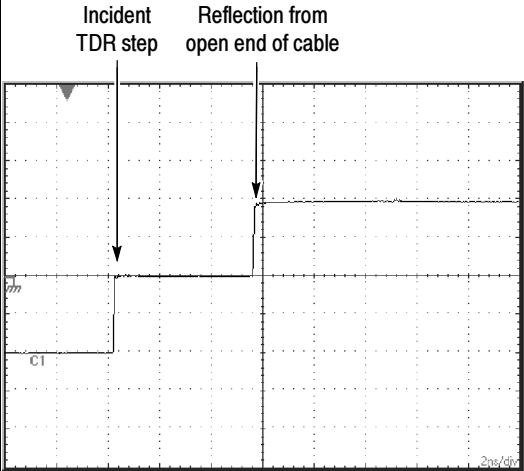
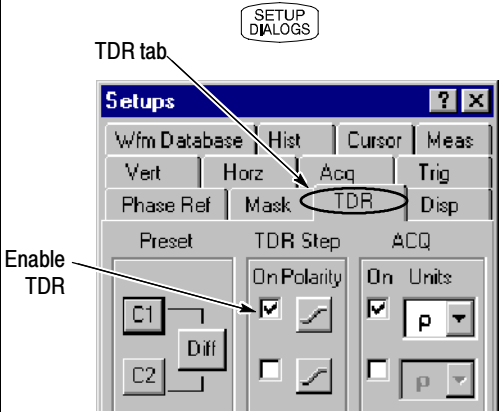
Figure 12: TDR displays for typical loads


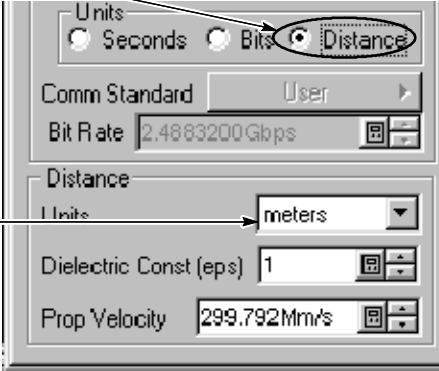

To Take a TDR Measurement

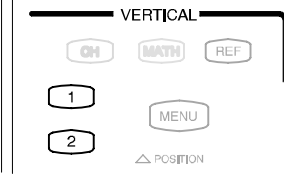
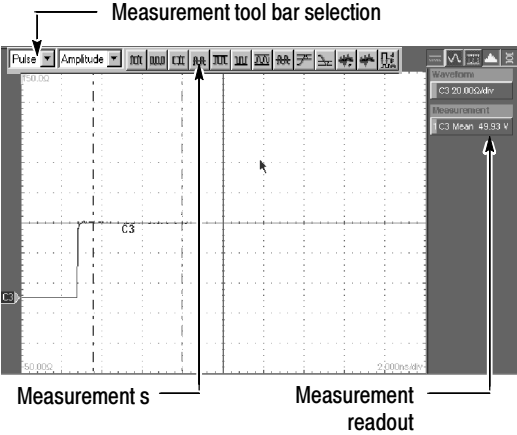
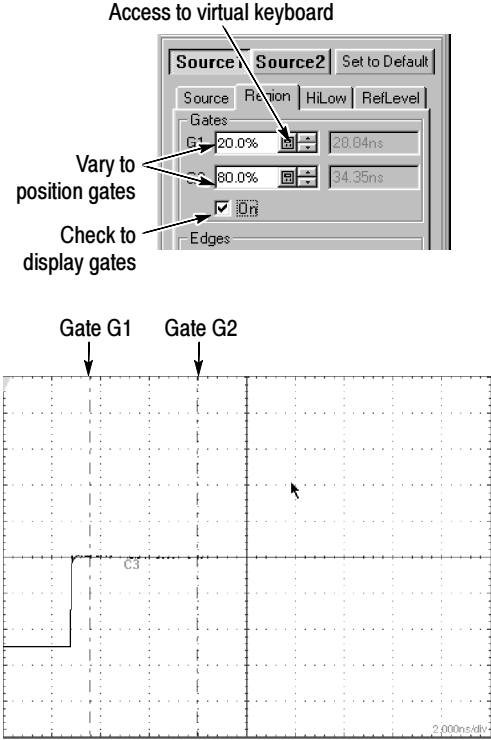
This example demonstrates the TDR feature of the 80E08 and 80E10 sampling modules. TDR is a method of examining and measuring a network or transmission line by sending a step signal into the network and monitoring the reflections.

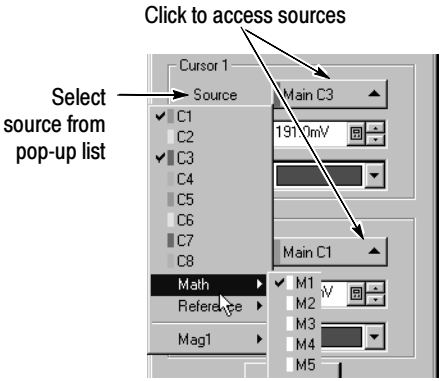
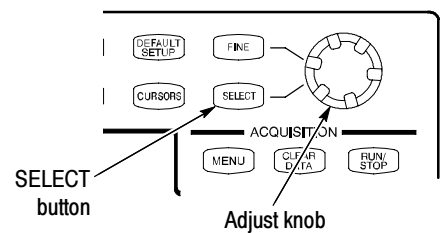
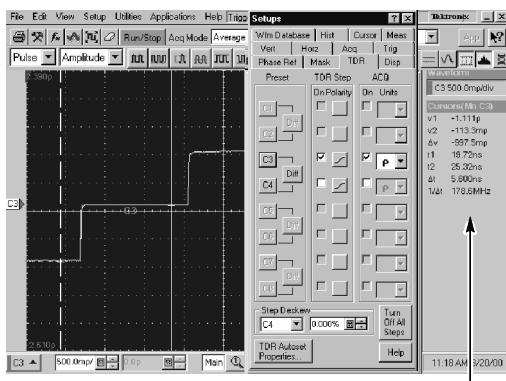
Overview	To take a TDR measurement	Control elements & resources
<p>Prerequisites</p>	<ol style="list-style-type: none"> 1. Connect your wrist strap to the antistatic connector on the front of your instrument. See <i>Caution</i> on page 9. 2. An 80E08 or 80E10 sampling module must be installed in the main instrument. The Acquisition system should be set to Run, and the vertical and horizontal controls should be set appropriately for the signal to be acquired. 	 <p>Connect wrist strap</p>  <p>See the main instrument online help for scaling and acquisition setup</p>
<p>Input</p>	<ol style="list-style-type: none"> 3. Connect the transmission line to the sampling module using proper probing/connecting techniques for your application (for example: connect an SMA cable of < 5 ns length). 	 <p>Remote modules</p>

Overview	To take a TDR measurement (cont.)	Control elements & resources
<p>Preset TDR</p>	<ol style="list-style-type: none"> 4. Initialize the instrument (press DEFAULT SETUP). 5. Press the SETUP DIALOGS button and select the TDR tab. 6. Press TDR Preset for the appropriate channel. <p>TDR Preset sets the Trigger Source to Internal Clock in the Trigger menu, turns on the TDR Step in the TDR Setups menu, turns on the channel and selects the acquisition Units in the TDR Setups menu, and sets the horizontal scale, position, and reference.</p> <p>The sampling module turns on a red light on the remote module, indicating that TDR is activated for that channel. You can use TDR on each channel independently.</p> 7. Press TDR Autoset Properties to display the Autoset Properties dialog box to prepare the TDR autoset. <p>A TDR autoset automatically changes the instrument settings such that the reflected edge is displayed on screen.</p> 	 <p>The screenshot shows the 'Setups' dialog box with the following elements labeled:</p> <ul style="list-style-type: none"> DEFAULT SETUP and SETUP DIALOGS buttons at the top. TDR tab in the 'Acq' menu. Enable TDR label pointing to the 'C1' button in the 'TDR Step' section. TDR preset label pointing to the 'C1' button. Set units label pointing to the 'Units' dropdown menu. TDR Autoset Properties... and Help buttons at the bottom.

Overview	To take a TDR measurement (cont.)	Control elements & resources
<p>Set other TDR parameters</p>	<p>8. Adjust the VERTICAL SCALE (500 mp/div in this example) and HORIZONTAL SCALE (2 ns/div in this example) to show a trace similar to that shown. Leave at least one division of baseline trace to the left of the first rise.</p> <p>The first rise of this waveform is the incident TDR step leaving the sampling module; the second rise is the reflection of the step returning from the end of the cable.</p> <p>For your device under test (DUT), you may need to adjust the Horizontal SCALE, POSITION, and Reference to display the reflections from your DUT near the left of the graticule.</p> <p>To locate reflections from your DUT, disconnect your probe or cable at the DUT and look for the reflection from the open end of the probe or cable.</p> <p>Assuming the line to be tested is an open-end microstrip on a circuit board and that you probe or cable is now connected to the line, you will see the new open reflection to the right according to the length of the line. There may be a visible disturbance where the connections is made to the board (for example see Figure 13 on page 28). The area between the entry to the board and the open reflection at the end of the board is the target area for your TDR measurements. Adjust Vertical SCALE, Vertical POSITION, Horizontal SCALE, and Horizontal POSITION as necessary for a good quality display of the measurement area.</p>	
<p>Changing TDR graticule units</p>	<p>9. The units of measure commonly used in TDR are units of rho (ρ), measured on the vertical axis. You can change the measurement units by using the ACQ Units selector in the TDR Setups dialog box.</p> <p>10. Press the SETUP DIALOGS button, and select the TDR tab.</p> <p>11. Select either V for Volts, p for rho, or Ω for ohms.</p>	

Overview	To take a TDR measurement (cont.)	Control elements & resources
Specifying horizontal timebase units	12. Select the HORIZONTAL tab.	
	<p>13. Select the Distance radio button. Use this control to specify the type of units to use for the horizontal axis for all timebases. You can select from seconds, bits, or distance. The timebase scale and position controls adopt the units you select.</p> <p>14. If your application requires it, you can also set either of the following controls (they interact, so set one or the other):</p> <p style="padding-left: 40px;">Enter a Dielectric Const (eps) value to match that of the device under test.</p> <p style="padding-left: 40px;">Enter a Prop Velocity value to match that of the device under test.</p>	<p>Distance button</p>  <p>Type of units</p>
	<p>15. Press the SETUP DIALOGS button.</p> <p>16. Continue with the automatic measurement process on the following page.</p>	

Overview	To take a TDR measurement (cont.)	Control elements & resources
<p>Take automatic measurements</p>	<p>17. Use the Vertical buttons to select the TDR waveform to be measured.</p>	
	<p>18. Select one of the measurement tool bars.</p> <p>19. Click the measurement you want (such as mean) in the measurement tool bar.</p> <p>20. Read the results in the measurements readout.</p>	
	<p>21. To take your measurement over a portion of the waveform, select the region tab to display the gate controls. Click the check box as indicated at the right to turn gating on and to display the gates on screen.</p> <p>22. Use the G1 (Gate1) and G2 spin controls (or click and type in values, use the keypad or multipurpose knobs, or touch and drag the gate) to adjust the gates on screen such that the area to measure is between the gates.</p> <p>If necessary to provide a good view of this portion of the waveform, adjust the Vertical SCALE and POSITION and the Horizontal SCALE, POSITION, and Reference. To see the difference scale and position can make in your waveform display, compare the waveforms in Figure 16 and also compare the waveforms in Figures 13 and 14.</p>	

Overview	To take a TDR measurement (cont.)	Control elements & resources
<p>Take cursor measurements</p>	<p>23. Press the SETUP DIALOGS button and select the Cursor tab.</p> <p>24. Select the Waveform cursor type.</p> <p>25. From the pop-up list for each of Cursor 1 and Cursor 2, select your TDR source.</p> <p>26. Press the SELECT button to toggle selection between the two cursors. The active cursor is the solid cursor.</p> <p>27. Turn the Adjust knob to position each cursor on the math waveform to measure the feature that interests you.</p>	<p style="text-align: center;">SETUP DIALOGS</p>  <p style="text-align: center;">Click to access sources</p> <p>Select source from pop-up list</p>  <p style="text-align: center;">SELECT button</p> <p style="text-align: center;">Adjust knob</p>
	<p>28. Read the results in the cursor readout. In this figure, waveform cursors are used to measure Δv and Δt of the waveform, which could be used to compute its slope (dv/dt).</p>	 <p style="text-align: right;">Cursor readout</p>

TDR Measurements Background

TDR is based on a simple concept: Whenever energy transmitted through any medium encounters a change in impedance, some of the energy is reflected back toward the source. The amount of energy reflected is a function of the transmitted energy and the magnitude of the impedance change. The time lapse between energy transmission and the reflection returning is a function of the distance from the source to the impedance discontinuity, and the propagation velocity.

An example of this concept is the echo you hear when sound encounters a wall and bounces back. In electrical systems, a similar phenomenon occurs when electrical energy traveling in a transmission line encounters a change in impedance. Any change in the impedance of the transmission line, such as a variation in the width of a circuit board trace, causes a reflection with an amplitude that is related to the magnitude of the impedance change.

A Time Domain Reflectometer sends out a step signal on the cable, circuit board, or integrated circuit under test. The reflection (or echo) received by the TDR is measured to find events along the path of the step.

Reflections are caused both by events that are expected, such as width changes and components, and by those that shouldn't be there, such as bridges, shorts, and opens. The strength of a TDR measurement is that it not only tells you there is a fault, but it also tells you the magnitude and the distance to that fault.

TDR can note any change in the characteristic impedance of the device-under-test (DUT). Any change in the impedance is shown on the TDR display as an upward bump or downward dip in the waveform, depending on the type of event (see Figure 13 for example discontinuities in a microstrip).

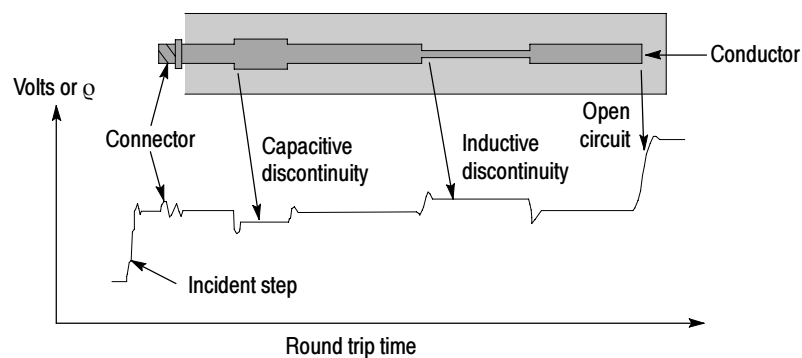


Figure 13: Microstrip discontinuities

Cause of Reflections

The reflections that a TDR displays and measures are caused by changes in the impedance of the path of the step (circuit board, cable, or integrated circuit). Any significant change in impedance will cause a reflection. As an example, if an open solder connection exists on a circuit board, you can see that change with TDR. TDR also displays changes in the conductor resistance. For example, if there is corrosion in a joint and there is high resistance at that point, this is seen by a TDR. TDR also displays changes in capacitance.

If you think of the TDR display in terms of bumps and dips, it tends to make interpretation a lot easier. A bump (upward deflection) indicates a higher-impedance event, such as an open (see Figure 14) or a reduction in line width (see Figure 13). A dip (downward deflection) indicates a lower-impedance event, such as a short (see Figure 15) or an increase in conductor width (see Figure 13). The time location of the high-impedance event or low-impedance event as well as the delta times is displayed on screen.

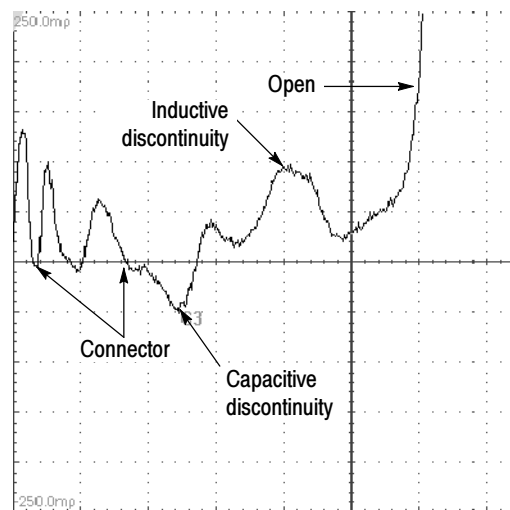


Figure 14: TDR waveform of microstrip in Figure 13

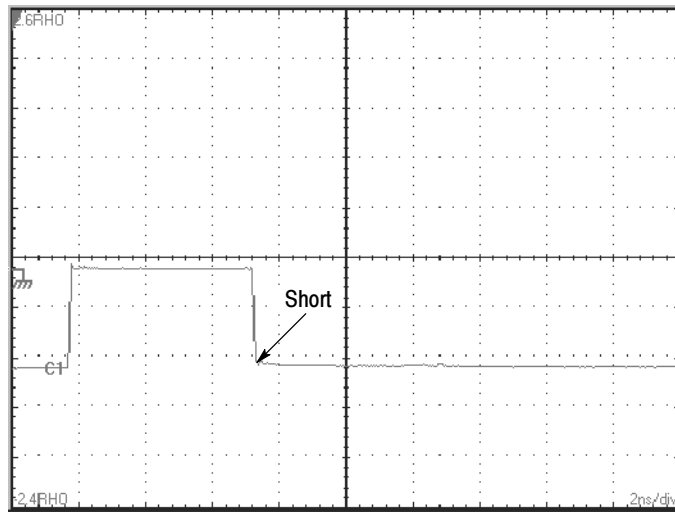


Figure 15: TDR step and reflection (short)

TDR Measurement Range

What is the range of your TDR? is a common question asked by people looking to purchase a TDR. This is a very important question that cannot be answered simply. Another important consideration is how close together the TDR can resolve features. This section discusses TDR range and the factors affecting it.

There are a number of factors that can affect the distance over which a TDR can locate features. The most important parameters that are TDR-related are step amplitude, step risetime, and step width.

Step amplitude is the amount of voltage produced by the TDR step. It is fixed for the 80E08 and 80E10 at 250 mV. In general, the higher the amplitude, the farther the TDR can see. Generally, this type of step is optimized for short range TDR.

Overall step width also affects range. It follows the setting of the Internal Clock Rate (25 kHz - 200 kHz). Step width is measured in time, but can also be thought of as distance when using a TDR. The longer the step width, the greater the range of the TDR. At 200 kHz, the step “on” time is 2.5 us - enough to see in air (one way transit) 375 meters (about 1,250 feet). To see events at greater distances, set the Internal Clock of the TDR to a lower frequency.

Finding the Velocity of Propagation and Locating Mismatches

The time between the incident edge and the reflected edge is valuable in determining the length of the transmission line from the TDR to a mismatch, or between two mismatches. The formula is:

$$D = v_p \times \frac{T}{2} = \frac{v_p T}{2}$$

where: D = distance to the fault
 v_p = velocity of propagation
 T = the time from the TDR to the mismatch and back again,
as measured on the instrument

Velocity of Propagation (v_p) is a measure of how fast a signal travels in that transmission line.

NOTE. The factor of 2 in the denominator is present because TDR systems display round-trip time (incident and reflected edges), whereas with distance it is usually desirable to display one-way distance. It is important to note that the distance scale does not inject this factor of two, and, therefore, the distance displayed is round-trip. See the main instrument user documentation and online help for more information about distance scale operation.

TDR Measurement Units

All TDR impedance measurements are based on the ratio of transmitted voltage to reflected voltage. As a result, measurements are not generally taken in absolute units, such as volts. Instead, TDR measurements are made on a relative scale, called reflection coefficient and abbreviated as ρ . The definition of ρ is the reflected signal amplitude divided by the incident signal amplitude. For example, if a 100-millivolt reflection results from a 1-volt incident step, the reflection is called a 100 millirho reflection: $\rho = E_{\text{reflected}}/E_{\text{incident}} = 100 \text{ m}\rho = 100 \text{ mV}/1 \text{ V}$. Given a known impedance and a measured reflection coefficient, the unknown impedance that caused the reflection can be calculated from the following equation:

$$\rho = \frac{E_{\text{reflected}}}{E_{\text{incident}}} = \frac{Z_L - Z_o}{Z_L + Z_o}$$

where Z_o is the known impedance, ρ is the measured reflection coefficient, and Z_L is the unknown impedance. An alternate form of the equation is:

$$Z_L = Z_o \left(\frac{1 + \rho}{1 - \rho} \right)$$

Figure 16 shows a typical waveform from a Tektronix TDS oscilloscope or CSA analyzer equipped with an 80E08 or 80E10 TDR/sampling module. In this case, the instrument is connected through a 50 Ω coaxial cable to a 75 Ω device under

test. The incident step is about 2 divisions in amplitude, and the reflection from the device under test is about 0.4 division high. These numbers equate to a reflection coefficient of 0.20 (0.4 divisions divided by 2 divisions). Inserting the known 50 Ω level and the reflection coefficient into the above equation yields the 75 Ω value:

$$Z_L = Z_o \left(\frac{1 + \rho}{1 - \rho} \right)$$

$$Z_L = 50 \left(\frac{1 + 0.2}{1 - 0.2} \right) = 75 \Omega$$

Notice that the instrument automatically performs this calculation and displays the impedance (Ω) or reflection coefficient (ρ) for each cursor and the difference between the two cursors.

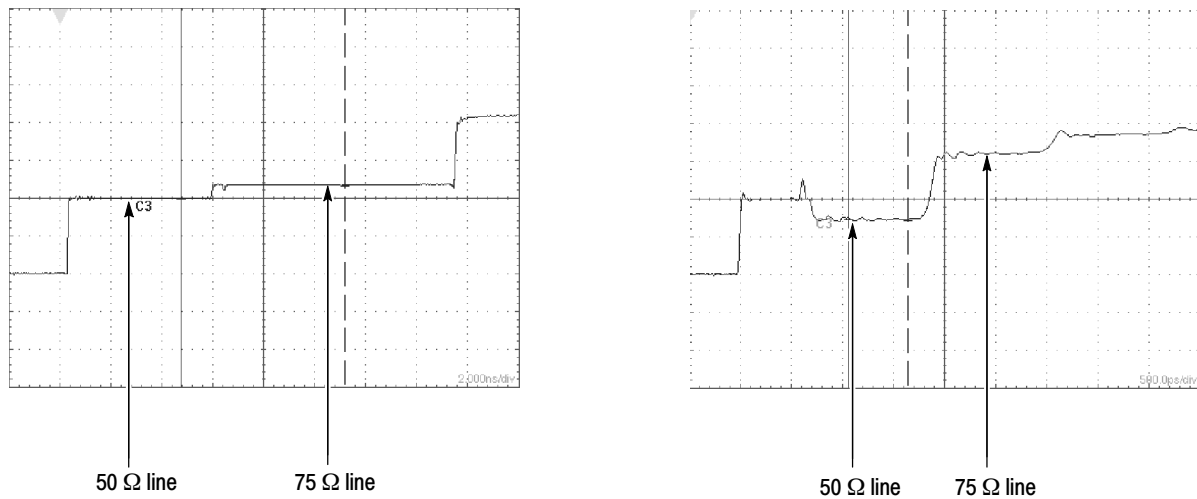


Figure 16: TDR step and reflection (50 Ω line terminated in 75 Ω)

Making Accurate TDR Measurements

A number of issues must be considered to make accurate TDR measurements. In general, it is relatively easy to make impedance measurements near the reference impedance (usually 50 Ω). Higher accuracy or measurements farther from the reference impedance requires more care. The following list covers a few key considerations in making accurate and repeatable impedance measurements.

Resolution. Resolution determines the shortest impedance discontinuity that a TDR instrument can measure. Because of round trip effects, Resolution = $1/2(\text{System Reflected Rise Time})$. If a discontinuity, such as a variation in the width of a trace, is small with respect to the system rise time, the reflection will not accurately represent the impedance of the discontinuity. In extreme cases, the discontinuity may effectively disappear. System rise time is the combined rise time of the step generator (TDR), the instrument, and the interconnect between the TDR and the circuit under test. In general, the most significant limitation in impedance testing is the probe. Close attention to probe geometry and probing techniques can greatly enhance resolution.

Reference Impedance. All TDR measurements are relative; they compare an unknown impedance to a known impedance. The accuracy of the results depends directly on the accuracy of the reference impedance. Any error in the reference impedance translates to error in the measured impedance. It is also a good idea to use a reference impedance close to the expected measured impedance because a smaller difference between the reference and unknown impedance reduces uncertainty in the measurement.

Cable Losses. Always use the shortest high-quality cable possible to connect to the test fixture. The cable that connects the TDR unit to the circuit board not only degrades the system rise time, but can cause other aberrations in the system response that add to measurement error.

Taking Differential and Common-Mode TDR Measurements

This section describes how to use the 80E08 or 80E10 to take differential and common-mode time-domain reflectometry (TDR) measurements.

Why Use?

To take TDR measurements on coupled transmission lines. Using common-mode and differential TDR, you can characterize coupled transmission lines.

What's Special?

The Tektronix 80E08 or 80E10 sampling modules are true differential sampling modules for more accurate differential TDR measurements.

What's Excluded?

This feature only works with an 80E08 or 80E10 sampling module.

Keys to Using

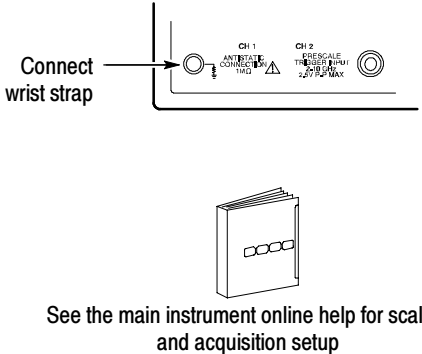
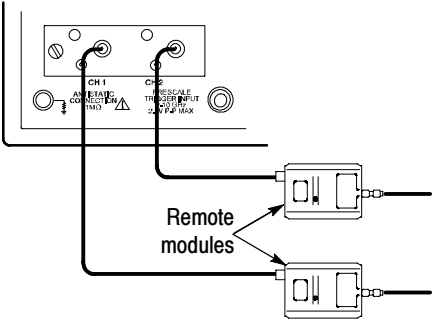
Read the following topics; they provide details that can help set up to take effective differential and common mode TDR measurements.

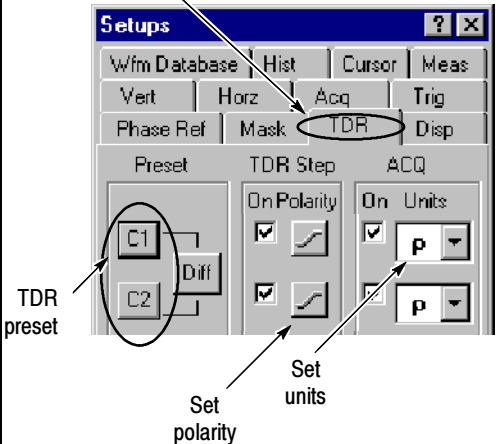
The 80E08 or 80E10 TDR/sampling modules are able to perform differential and common-mode TDR measurements. As described earlier, the sampling module has two input channels and two independent step generators.

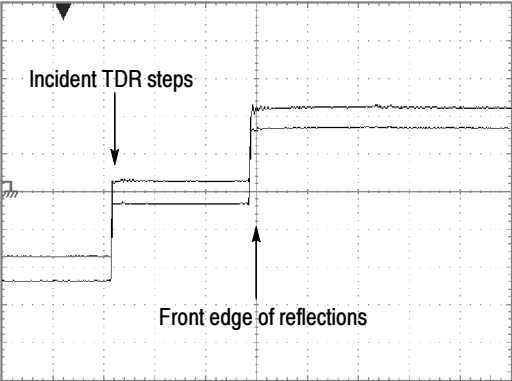
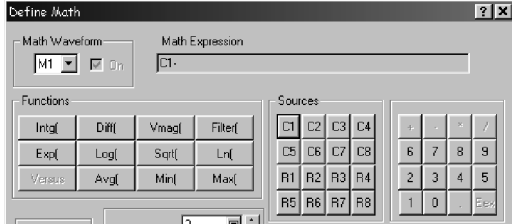
The step-generator output for each channel is selectable for positive or negative polarity and amplitude. This section will show you how to use the two channels and step generators of the 80E08 or 80E10 to perform differential and common-mode TDR measurements.


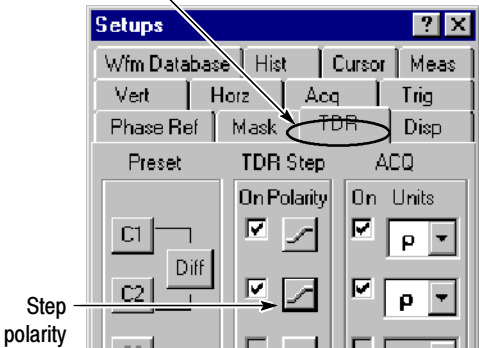

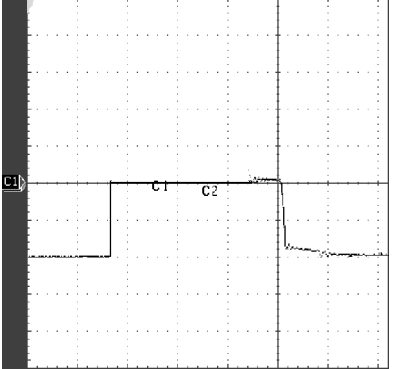
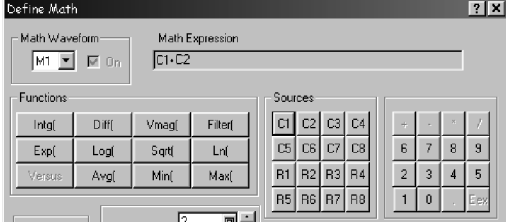
To Take a Common-Mode or Differential TDR Measurement

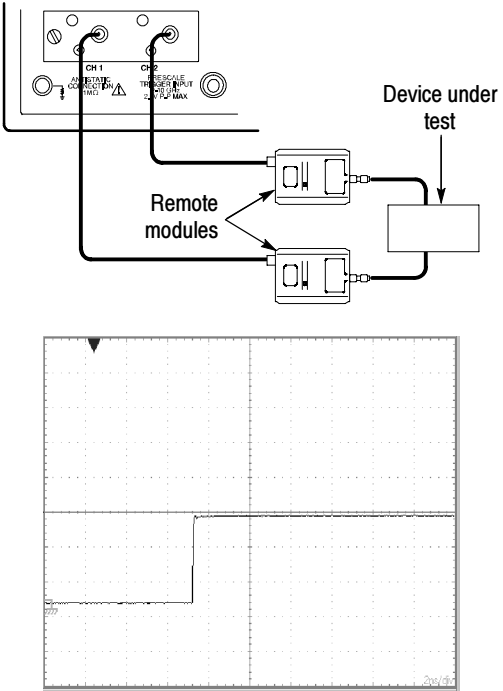
This example demonstrates the common-mode and differential TDR features of the 80E08 or 80E10 sampling modules.

Overview	To take a common mode or differential TDR measurement	Control elements & resources
<p>Prerequisites</p>	<ol style="list-style-type: none"> 1. Connect your wrist strap to the antistatic connector on the front of your instrument. 2. An 80E08 or 80E10 sampling module must be installed in the main instrument. The acquisition system should be set to Run. 	
<p>Input</p>	<ol style="list-style-type: none"> 3. Connect transmission lines to the sampling module using proper probing/connecting techniques for your application (for example: two SMA cables, preferably of matched length). Connect the device under test to the transmission lines. (Connect the conductors of a differential line to the center conductors. Connect the shields together.) 	

Overview	To take a common mode or differential TDR measurement (cont.)	Control elements & resources
<p>Preset TDR</p>	<p>4. Initialize the instrument (press DEFAULT SETUP).</p> <p>5. Press the SETUP DIALOGS button and select the TDR tab.</p>	<p>DEFAULT SETUP</p> <p>SETUP DIALOGS</p>
	<p>6. Press TDR Preset for both channels (for the sampling module connected to the cables) to turn them on. Pressing Preset performs the following:</p> <ul style="list-style-type: none"> ■ Turns on the channel. ■ Turns on a step. ■ Sets trigger source to Internal Clock. ■ Sets acquisition to Averaging. ■ Changes display style to Show Vectors. <p>The sampling module will turn on the red TDR indicator lights, indicating that TDR is activate for the channels.</p> <p>7. Select the polarity desired for both channels.</p> <p>8. Set the units to <i>p</i>.</p>	<p>TDR tab</p>  <p>TDR preset</p> <p>Set polarity</p> <p>Set units</p>
	<p>9. Press the SETUP DIALOGS button to dismiss the dialog box.</p>	<p>SETUP DIALOGS</p>

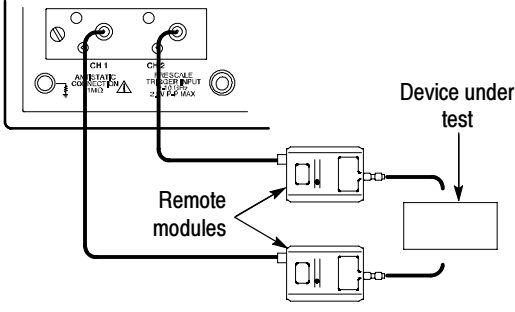
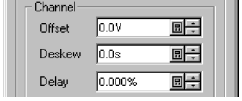
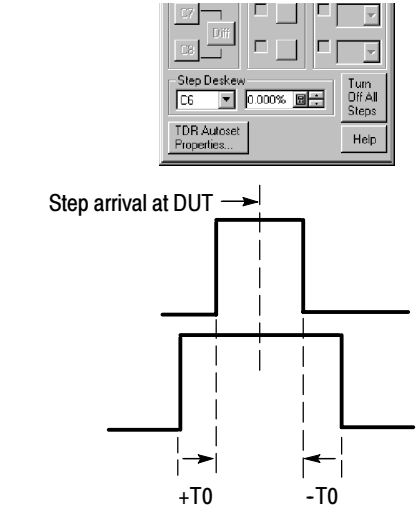
Overview	To take a common mode or differential TDR measurement (cont.)	Control elements & resources
<p>Set Other TDR parameters</p>	<p>10. The Step Deskew is adjustable for both channels. Adjust the step deskew to set the time at which the step generator for the right channel asserts the TDR step relative to the left channel and vice-versa. Notice that the edges moves horizontally, relative to each other. Adjust the step generator steps to divide the mismatch between channels equally between the incident step and the reflections.</p> <p>11. After dividing the mismatch equally between channels using Step Deskew, adjust Channel Delay to align the front edge of the reflections. If needed, next adjust the Channel Deskew. (For more information see <i>Adjusting TDR Step Deskew</i> on page 39).</p> <p>12. Press the SETUP DIALOGS button.</p> <p>13. Adjust the VERTICAL (2.5 p in this example) and HORIZONTAL SCALE (2 ns in this example) to show a trace similar to that shown. Leave at least one division of baseline trace to the left of the first rise.</p> <p>The first rise of this trace is the incident TDR step leaving the sampling module; the second rise is the reflection of the step returning from the end of the cable.</p>	
<p>Common mode TDR</p>	<p>14. Notice that both channels assert a positive TDR step for common-mode TDR.</p> <p>15. When the TDR steps on the two channels are the same polarity (both positive or negative), you can define a math waveform that represents the average common-mode signal by pressing the VERTICAL MENU button, selecting the Vert tab, selecting Waveform M1, On, and then selecting Define, C1, +, C2, Math Waveform On, and OK.</p>	
<p>Take a measurement</p>	<p>16. Take your measurement. For more information see <i>Take automatic measurements</i> on page 26, or <i>Take cursor measurements</i> on page 27.</p>	

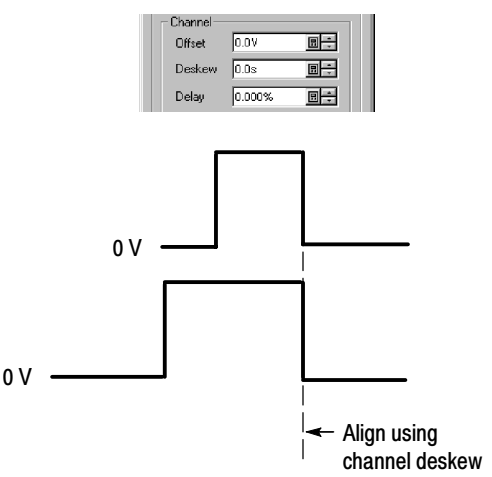
Overview	To take a common mode or differential TDR measurement (cont.)	Control elements & resources
<p>Enable differential TDR measurements</p>	<p>17. Press the SETUP DIALOGS button, and select the TDR tab.</p>	
	<p>18. Click the TDR STEP Polarity box for one channel to invert the polarity of one of the step generators.</p> <p>Note: Although you have inverted a TDR step, the step is only displayed inverted when the acquisition units are Volts.</p>	<p>TDR tab</p> 
	<p>19. Press the SETUP DIALOGS button.</p>	
<p>Differential TDR</p>	<p>20. One channel is asserting a positive step and the other channel is asserting a negative TDR step. These conditions set up differential TDR.</p> <p>21. When the TDR steps on the two channels are opposite (one positive and one negative), you can define a math waveform that represents the difference signal by pressing the VERTICAL MENU button, selecting the Vert tab, selecting Waveform M1, On, and then selecting Define, C1, +, C2, Math Waveform On, and OK. Set the scale to ρ. (If using volts, subtract the waveforms.)</p>	 
<p>Take a measurement</p>	<p>22. Take your measurement. For more information see <i>Take automatic measurements</i> on page 26, or <i>Take cursor measurements</i> on page 27.</p>	

Overview	To take a common mode or differential TDR measurement (cont.)	Control elements & resources
<p>TDT measurements</p>	<p>23. You can make forward and reverse Time Domain Transmission (TDT) measurements using the 80E08 or 80E10. To perform a TDT measurement: connect one sampling module channel to the input of the device under test and the other sampling module channel to the output of the device under test.</p> <p>24. Then alternately enable the step generators on one channel while sampling the transmitted signal on the other channel to perform forward and reverse TDT measurements. You measure the step transmitted through the device, rather than reflections from the device (as in TDR).</p> <p><i>Note: If the second channel is not connected to the same device as the first channel, crosstalk is displayed, as opposed to the step transmitted through the device.</i></p>	 <p>The diagram illustrates the hardware setup for Time Domain Transmission (TDT) measurements. At the top left, a control panel features two channels, CH 1 and CH 2. CH 1 is labeled 'STEP GENERATOR' and CH 2 is labeled 'SAMPLE'. Below the panel are two 'Remote modules'. Wires connect the control panel to the remote modules and then to a 'Device under test'. The device has two ports: one connected to the output of the first remote module (CH 1) and another connected to the input of the second remote module (CH 2). Below the diagram is a waveform graph on a grid. The graph shows a step function that rises from a low level to a high level and then remains constant. A scale indicator '20s/div' is visible in the bottom right corner of the graph.</p>
<p>Take a measurement</p>	<p>25. Take your measurement. For more information see <i>Take automatic measurements</i> on page 26, or <i>Take cursor measurements</i> on page 27.</p>	

Adjusting TDR Step Deskew

When making differential or common-mode TDR measurements, the two steps must arrive at the same time at the reference plane (usually the connection point to the device under test). To adjust the TDR step deskew perform the following steps:

Overview	Adjusting TDR step deskew	Control elements & resources
<p>Prerequisites</p>	<p>1. Either disconnect the transmission cables from the device under test (DUT) at the point where the cables connect to the device, or short both lines to ground at the DUT.</p>	
	<p>2. Set channel deskew and channel delay to zero.</p>	
<p>Adjust TDR step deskew</p>	<p>3. Then, from the TDR setup window, adjust the TDR Step Deskew so that the propagation delay (T_0) between the incident edges is equal to the propagation delay between the reflected edges, as shown in the figure.</p> <p>Both channels have adjustable TDR Step Deskew. First, select one channel and adjust the step deskew. Next, if needed, select the second channel and adjust its step deskew to obtain the correct propagation delay.</p> <p>If using a math function, do not adjust the step more, instead adjust channel deskew and channel delay as shown in the following step.</p>	

Overview	Adjusting TDR step deskew (cont.)	Control elements & resources
<p>Adjust channel deskew</p>	<p>For some measurements, math summing, and comparisons, you may want to visually line up the reflection edges of both TDR steps, even though you have delayed the step assertion time for one channel in the preceding step.</p> <p>4. To do this, first deskew the TDR steps as shown in step 3, then, from the Vertical setup window, deskew the channels.</p> <p>The 80E08 and 80E10 modules have channel delay capabilities. When deskewing channels, set the Channel Deskew to zero, then use the Channel Delay control to align the reflected edges. If needed, then use the Channel Deskew control.</p>	

NOTE. For further information about deskew and an alternate TDR deskew method, refer to the *Quick Start User Manual for the main instrument.*

Connector and Adapter Care Requirements

This section describes proper care and use of the connector and adapter for electrical modules, including protection against electrostatic discharge (ESD), cleaning connectors, and the assembly and torquing of connectors.

Electrostatic Discharge

Protection against ESD is essential while connecting, inspecting, or cleaning connectors attached to a static-sensitive circuit. Static discharges too small to be felt can cause permanent damage, and devices under test can carry an electrostatic charge. To prevent damage to devices and components, use the procedures that follow.

Overview	To protect against ESD	Control elements & resources
ESD prevention	<ol style="list-style-type: none"> 1. Always use a grounded antistatic mat in front of your test equipment. 2. Always wear a heel strap when working in an area with a conductive floor, even if you are uncertain about its conductivity. 3. Always wear a grounded wrist strap having a 1 MΩ resistor in series when handling components and devices or when making connections to the test set. 	
ESD procedures	<ol style="list-style-type: none"> 1. Connect your wrist strap to the antistatic connector on the front of your instrument. Refer to the illustration at right. 2. When cleaning, ground the hose nozzle to prevent ESD. 3. Set the pressure correctly. See <i>Cleaning Connectors</i> on page 42. 	<p>The diagram shows a top-down view of a test instrument's front panel. On the left, there is a circular 'ANTISTATIC CONNECTOR'. An arrow labeled 'Connect wrist strap' points to this connector. To the right of the antistatic connector are two channels: 'CH 1' and 'CH 2'. Below these channels is a 'PRESSURE SCALE' with markings for '100 PSI MAX' and '20 PSI MAX'. The diagram illustrates the correct placement of a wrist strap for ESD protection.</p>

Visual Inspection

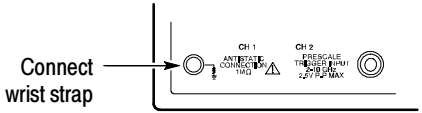
Visual inspection, and, if necessary, cleaning should be done every time a connection is made. Making a connection with a damaged or dirty connector can damage connectors beyond repair. In some cases, magnification is necessary to see damage to a connector. However, defects visible only under magnification are not the only thing to look for. Use the following guidelines when checking connectors:

- Examine connectors first for obvious damage and defects such as worn plating on the interface; broken, bent, or misaligned center conductors; and deformed threads.

- Reduce connector wear by keeping connectors clean and by connecting them properly.
- Replace calibration devices with worn connectors, and use an adapter on the input connector, when applicable, to minimize wear.
- Inspect connector mating-plane surfaces for dents, scratches, and for dirt and particles. Check for damage due to uneven or excessive misalignment or wear.
- Carefully inspect the contact fingers in the female center conductor when using slotted connectors. Damage, which is not always easy to see, can result in poor electrical contact. When mating precision to nonprecision devices, this is especially important.

Cleaning Connectors

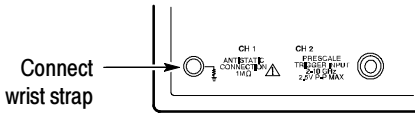
Clean connectors are essential for ensuring the integrity of RF and coaxial connections. This section covers precautions, cleaning connector threads, cleaning the mating plane surfaces, and inspecting the connector.

Overview	To follow proper cleaning procedures	Control elements & resources
<p>Cleaning precautions</p>	<ol style="list-style-type: none"> 1. Ground the hose nozzle to prevent ESD. See <i>Electrostatic Discharge</i> on page 41. 2. Air or nitrogen source should have an effective oil-vapor filter and liquid condensation trap just before the outlet hose. 3. Always use protective eyewear when using compressed air or nitrogen. 4. Set the pressure to less than 414 kPa (60 psi) to control the velocity of the air stream. Compressed air can cause ESD when directed into a connector. 5. Keep isopropyl alcohol away from heat, sparks, and flame. Store properly, and in case of fire, use alcohol foam, dry chemical, or carbon dioxide, since water may not work. 6. Use isopropyl alcohol with adequate ventilation and avoid contact with eyes, skin, and clothing. Wash thoroughly after handling. 7. In case of a spill, soak up with sand or earth, and flush spill area. 8. Dispose of isopropyl alcohol in accordance with the applicable federal, state, and local regulations. 	 <p>Connect wrist strap</p>

Overview	To follow proper cleaning procedures (cont.)	Control elements & resources
<p>Cleaning the connector threads</p>	<ol style="list-style-type: none"> 1. Use compressed air or nitrogen to loosen particles on the connector mating plane surfaces. See the preceding <i>Precautions</i>. 2. To remove dirt or stubborn contaminants on a connector that cannot be cleaned with compressed air or nitrogen, apply a small amount of isopropyl alcohol to a lint-free cleaning swap. A standard foam-tipped swap is recommended. 3. Clean the connector threads. 4. After the alcohol evaporates, blow the threads dry using low-pressure compressed air or nitrogen. Make sure the threads are completely dry before using. 	
<p>Cleaning the mating plane surfaces</p>	<ol style="list-style-type: none"> 1. Using a small amount of isopropyl alcohol on a lint-free cleaning swap, clean the mating surfaces of the center and outer conductors. 2. After the alcohol evaporates, blow the mating surfaces dry using low-pressure compressed air or nitrogen. Make sure the connector is completely dry before using. 	
<p>Inspecting the connector</p>	<ol style="list-style-type: none"> 1. Inspect the connectors to make sure they are clean and undamaged. Refer to <i>Visual Inspection</i> on page 41. 	

Assembly and Torquing

The most common cause of measurement errors are bad connections. The procedures in this section describe how to make good connections.

Overview	To properly perform assembly and torquing of connectors	Control elements & resources
<p>Prerequisites and precautions</p>	<ol style="list-style-type: none"> 1. Ground yourself and all devices. Wear a grounded wrist strap and work on a grounded, conductive table mat. Also see <i>Electrostatic Discharge</i> on page 41. 2. Inspect connectors. See <i>Visual Inspection</i> on page 41. 3. If necessary, clean the connectors. See <i>Cleaning Connectors</i> on page 42. 4. Use a connector gage to verify that all center conductors are within the observed pin depth values. 5. For multiple connections, always put the fixed wrench on the inside (stationary) half of a connection and apply torque to the outside movable half. 6. Always torque a single connection, never multiple connections. 	
<p>Torquing an inline connector to a stationary connector</p>	<ol style="list-style-type: none"> 1. Carefully align connectors. Male connector pin must slip concentrically into the contact finger of the female connector. 2. Push the connectors straight together and tighten the connector nut finger tight. Do not turn the device body. There is usually a slight resistance as the center conductors mate. Uniform, light contact is sufficient for the preliminary connection; do not overtighten. 3. Ensure that the connectors are properly supported. As needed, relieve any side pressure on the connection from long or heavy devices or cables. 	
<p>Torquing multiple inline connectors</p>	<ol style="list-style-type: none"> 1. If starting from a fully disassembled state, order the connections so that they are assembled from the outside moveable portions toward the inward (stationary) portions. Disassemble from the inside outward. 2. If starting from a partially disassembled state, such as with a protective coupler, leave subassemblies intact. 3. Maximize protection and minimize disturbance for the connection that is intended to be preserved by the protective coupler. 	

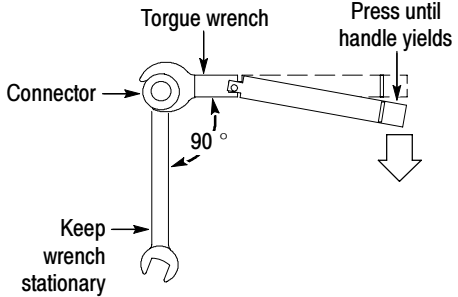
Overview	To properly perform assembly and torquing of connectors (cont.)	Control elements & resources
Joining two stationary connectors with a semi-rigid coaxial cable	<ol style="list-style-type: none"> Position the cable and order the connections to minimize the side and end loading on the last connection. If available, use a protective connector to prevent or reduce damage to a connector. 	
Final connection	<ol style="list-style-type: none"> Use a torque wrench to make the final connection. See Table 4 on page 45 for torque wrench information. Rotate only the connector nut that you are tightening. If necessary, use an open-end wrench to keep the body of the device from turning. Position both wrenches within 90 degrees of each other before applying force. Refer to the illustration at right. Hold the torque wrench lightly at the end of the handle. Apply downward force perpendicular to wrench handle; this applies torque to connection through the wrench. Tighten the connection just to the point that the wrench breaks over. Do not overtighten the connection. 	

Table 4: Torque wrench Information

Connector type	Torque setting	Torque tolerance
SMA	56 N-cm (5 in-lb)	± 5.6 N-cm (± 0.5 in-lb)
1.85 mm 2.4 mm 2.92 mm 3.5 mm	90 N-cm (8 in-lb)	± 9.0 N-cm (± 0.8 in-lb)

Detecting Damaged Inputs

Checking For Damage

Because of their technology, high-bandwidth sampling modules are vulnerable to damage through static discharge and overvoltages (EOS) to their inputs. Damage can occur instantaneously. Under most conditions when EOS damage occurs, the trace will be flat. It typically involves short-period, high-current discharge. The damages can be blown diodes as indicated by a large offset or no response to input.

To check for damage, use one of the following procedures:

- If checking a TDR capable sampling module, attach a 50 Ω termination to the channel input and perform a TDR measurement of the attached fitting. Adjust the HORIZONTAL SCALE to 500 ns per division. This should display the entire TDR step from edge to edge. Display the step top at 40 mV per division and check for flatness. If the top is bowed, sagged, hooked, or tilted, assume static has damaged the module and service is required. See Figure 17.
- If checking a non-TDR sampling module, use a similar procedure as just described, but use an external step source.

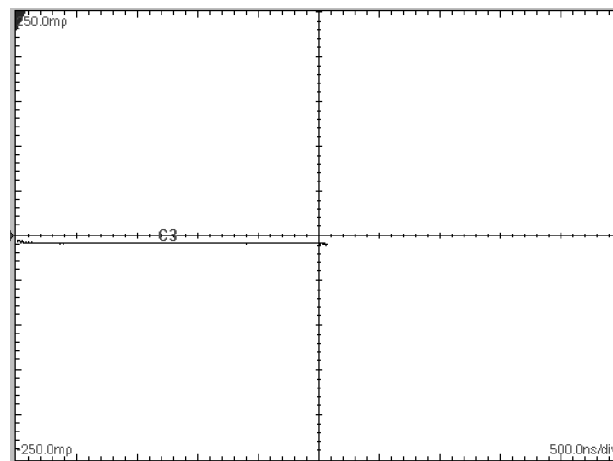


Figure 17: TDR step of undamaged sampling module

EOS (Electrical Overstress) Prevention

EOS occurs when an electronic device is subjected to an input voltage higher than its designed maximum tolerable level. Similar to ESD (Electrical Static Damage), EOS usually is also related to static charges generated by moving elements. However, unlike ESD that typically deals with thousands of volts,

EOS can occur at a low voltage level. For Tektronix 80E00-series modules, EOS damage could occur at levels as low as 10 V. EOS can have a cumulative effect; repetitive EOS causes incremental damage over time and results in sampling function deterioration.

Prevention

Standard ESD precautions are not very effective for EOS damage prevention. This is particularly true when the DUT (Device Under Test) is isolated from any reference voltage levels, including the ground level. To prevent EOS damage of 80E00-series modules, strictly follow these EOS-prevention requirements:

- Observe all ESD prevention procedures.
- Before letting the probe tip touch the device under test, use a ground-conducting element to discharge any residual charge at the test point.
- While measuring the DUT, make sure that no nearby personnel or objects are moving, since this can induce spurious charges on the probe head. Such charges can easily reach levels of several hundred volts.
- For non-critical applications, proper usage of a static-isolation unit, such as the Tektronix 80A02 EOS/ESD Protection Module, can safely discharge the residual charges and protect the modules from EOS damages.

Checking For Damage

If the waveform top is bowed, sagged, hooked, or tilted, assume static has damaged the module and service is required. Figure 18 on page 48 shows a typical waveform signature indicating EOS damage.

Since EOS can be cumulative, EOS damage can accumulate until there is even greater damage as shown in Figure 19 on page 48. In this example, the percentage of overshoot is increased.

To check for damage, use one of the following procedures:

If checking an 80E08 or 80E10 sampling module and your instrument has TDR capability, attach a 50 Ω termination to the channel input and perform a TDR measurement of the attached fitting:

1. Select the TDR channel to turn it on.
2. Press the TDR preset.
3. Adjust the HORIZONTAL SCALE to 2 μ s per division. The vertical setting should be 200 mV as shown in the illustrations. This should display the entire TDR step from edge to edge. Display the step top at 40 mV per division and check for flatness. The top of the waveform should be flat.

If checking a non-TDR sampling module, use a similar procedure as just described, but use an external step source.

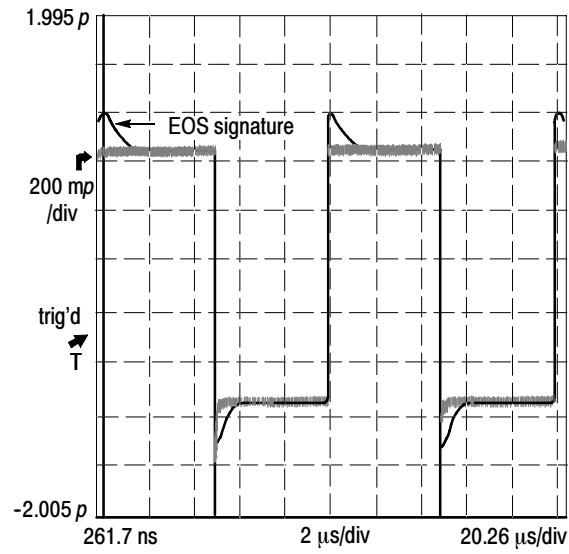


Figure 18: First example of EOS error

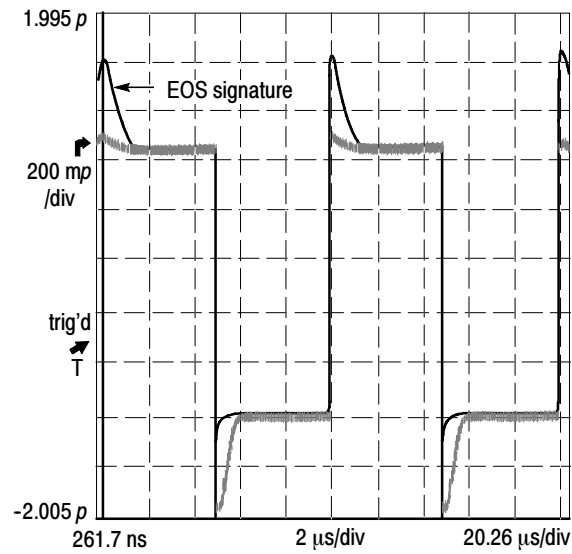


Figure 19: Second example of EOS error showing cumulative effect

Specifications

This section contains specifications for the 80E07, 80E08, 80E09, and 80E10 remote sampling modules. All specifications are guaranteed unless noted as “typical.” Typical specifications are provided for your convenience but are not guaranteed. Specifications that are marked with the ✓ symbol are checked in *Performance Verification* procedures provided in the Specifications and Performance Verification manual for your main instrument.

All specifications apply to all models of sampling module unless noted otherwise. To meet specifications, these conditions must first be met:

- The instrument must have been calibrated/adjusted at an ambient temperature between +20 °C and +30 °C.
- The instrument must have been operating continuously for 20 minutes within the operating temperature range specified.
- The instrument must be in an environment with temperature, altitude, humidity, and vibration within the operating limits described in these specifications
- A compensation must have been performed. Recompensation is required if a module is moved to another compartment.

Table 5: Electrical sampling modules - Signal acquisition

Specifications	Characteristics
Real time accessory interface	Tekprobe-SMA interface is provided through the electrical sampling-module interface, one per vertical channel.
Extender accommodation	Module extenders (015-1568-xx, 015-1569-xx, 80N01, and 80A03) are not permitted and are mechanically blocked from being used in front of the main module.
Number of input channels	2
Input connector	
80E07 and 80E08	2.92 mm (K) female SMA-compatible connector
80E09 and 80E10	1.85 mm (V) female connector
✓ Input impedance	50 Ω ± 1 Ω
Vertical dynamic range, non-clipping	1 V _{pp} (offset ± 500 mV)
Vertical operating range ¹ , maximum	± 1.1 V
Vertical nondestruct range ² , maximum input voltage	± 2.0 V (DC+peak AC)
Vertical number of digitized bits	14 bits full scale

Table 5: Electrical sampling modules - Signal acquisition (cont.)

Specifications	Characteristics			
Vertical sensitivity range ³	The range of available full scale input settings.			
Maximum	1 mV per division (10 mV full screen)			
Minimum	100 mV per division (1 V full screen)			
Vertical offset range ¹	± 1.1 V			
Compensation temperature range	± 5 °C about temperature where compensation was performed. If the module is moved to another compartment on the mainframe, the channel(s) must be recompensated.			
✓ DC voltage accuracy, single point, compensated	The sampling module and mainframe together as a system shall meet or exceed the following DC accuracy requirements after compensation has taken place. For operation over 10-40 °C, a temperature tolerance of ± 2 °C guaranteed (± 5 °C typical) relative to the compensation temperature, is permitted. If sampling module is moved to a different compartment or mainframe, re-compensation must be done. ± 2 mV <system offset offset> ± 0.007 * (assigned offset) <system offset gain> ± 0.02 * (vertical value - assigned offset) <system gain/offset> System deviation from linear least squares fit, at the maximum bandwidth setting: ± 10 mV			
✓ Analog bandwidth, maximum frequency setting				
80E07	DC to 30 GHz, better than ± 3 dB			
80E08	DC to 30 GHz, better than ± 3 dB			
80E09	DC to 60 GHz, better than ± 3 dB			
80E10	DC to 50 GHz, better than ± 3 dB			
Analog bandwidth, reduced frequency set points, typical				
80E07, 80E08	20 GHz			
80E09, 80E10	40 GHz, 30 GHz			
Rise time, typical	Estimated based upon assumed 0.35 calculated product of typical bandwidth and risetime			
	60 / 50 GHz	40 GHz	30 GHz	20 GHz
80E07	--	--	11.67 ps	17.5 ps
80E08	--	--	11.67 ps	17.5 ps
80E09	5.83 ps	8.75 ps	11.67 ps	--
80E10	7 ps	8.75 ps	11.67 ps	--

Table 5: Electrical sampling modules - Signal acquisition (cont.)

Specifications	Characteristics			
Step response aberrations, typical	$\pm 1\%$ or less over the zone 10 ns to 20 ps before step transition $+6\%$, -10% or less over the first 400 ps following step transition $+0\%$, -4% or less over the zone 400 ps to 3 ns following step transition $+1\%$, -2% or less over the zone 3 ns to 100 ns following step transition $\pm 1\%$ or less after 100 ns following step transition			
✓ Random noise, displayed	60 / 50 GHz	40 GHz	30 GHz	20 GHz
80E07	--	--	<410 μV_{RMS}	<380 μV_{RMS}
80E08	--	--	<410 μV_{RMS}	<380 μV_{RMS}
80E09	<600 μV_{RMS}	<480 μV_{RMS}	<410 μV_{RMS}	--
80E10	<700 μV_{RMS}	<480 μV_{RMS}	<410 μV_{RMS}	--
Random noise, displayed, typical	60 / 50 GHz	40 GHz	30 GHz	20 GHz
80E07	--	--	<300 μV_{RMS}	<280 μV_{RMS}
80E08	--	--	<300 μV_{RMS}	<280 μV_{RMS}
80E09	<450 μV_{RMS}	<330 μV_{RMS}	<300 μV_{RMS}	--
80E10	<600 μV_{RMS}	<370 μV_{RMS}	<300 μV_{RMS}	--
Acquisition delay adjust range, typical	± 250 ps, each channel			
Acquisition delay adjust resolution	135 fs			

- ¹ **Offset range and / or sensitivities may be constrained where the Maximum Operating Range could be exceeded.**
- ² **Vertical nondestruct range defines the maximum range over which offset plus peak input signal can operate without irreversible damage to the instrument. Operation to instrument specification is not guaranteed outside of the vertical operating range.**
- ³ **The base sensitivity ranges from 10 mV to 1 V full scale in a 1-2-5 sequence of coarse settings. Between coarse settings, the sensitivity can be finely adjusted with a resolution equal to 1 mV.**

Table 6: Electrical sampling module - TDR system (80E08 and 80E10)

Specifications	Characteristics
Number of TDR channels	2
TDR operation modes	Step output with positive edge polarity, negative edge polarity, and off, independently selectable each channel.
TDR maximum input voltage	Specifications are not guaranteed with any DUT applying signal. Do not apply external signal during TDR operation.
✓ TDR reflected edge rise time ¹	
80E08	22 ps or less, each polarity
80E10	16 ps or less, each polarity
TDR reflected edge rise time ¹ , typical	
80E08	20 ps or less, each polarity
80E10	15 ps or less, each polarity
TDR incident edge rise time, typical	
80E08	18 ps or less, each polarity
80E10	12 ps or less, each polarity
TDR incident edge amplitude	± 250 mV step into 50 Ω
✓ TDR aberrations, incident edge ²	At maximum sampler bandwidth setting, both polarities of TDR: ± 1% or less over the zone 10 ns to 20 ps before step transition +12% -2% or less over the zone 14 ps to 400 ps following step transition ± 2% or less over the zone 400 ps to 5 ns following step transition +1% -2% or less over the zone 5 ns to 100 ns following step transition ± 1% after 100 ns following step transition
TDR incident edge delay adjust range, typical	± 250 ps, each channel and each polarity
TDR incident edge delay adjust resolution, typical	135 fs
TDR maximum repetition rate	200 kHz

¹ IEEE std 1057, section 4.8.2, transition duration of step response.

² IEEE std 1057, section 4.8.4, overshoot and precursors.

Table 7: Electrical sampling modules - Timebase system

Specifications	Characteristics
Horizontal position range	Minimum horizontal position setting is 29 ns, external direct trigger operation.

Table 8: Electrical sampling modules - Mechanical

Specifications	Characteristics
Construction material	Main and remote chassis parts constructed of aluminum alloy; front panels constructed of plastic laminate; circuit boards constructed of glass-laminate. Cabinet sleeves and end covers are aluminum.
Weight (unpackaged)	
80E07, 80E08	861 gm (29.11 oz)
80E09, 80E10	868 gm (29.35 oz) including two 2.4 mm to 2.92 mm adapters
Overall dimensions	Does not include connectors, connector savers, connector covers, push buttons, cables, strain reliefs, or lock-down hardware protruding from the front or rear panels.
Main module	Height: 25 mm (1.0 in) Width: 79 mm (3.1 in) Depth: 135 mm (5.3 in)
Remote module	Height: 25 mm (1.0 in) Width: 55 mm (2.2 in) Depth: 75 mm (3.0 in)
Remote cable length	2 meters

NOTE. For System - Environmental specifications, refer to the Specifications and Performance Verification manual for the main instrument.

Glossary

Accuracy

The closeness of the indicated value to the true value.

Analog-to-Digital Converter

A device that converts an analog signal to a digital signal.

Attenuation

A decrease in magnitude of current, voltage, or power of a signal.

Attenuator

An electronic transducer that reduces the amplitude of a signal.

Autoset

A means of letting the instrument set itself to provide a stable and meaningful display of a given trace.

Bandwidth

The range of frequencies handled by a device or system. Bandwidth is a measure of network capacity. Analog bandwidth is measured in cycles per second. Digital bandwidth is measured in bits of information per second.

Channel

A place to connect a signal or attach a network or transmission line to sampling modules.

Common Mode

A circumstance where a signal is induced in phase on both sides of a differential network.

dB

Decibel: a method of expressing power or voltage ratios. The decibel scale is logarithmic. The formula for decibels is:

$$\text{dB} = 20 \log (V_i/V_{\text{ref}})$$

where V_i is the voltage of the incident pulse, V_{ref} is the voltage reference, and \log is the decimal-based logarithmic function.

Dialog Box

A displayed box in which you enter instrument commands.

Differential Mode

A circumstance where the true signal and its logical complement are transmitted over a pair of conductors.

Digital Signal

A signal made up of a series of on and off pulses.

Electrical Overstress (EOS)

Electrical overstress occurs when an electronic device is subjected to an input voltage higher than the designed maximum tolerable level.

External Attenuation

Attenuation that is outside the sampling module.

Impedance

The opposition to an AC signal in the wire. Impedance is very much like resistance to a DC signal in a DC circuit. Impedance is made up of resistance and inductive and capacitive reactance.

Incident Step

The electrical energy transmitted by the TDR step generator. An acquired waveform shows this step and all reflections on the signal conductor.

Initialize

Setting the main instrument to a completely known, default condition.

Internal Clock

A trigger source generated internally within the instrument and used to synchronize TDR step generators. Also available at the front panel Internal Clock Output connector.

Rho (ρ)

When making TDR measurements, the ratio of the incident step to the reflected step. A value of one (1) indicates complete reflection.

Setting

The state of the front panel and system at a given time.

TDR

Time-Domain Reflectometer: an instrument that sends out steps of energy and measures the amplitude and time interval of the reflections. If the velocity of the energy through the cable is known, distances to features can be computed and displayed. Conversely, the speed that energy travels through a cable of known length can also be computed. The way in which the energy is reflected and the amount of the energy reflected indicate the condition of the cable.

Time Domain Transmission (TDT)

A method of characterizing a transmission line or network by transmitting a signal through the network and monitoring the output.

Trigger

An electrical event that initiates acquisition of a sample as specified by the time base.

Waveform

The visible representation of an input signal or combination of signals.

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