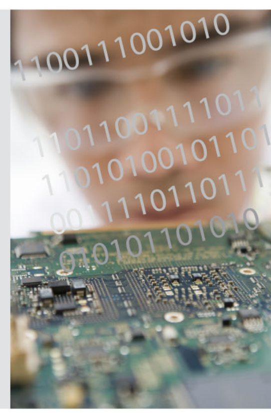
IConnect® and MeasureXtractor™
Signal Integrity, TDR, and S-parameter Analysis Software

Quick Start User Manual



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Tektronix

IConnect® and MeasureXtractor™
Signal Integrity, TDR, and S-parameter Analysis Software

Quick Start User Manual

www.tektronix.com

071-2677-01

Tektronix

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Compliance Information

This section lists the environmental standards with which the instrument complies.

Environmental Considerations

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

Product End-of-Life Handling

Observe the following guidelines when recycling an instrument or component:

Equipment Recycling. Production of this equipment (the hardware key) 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. 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.

This symbol indicates that this product complies with the applicable European Union requirements according to Directives 2002/96/EC and 2006/66/EC on waste electrical and electronic equipment (WEEE) and batteries. For information about recycling options, check the Support/Service section of the Tektronix Web site (www.tektronix.com).

Preface

IConnect® and MeasureXtractor™ is TDR (time domain reflectometry) software that provides high-speed interconnect characterization. It is an integrated tool for measurement, compliance testing, modeling and validation for interconnects in printed and flexible circuit boards, packages, ATE sockets, connectors, cables, and cable assemblies. IConnect provides accurate measurements and equivalent circuit models that predict reflections, ringing, and crosstalk in interconnects.

This software supports signal acquisition from the following instruments:

- Tektronix: DSA8300 (recommended), DSA8200, CSA8000, CSA8000B, CSA8200, TDS8000, TDS8000B, and TDS8200

Key Features

- Optimized for use with the Tektronix DSA8300 Digital Serial Analyzer sampling oscilloscope with 80E10, 80E08 and 80E04 true differential TDR modules
- Single-click solution for PCI Express, Serial ATA, and HDMI manufacturing and standard compliance testing (including eye mask tests)
- Analyze interconnect jitter, losses, crosstalk, reflections, and ringing concurrently in time and frequency domains
- Perform interconnect link analysis to verify system level simulation accuracy
- Model PCBs, flexboards, connectors, cables, packages, and sockets
- Generate Eye Diagrams with optional aggressors, periodic jitter insertion, and random jitter and noise insertion
- Convert TDR/T data into SPICE with MeasureXtractor; model passivity, stability, and causality guaranteed
- Obtain S-parameters (differential, single ended, mixed-mode; insertion, return loss, frequency domain crosstalk) using your TDR oscilloscope
- Simple calibration procedure minimizes human errors and makes fixture de-embedding a simple task
- Obtain more accurate impedance measurements (Z-Line)
- Automate manufacturing test and R&D measurements with scripts and programmatic control command line interface

Documentation

This manual provides installation, basic operation, and application example instructions for the IConnect® and MeasureXtractor™ TDR Software. For more detailed information, see the online help (**Help > Help Contents**).

Conventions Used in This Manual

The following icon is used in this manual:

Sequence
Step

Installation

IConnect Software Versions

IConnect is available in the following versions:

- IConnect Evaluation: A free and fully functional evaluation version with a limited number of uses and limited time window of operation
- IConnect and MeasureXtractor: Includes all application features (MeasureXtractor, modeling, S-parameters, Z-Line, Eye Diagram Viewer, standards compliance testing and more)
- IConnect w/o MeasureXtractor: Includes all application features except MeasureXtractor
- IConnect S-Parameters and Z-Line: Provides S-parameter and Z-Line functions

Minimum System Requirements

- Microsoft Windows 7 Ultimate (32- and 64-bit) or XP on supported Tektronix oscilloscopes or a PC
- TekVISA software (to run the S-parameter Wizard tool or to communicate with an oscilloscope over a local area network (LAN)
- National Instruments GPIB board or a USB to GPIB adaptor (not required when running IConnect on supported Tektronix oscilloscopes or over a LAN connection from a Windows PC to a supported Tektronix oscilloscope)
- External 1024 x 768 resolution monitor when running on any Tektronix sampling oscilloscope other than the DSA8300

Installing Software

IConnect Software

See the installation instructions that came with the IConnect software CD (071-2676-XX). You can download this file from the Tektronix Web site (www.tek.com/manuals).

TekVISA Software

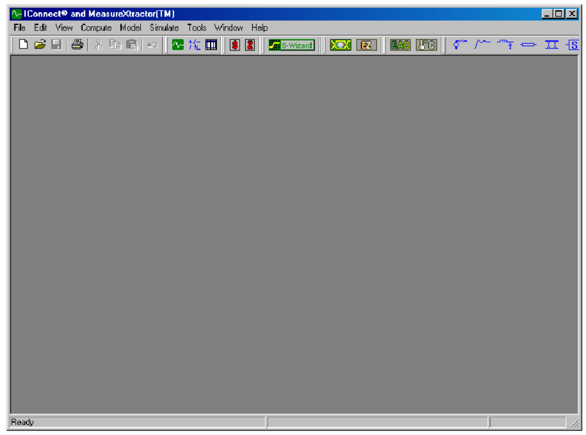
If you plan to run IConnect on a PC and acquire waveforms from an oscilloscope connected to a LAN, or run the S-parameter Wizard function (on the oscilloscope or remotely from a PC), you must install TekVISA software on your PC.

NOTE. *TekVISA is already installed on Tektronix DSA8300 oscilloscopes. Legacy Tektronix sampling oscilloscopes (DSA8200 series and earlier) will need to have the specified version of TekVISA installed to correctly operate with this release of IConnect.*

1. Check which version of TekVISA is installed on your oscilloscope and PC (open the TekVISA tool and click **Help > About**). If the version is earlier than **3.3.4.6**, go to the Tektronix Web site (www.tektronix.com/software), search for **tekvisa**, and download version 3.3.4.6.
2. Follow the installation instructions provided with the TekVISA download file.

Starting and Stopping the Application

1. Before starting IConnect, plug the hardware key into the appropriate USB or parallel port on your computer. If you already have a peripheral device connected to your parallel port, plug the IConnect hardware key into the parallel port, and plug the peripheral device into the back of the IConnect hardware key.
2. Click **Start > Programs Tektronix Applications > IConnect and MeasureXtractor > IConnect and MeasureXtractor** to start IConnect:
3. To stop IConnect, click **File > Exit** or the window Close button. If you have any unsaved viewers, IConnect prompts you to save the views before closing.



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***NOTE.** If you open other applications from within IConnect, such as the S-Parameter Wizard, closing IConnect does not close those applications.*

Running IConnect on a Tektronix Oscilloscope

You can install and run IConnect on a supported Tektronix oscilloscope. Running IConnect on an oscilloscope makes it unnecessary to use a separate PC with a GPIB card, keeping your benchtop area less cluttered.

To most effectively run IConnect on legacy Tektronix sampling oscilloscopes (models earlier than the DSA8300), connect an external 1024 x 768 resolution monitor to the oscilloscope. The external monitor lets you view all of the IConnect user interface, while the instrument display shows the application software. See your oscilloscope documentation for help on setting up dual monitor support.

***NOTE.** You do not need theTekVISA software to run IConnect on a separate PC that is connected to an oscilloscope directly through a GPIB interface card. However, you do need TekVISA to remotely operate IConnect over a local area network or to run the S-parameter Wizard.*

Running IConnect on a PC

You can install and run IConnect on a PC and communicate with an oscilloscope using a GPIB card installed on the PC, a USB/GPIB adapter, or a LAN connection.

LAN Interface

Use the following steps to set up communications between IConnect on a PC and an oscilloscope connected to a local area network (LAN):

NOTE. *You must install TekVISA on your PC, and both the instrument and the PC must have a working connection to the LAN, before doing this procedure.*

The following instructions are written for TekVISA version 3.3.4.6. You can download TekVISA from the Tektronix Web site.

1. On the oscilloscope, click the VXI-11 server icon in the system tray and select**Start VXI-11 Server** to enable the VXI-11 server.
2. On the oscilloscope desktop, right-click the **My Computer** icon and select **Properties**. Click the **Computer Name** tab and write down the full name of the oscilloscope computer.
3. On the PC, right-click the **TekVISA** icon in the system tray and select **Instrument Manager**.
4. Click **Search Criteria** and click the **Local LAN** bar in the Search Criteria tool.
5. Click the **Search Remote LAN** check box and enter the oscilloscope computer name to the **Add LAN Search Location** field (from step 2). Click the down arrow to add this name to the search list.
6. Click **Search for Selected** and click **Done** to close the applet. The instrument you just added should be listed in the **Instruments** field on the main TekVISA Instrument Manager page.
7. Select the instrument you just added in this list and click **Properties**.
8. Enter **GPIB8::1::INSTR** in the Device Name field type and click **OK**.

NOTE. *This is the default Tektronix oscilloscope GPIB address. If the oscilloscope GPIB address was changed from the default, enter the correct oscilloscope GPIB address.*

9. Start IConnect on the PC. Click the **Waveform Acquisition** toolbar button and select **Tektronix DSA/TDS/CSA8xxx Local**. This should connect IConnect to the specified instrument.

NOTE. *The VXI-11 LAN connection also provides a mechanism with which to send GPIB commands from a PC to a Tektronix oscilloscope. This virtual GPIB connection works as well as a real (physical GPIB card and cable) GPIB connection.*

GPIB Card Interface

- Install any VISA drivers that are required by the GPIB controller board installed in the PC.
- Check the index number of the GPIB board installed in the PC that is running IConnect. If the GPIB board index number is not GPIB0, change the default IConnect GPIB board setting to match that of the GPIB board. (See page 18, *Acquiring, Saving, and Loading Waveforms*.)

- Set the oscilloscope to online mode. If the oscilloscope is not in the online mode (is set to local mode), the oscilloscope ignores commands transmitted over the GPIB bus. See the oscilloscope user manual for details on setting the online mode.
- Set or verify that the oscilloscope is in talk/listen mode to enable two-way communication between the oscilloscope and the GPIB controller.
- Set the IConnect GPIB address to match that of the oscilloscope. (See page 18, *Acquiring, Saving, and Loading Waveforms*.) Any address between 0 and 31 is valid, although 0 is discouraged it is the default address of most GPIB controllers. IConnect has default values of 1 for Tektronix instruments. Change this value in IConnect to match your GPIB and equipment configuration.

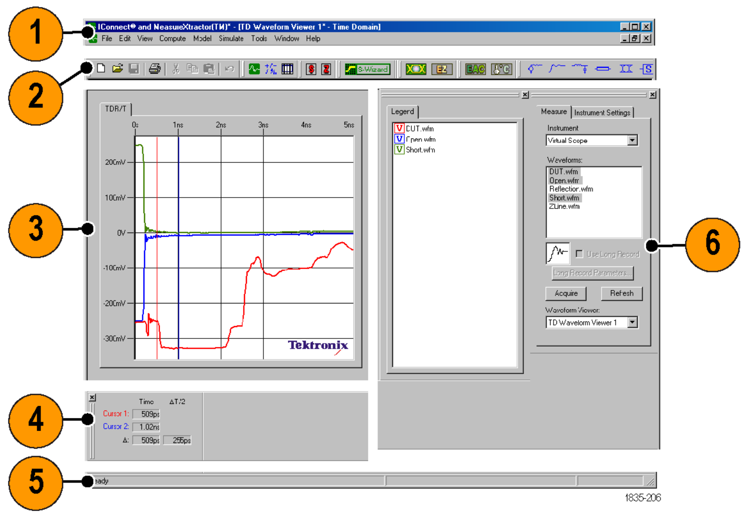
USB to GPIB Adapters

A USB to GPIB adapter enables a PC to communicate with a GPIB device. Follow the installation and operation instructions that came with the USB to GPIB adapter. The adapter must support the IEEE 488.2 specification. The USB to GPIB interface should be transparent, with IConnect communicating with the oscilloscope using normal GPIB commands.

Operating Basics

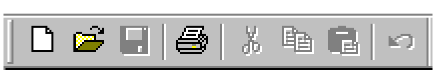
The User Interface

1. Menu Bar.
2. Toolbar. (See page 5, *The Toolbar*.)
3. Waveform/Data Views. (See page 6, *The Waveform/Data Views*.)
4. Cursor View. (See page 9, *Cursors and Cursor Readouts*.)
5. Status Bar. (See page 10, *The Status Bar*.)
6. Task Tabs. (See page 9, *The Task Tabs*.)

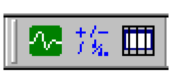


The Toolbar

The Toolbar provides one-click access to common operations. Click **View > Toolbars** and select the toolbar elements to display.

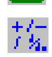


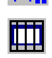
The **Standard** toolbar buttons control common application operations including opening a new view or model window, open or save a file, cut and copy tasks, print, and undo.

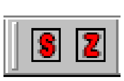


The **Auxiliary** toolbar buttons provide the following functions:

 Opens task tabs with which you can acquire or load waveforms

 Performs specific measurements or computations

 Captures screen images to a file, clipboard, or printer

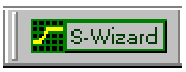


The **Algorithm** toolbar buttons. The S and Z buttons provide fast access to parameters and actions to compute S-parameter and Z-Line measurements.

The **Enhanced Accuracy** toolbar buttons. The **EAC** [1] button runs the Enhanced Accuracy Characterization command (on DSA8200 oscilloscopes) for improved long-record accuracy.

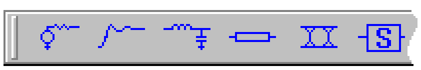
NOTE. *The DSA8300 acquisition hardware does not require the IConnect EAC function.*

The **Compensate Oscilloscope** [2] button runs the temperature compensation function of the oscilloscope for improved long record waveform measurement accuracy. (See page 12, *Measurement Best Practices*.)



The **S-parameter Wizard** button provides a graphical interface and procedure guidance to automatically acquire TDR and TDT waveforms from a DUT connected to a Tektronix sampling oscilloscope to calculate and generate S-parameter and Touchstone files. (See page 38, *Automatically Creating S-Parameter Files (S-Parameter Wizard)*.)

The **Viewers** toolbar buttons. The **Eye Diagram** button opens the Eye Diagram viewer for setting up and displaying Eye Diagrams. The **EZ** button opens the EZ Z-Line viewer for creating and comparing Z-Line measurements against a known DUT reference.



The **Model** toolbar buttons open model viewers to extract a variety of interconnect models from measurement data for use in design simulation and validation. (See page 49, *Advanced Modeling (MeasureXtractor™)*.)

1 IConnect checks the oscilloscope thermal compensation status when you run the EAC function. If the oscilloscope or any module is not compensated, IConnect initiates the oscilloscope compensation program, and then runs the oscilloscope EAC program. If the oscilloscope and all modules are compensated, IConnect just runs the oscilloscope EAC program.

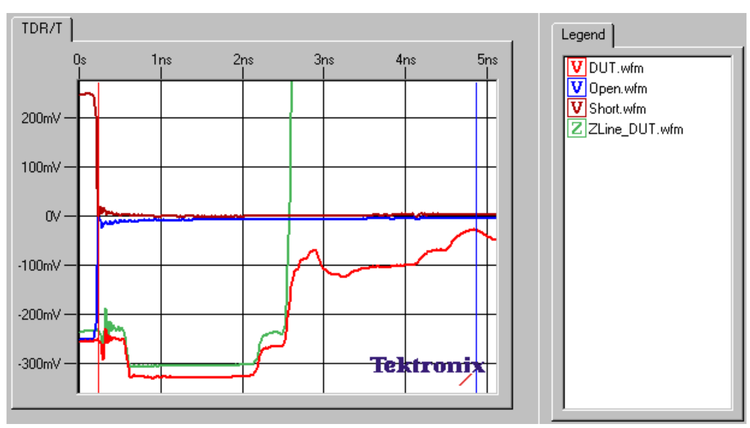
2 The Compensate Oscilloscope button runs the compensation program regardless of the current compensation status of the oscilloscope.

The Waveform/Data Views

The Waveform/Data views show acquired and calculated waveform and data traces and a list of the waveforms in the viewer. The type of waveform trace or data shown depends on the selected operation. If there are multiple views available, each view is accessed with a separate tab.

The icons to the left of the file names identify the waveform type:

- **V**: Voltage
- **Z**: Impedance
- **S**: S-parameter
- **?**: Unknown



Waveform trace operations. A waveform trace is a plot of a measurement waveform or a data waveform calculated by IConnect based on measurement waveforms. The following table lists the operations that you can do on a selected waveform trace:

Operation	Description
Select a waveform	Click a waveform to select it. You can also select a waveform by clicking on the waveform name in the **Legend** tab for that view. Selecting a waveform sets the display to show the vertical scale and units of the selected waveform.
Move a waveform	Click and drag a waveform to move it.
Save a new waveform or an existing waveform to a new name and/or location	Right-click a selected waveform and select **Save As**. Navigate to where you want to save the file, and enter a new file name if required.
Export waveform data to a different format	Right-click a selected waveform and select **Export**. Navigate to where you want to save the file, enter a new file name if required, and select the type of file to save to. Available export formats depend on the selected waveform.
Delete a waveform from the view	Right-click a selected waveform and select **Delete**. You can also select a waveform and press the keyboard **Delete** key. Use the **Undo** button on the Toolbar to restore deleted waveforms.
Show or remove a cursor readout for the selected waveform	Right-click a selected waveform and select **Cursor Readout**. A check mark indicates that the cursor readouts are enabled for the selected waveform. Select **Cursor Readout** again to remove the cursor readout.
Create a label to associate with a specific waveform	Right-click a selected waveform and select **Label** to create a default label with the waveform name. Click and drag a label to move it. Right-click on a label to edit the label text, size, color, and other properties. A label does not move when you move its associated waveform.
Hide a waveform	Right-click a selected waveform and select **Hide** to remove the waveform from the waveform view (the waveform remains in the Legend list). The application can still access hidden waveforms to perform calculations. To restore a hidden waveform, right-click the waveform in the Legend list and select **Unhide**.
Reset a waveform position	Right-click a selected waveform and select **Reset Position** to reset the waveform to its original position when acquired.
Align one DUT waveform with another DUT waveform (EZ Z-Line function)	Right-click a selected waveform and select **Adjust to Position**. The Adjust to Position feature lets you align one DUT TDR waveform plot with another DUT plot to provide a more accurate comparison of their Z-Line plots.
Apply a predefined low pass filter and recalculate a waveform	Right-click a selected waveform and select **Filter (*n*)**. The value of n is set in the **Computation** tab, with the compute type set to **Filter Waveform**.
Display a waveform in a Spectrum view	Right-click a selected waveform and select **Spectrum**.
Change the color and other properties of a waveform	Right-click a selected waveform and select **Properties** to change the waveform color, add comment text, hide or unhide the waveform, or enable or disable cursor readouts.
Convert a S-Parameter waveform to an impedance versus frequency waveform	Right-click a reflected waveform and select **Impedance**. IConnect opens a new FD Waveform Viewer showing the impedance versus frequency plot. ***NOTE.*** *You should only do a S-Parameter to impedance versus frequency conversion on reflection (return loss) S-Parameter waveforms. Reflection waveforms are typically named S11, S22, S33, and so on. Doing a conversion on a nonreflection waveform generates invalid results.*

Waveform view operations. Waveform View operations apply to the entire waveform plot area, and are accessible by right-clicking inside a waveform view when no waveform traces are selected. The following table lists the operations that you can do to the waveform view:

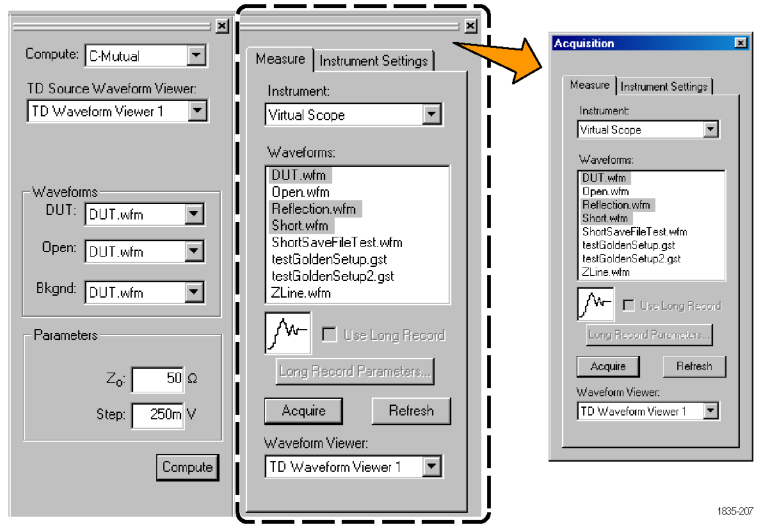
Operation	Description
Zoom in on a specific region of the view	Click and drag in a view to zoom in on that region.
Set the horizontal and vertical scales to show all waveform traces (Autoscale)	Right-click in a waveform view and select **Autoscale**.
Undo zoom operations to see the waveform trace as defined by the current scaling, whether set manually or by Autoscale	Right-click in a waveform view and select **Zoom to 100%**.
Set the horizontal and vertical scales for the waveform view	Right-click in a waveform view and select **Set Scale**. Enter the horizontal and vertical limits of the graph.
Create a label to save with the waveform view	Right-click in the waveform view, select **Label**, and enter the label text. Click and drag a label to move it. Right-click on a label to edit the label text, size, color, and other properties.
Import waveform or other data into a view	Right-click in a waveform view and select **Import**. Select the type of data to import, then navigate to and select the file to import.
Change the waveform plot units	Right-click in a waveform view and select **Plot**. Select the type of plot and set other parameters as needed. The available plot types depend on the waveform view (waveform traces or spectrum view).
Export the waveform view data to a Touchstone format file	Right-click in the waveform view and select **Export > Touchstone**, and specify the port type. Navigate to where you want to save the Touchstone file and enter a new file name if required. The available file options (based on the port numbers) depend on the number of the S-parameter waveforms.

The Task Tabs

The task tabs provide access to parameters and actions for acquiring waveforms or setting measurement parameters. Click the Auxiliary or Algorithm toolbar buttons to open associated Task tabs.

Click a tab to show the parameters for that tab. Task tab contents change depending on the selected measurement or operation.

You can undock a task tab from the main window by clicking and dragging on the double-line area at the top of the tabs to move that tab away form the main application window.



Cursors and Cursor Readouts

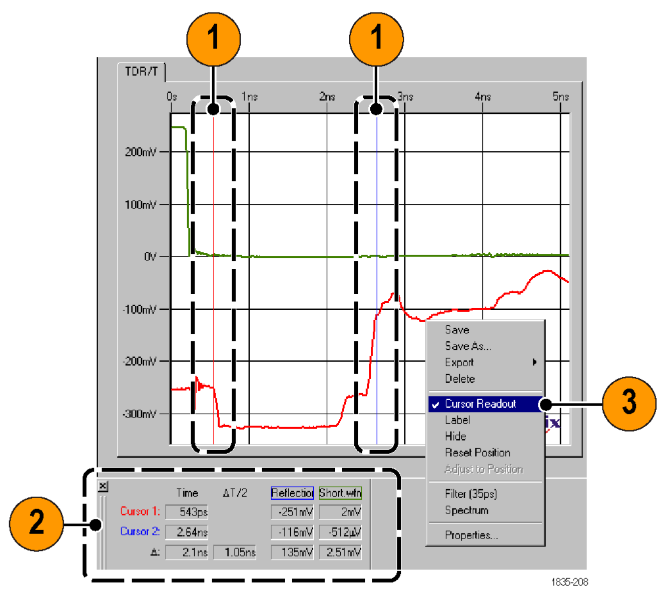
Cursors provide a way to take measurements at a specific point on a waveform. The cursor readouts show the waveform values at the cursor position.

1. Click and drag a cursor to move it. The two vertical cursors (colored red and blue) let you take measurements at two points on one or more waveforms.

   You can also use the keyboard arrow keys to move a waveform, and Ctrl+ the arrow keys for fine movements.

2. Look at the Cursor readouts to see the horizontal and vertical values at the cursor positions for each waveform and the difference (delta) value between the cursors for each waveform. The measurement units depend on the View plot type.

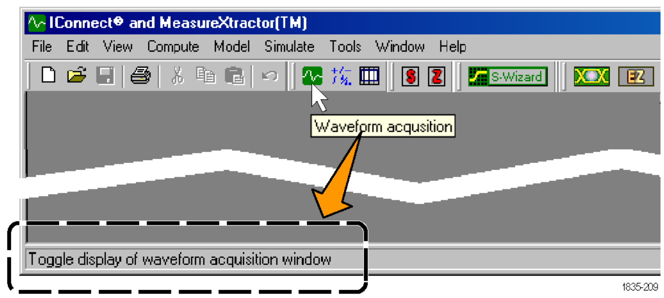
3. To enable a cursor readout for a waveform, right-click a waveform and select **Cursor Readout**. (See page 7, *Waveform trace operations*.)



The Status Bar

The Status Bar shows the status of the current operation and displays help text associated with the button, field, or area at the current mouse cursor position.

Rolling the cursor over an interface element displays a pop-up description of that item, and more detailed information in the Status bar.

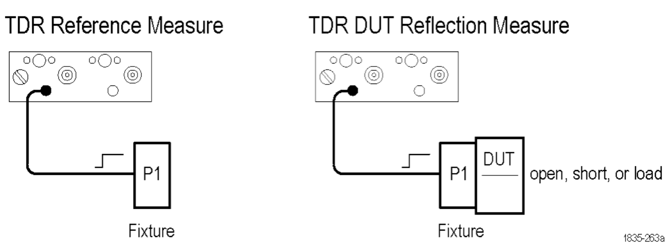


Connecting the DUT

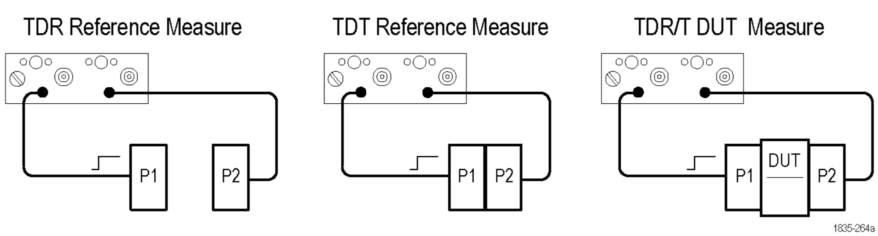
Follow the procedures in your oscilloscope manual (and any associated TDR module or probe manuals) to correctly connect the test cables, test fixture (if used) and DUT to the oscilloscope. Use electrostatic handling precautions when initially connecting and while taking TDR measurements, as the TDR measurement modules are extremely susceptible to electrostatic damage. Follow the oscilloscope procedures to deskew the test cables for accurate TDR/T measurements.

Typical Measurement Setups

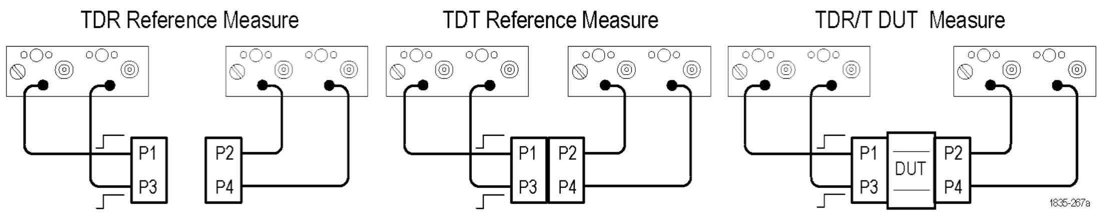
1-Port Single-Ended



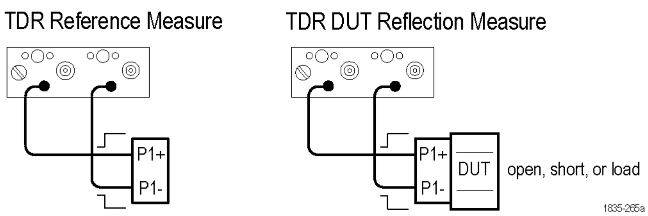
2-Port Single-Ended



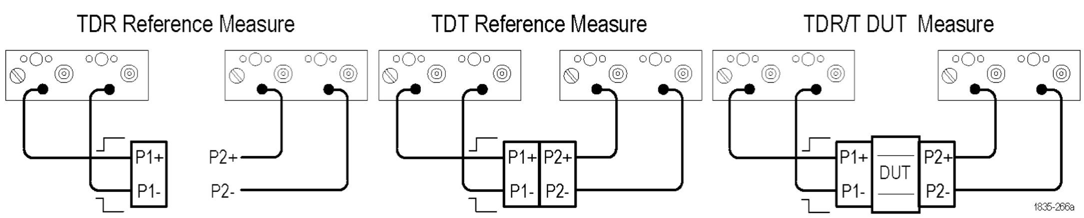
4-Port Single-Ended



1-Port Differential



2-Port Differential



NOTE. *In the 4-Port Single-Ended mode, Full Thru calibration improves the phase accuracy on the crosstalk measurements by measuring a Thru reference for each of the six TDT paths, in both directions. This creates twelve reference thru waveforms in all.*

Making good connections to the device under test.

CAUTION. *Circuitry in the sampling module is very susceptible to damage from electrostatic discharge or from overdrive signals. To prevent electrostatic damage to the main instrument and sampling modules, follow the precautions described in the manuals accompanying your oscilloscope. Be sure to only operate the sampling module in a static-controlled environment. Be sure to discharge the center and outer connectors of cables to ground before attaching the cable to the sampling module.*

Good connections to the DUT are critical to achieve high quality measurements. Using high-quality, low-loss microwave grade cables and probes enable the oscilloscope to deliver full incident rise time to the DUT. Since the minimum discontinuity that can be resolved by a TDR step must be separated from the discontinuity next to it by about one-half the observed rise time, delivering a faster rise time to the DUT lets IConnect resolve smaller DUT sizes or achieve higher measurement resolution.

Use the following guidelines when connecting the DUT to cables, probes, and/or a fixture:

- Use high-quality, low-loss microwave grade cables or probes. Generic cables such as RG-58 are rather stiff and the delay (therefore phase) varies considerably when the cable is flexed.
- Make sure that module connectors are clean. Clean connectors with a swab moistened with isopropyl alcohol if needed. Allow the connector to dry completely before using.
- Use a torque wrench on connections.
- When using a barrel, use the correct wrench to hold the barrel while tightening the connectors.
- Use high-quality reference standards. For best insertion loss accuracy, use a Thru reference. For best return loss accuracy, use an Open or Short, with a Load reference.
- When the DUT requires a fixture, make sure that the fixture has a low-inductance, low-resistance ground return path to the oscilloscope to provide the cleanest measurement interface.

Measurement Best Practices

Taking accurate measurements is the most important element in measurement-based modeling. Without accurate measurements, skilled modeling and thorough verification are a waste of time. The following tips will help you to take accurate measurements.

Warm Up the Oscilloscope

A Time Domain Reflectometry (TDR) oscilloscope is a high-performance, high-accuracy instrument. To fully use the accuracy and precision of the instrument, allow the instrument to warm up for 20-30 minutes before performing any measurements, to allow its temperature to stabilize. The oscilloscope manual may provide exact specifications on warm-up times for your particular instrument. You should also keep the air temperature of the instrument environment as stable as possible during measurement sessions.

Compensate the Oscilloscope

Compensation optimizes the capability of the instrument to make accurate measurements at the ambient temperature. Click the **Compensate Oscilloscope** button to run the compensation program on supported Tektronix oscilloscopes. To run compensation on other oscilloscope models, see the oscilloscope user documentation.

Enhanced Accuracy Measurements

Enhanced Accuracy is a function on supported Tektronix oscilloscopes that improves measurement accuracy of long record length acquisitions. Click the **EAC** button to run the EAC program on supported Tektronix oscilloscopes (DSA8200 Series with serial number B030000 and above, or DSA8200 Series with the DSA82EFEUP (Electrical Front End board) upgrade).

NOTE. *The DSA8300 acquisition hardware does not require the IConnect Enhanced Accuracy (EAC) mode.*

Observe Electrostatic Discharge Prevention Guidelines

Circuitry in the sampling module is very susceptible to damage from electrostatic discharge or from overdrive signals. To prevent electrostatic damage to the main instrument and sampling modules, follow the precautions described in the manuals accompanying your oscilloscope. Be sure to only operate the sampling module in a static-controlled environment. Be sure to discharge the center and outer connectors of cables to ground before attaching the cable to the sampling module.

Deskew the Oscilloscope Channels and Test Cables

Deskew the channels in the TDR oscilloscope when taking differential measurements (for coupled models). Follow your oscilloscope deskewing procedure before acquiring differential data.

Use Signal Averaging

Use signal averaging with the oscilloscope to reduce noise. 128 averages can provide an extra 20 dB of dynamic range.

Display the Correct TDR Waveform Information

To take useful TDR measurements for model extraction in IConnect, it is necessary to remove the incident transition from the displayed TDR waveform. (See page 13, *Displaying the Correct TDR Waveform*.)

Capture an Adequate Length Waveform Data Record

Capture all the transitions in the reflection or transmission waveform that characterize the DUT. In many cases this includes the low-frequency asymptote, which means that the waveform must settle to an appropriate level:

- To 0 V for short termination
- To the full incident step amplitude for an open termination
- To exactly half the incident step amplitude for a matched, or 50 Ω termination

If the measurement window stops before the waveform has settled, the resulting measurements and modeling may be inaccurate. For more information on TDR-based interconnect modeling and basics of TDR, download the *IConnect TDR Software Modeling Quick Guide* from the Tektronix Web site.

Displaying the Correct TDR Waveform

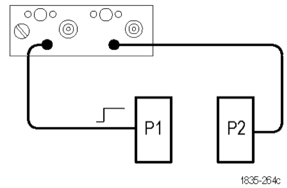
IConnect requires just the reflected part of the TDR waveform for making measurements. Adjust the oscilloscope to remove the incident waveform step from the displayed waveform. There are two ways to remove the incident step; use the Autoset TDR function on supported Tektronix oscilloscopes, or manually set the waveform display to remove the incident step.

Auto Setup of TDR Waveforms (Tektronix 8000 Series Sampling Oscilloscopes)

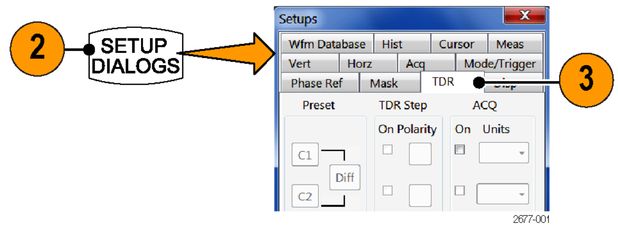
Prerequisites:

- Let the oscilloscope warm up at least 20 minutes, or until it has passed its warm-up compensation test, before taking measurements.
- (Optional) To achieve maximum measurement accuracy, after instrument warm-up, click the **Compensation** button to open the Compensation dialog box and execute compensation on the mainframe and TDR modules.

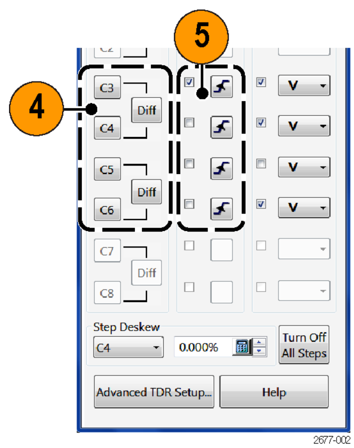
1. Connect cables and fixtures to the oscilloscope using safe antistatic handling practices. Do not connect the DUT.



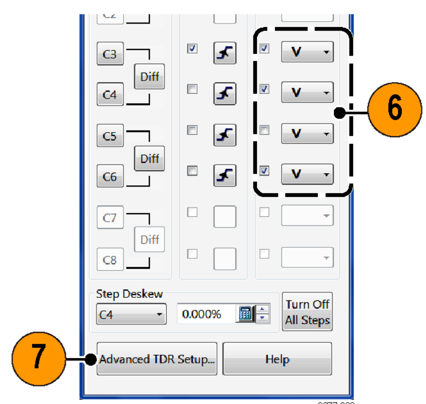
2. On the oscilloscope, press the **Setup Dialogs** button.
3. Click the **TDR** tab.



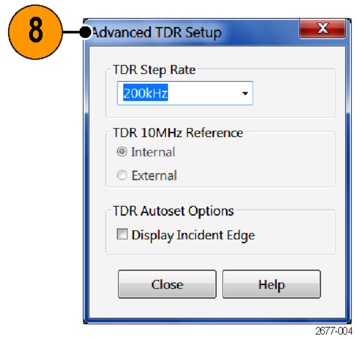
4. In the **Preset** settings, click the channels to use for your TDR measurements. For Differential measurements, click the **Diff** button for each pair of channels used.
5. In the **TDR Step** settings, enable measurement channels and set the step pulse polarity.



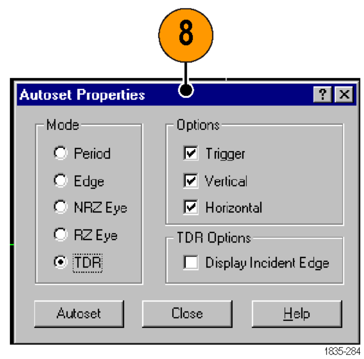
6. In the **ACQ** settings, enable measurement channels and set the units to **V** for each channel taking a TDR measurement.
7. Click the **Advanced TDR Setup** button (**TDR Autoset Properties** button for legacy oscilloscopes).



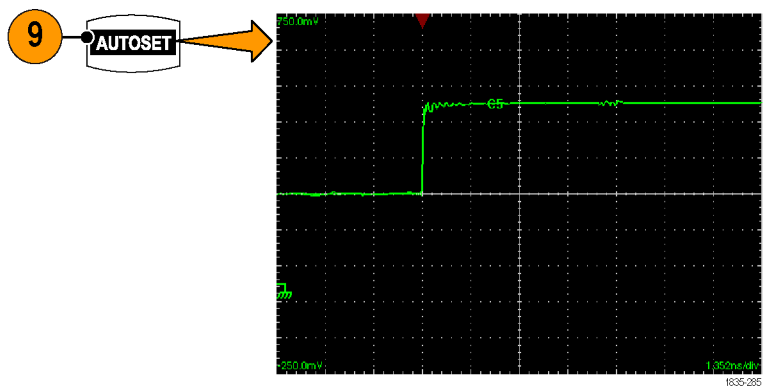
8. (DSA8300) Set the TDR **Step Rate**, **10 MHz Reference** source, and **Autoset Options** fields as shown in the Autoset Properties dialog box. Click **Close**.



(DSA8200 and other legacy oscilloscopes) Set the **Mode**, **Options**, and **TDR Options** fields as shown in the Autoset Properties dialog box. Click **Close**.

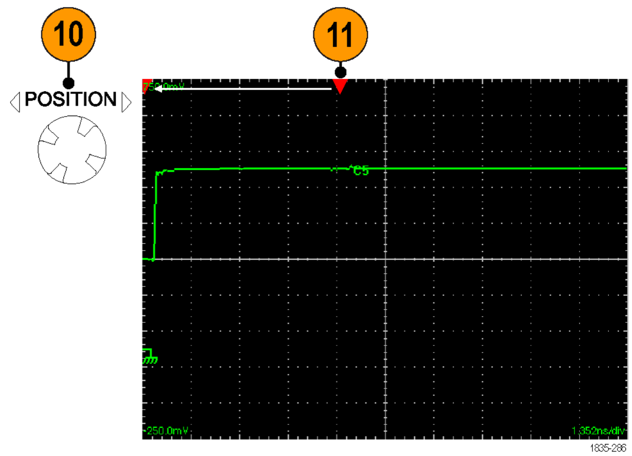


9. Press the **Autoset** front panel button to acquire and display the TDR waveform.

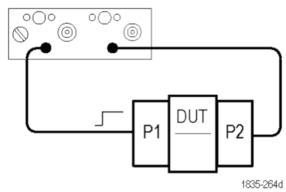


10. Use the Horizontal **POSITION** knob to move the waveform to near the left edge of the screen.

11. Right-click the **Reference** icon and select **Left** to move it to the left side of the screen.



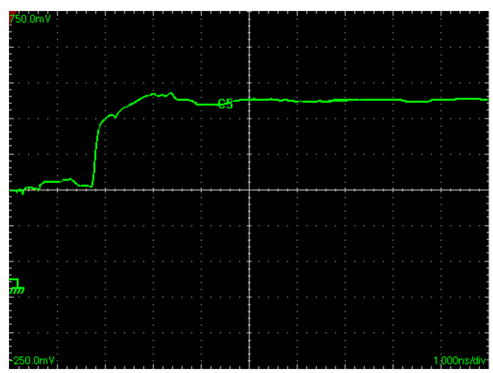
12. Connect the DUT to the text fixture.



13. Make sure that the DUT reflection step is on screen.

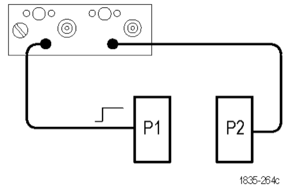
14. The waveform record length should be two to three times as long as the distance from the left screen edge to the DUT reflection step, to accurately capture the required data. Use the Horizontal SCALE knob to set this if necessary.

You are now ready for IConnect to acquire waveforms from the oscilloscope.

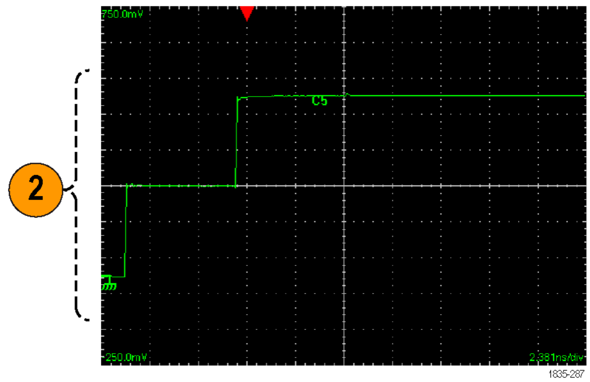


Manual Setup of TDR Waveforms

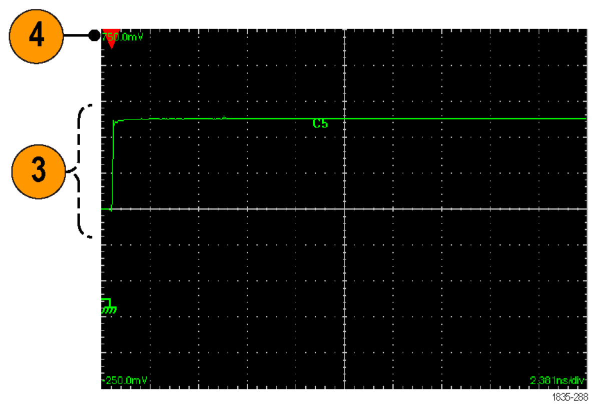
1. Connect cables and fixtures to the oscilloscope using safe antistatic handling practices. Do not connect the DUT.



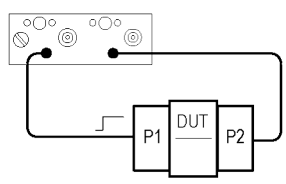
2. Set the oscilloscope to take TDR measurements. Adjust the oscilloscope to display both the incident and reflection steps of the TDR waveform.



3. Adjust the oscilloscope to position the incident step off-screen and the reflection step waveform edge near the left edge of the screen.
4. Position the **Reference** marker to just left of the rising edge of the waveform.

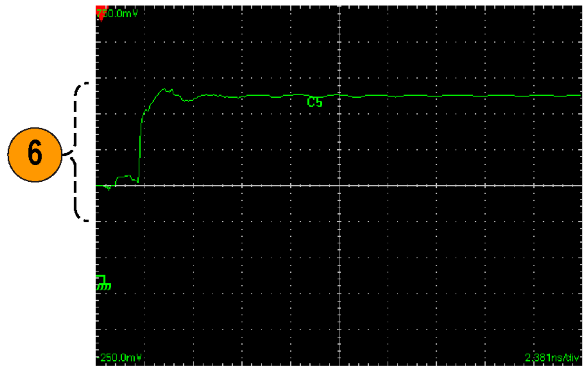


5. Connect the DUT.



6. Ensure that the DUT reflection step is on screen. Use the Horizontal **SCALE** knob to adjust this if necessary.

7. The waveform record length should be two to three times as long as the distance from the left screen edge to the DUT reflection step, to accurately capture the required data. Use the Horizontal **SCALE** knob to adjust this if necessary.



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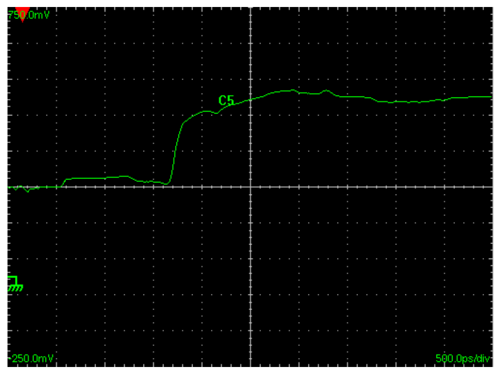
8. Repeat steps 6 and 7 until the waveform is correct.

   You are now ready for IConnect to acquire waveforms from the oscilloscope.



Acquiring, Saving, and Loading Waveforms

Acquire and Save Waveforms from an Oscilloscope

Use this procedure to acquire waveforms from a connected instrument.

Set the oscilloscope to take the appropriate TDR or TDT measurements before acquiring waveforms in IConnect. (See page 13, *Displaying the Correct TDR Waveform*.) Make sure to acquire all necessary waveforms for the IConnect measurement without changing the timebase on the oscilloscope.

***NOTE.** If you are taking S-parameter measurements on a Tektronix CSA8200, use the S-parameter Wizard to set up and acquire the measurements. The S-parameter Wizard automates the waveform setup and acquisition process, saving significant time and reducing measurement inaccuracies.* *(See page 38, Automatically Creating S-Parameter Files (S-Parameter Wizard).)*

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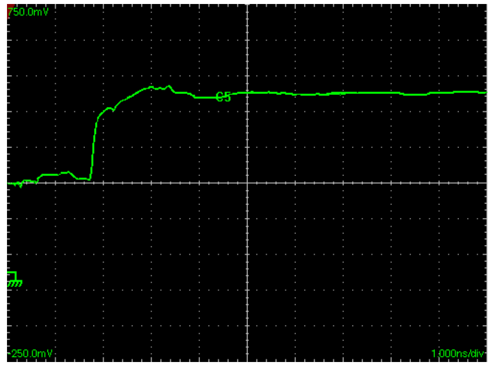
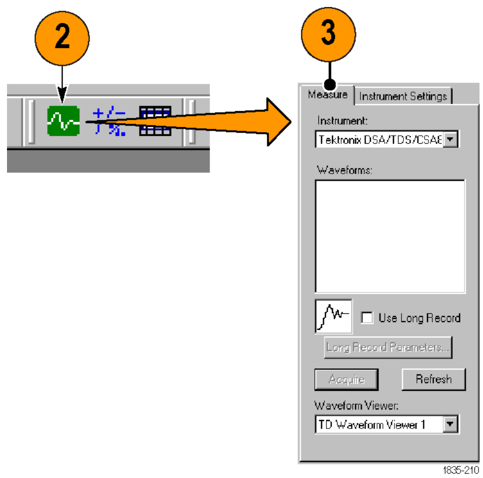
1. Set the oscilloscope to display the correct TDR waveform. (See page 13, *Displaying the Correct TDR Waveform*.)



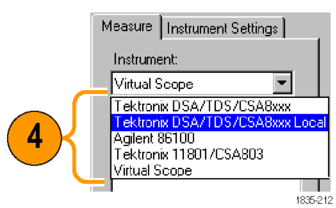
2. In IConnect, click the **Waveform Acquisition** button.

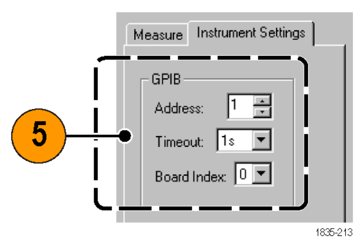
3. Click the **Measure** tab.



4. Select the appropriate instrument from the **Instrument** list. If you get a "Could not allocate" message, the next step sets up the GPIB connection to the oscilloscope.

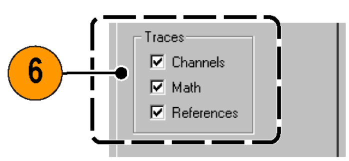
5. If the oscilloscope is being accessed using a GPIB card, click the **Instrument Settings** tab and verify or set the GPIB parameters, including the GPIB board index.

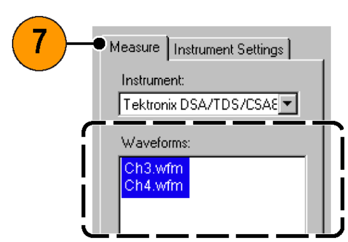




6. Select the waveforms or traces to acquire from the instrument. The displayed values depend on the selected oscilloscope.

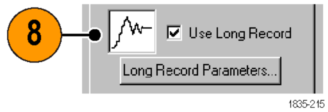
7. Click the **Measure** tab and select the waveform(s) or traces to acquire. Use standard Microsoft Windows operations to select multiple waveforms.





8. If you are using a Tektronix instrument with long record length capability, you can set the **Use Long Record** check box and click the **Long Record Parameters** button to set the long record length parameters for the acquired signal.

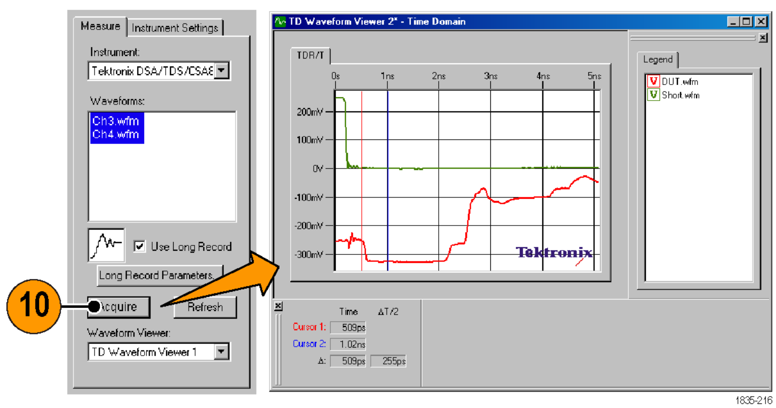
Make sure to increase the Timeout value when using long records. Long record lengths are useful when working with long transmission lines.



9. (Optional) Click the **EA Characterize** button to manually run enhanced measurement accuracy characterization on supported Tektronix oscilloscopes. EAC improves long record length measurement accuracy. The EAC function checks the oscilloscope compensation status. If the oscilloscope or any modules are not compensated, IConnect runs the oscilloscope compensation program before running EAC.

10. Click the **Acquire** button. IConnect opens the **TD Waveform Viewer** window and displays the acquired waveforms. You can now use IConnect to analyze or model the DUT.

The Acquire function also checks the status of the Tektronix oscilloscope temperature compensation. If the oscilloscope is compensated (modules and mainframe), IConnect runs the EAC function (on supported oscilloscopes) and acquires the waveforms. If the oscilloscope is not compensated, IConnect displays a dialog box asking if you want to compensate the oscilloscope before acquiring waveforms. Click **Yes** to compensate the oscilloscope before acquiring waveforms.

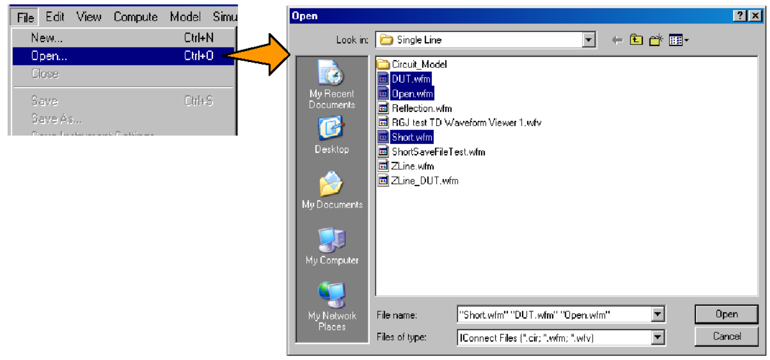


11. To save a waveform to a file, right-click a selected waveform in the viewer or Legend list and select **Save**. Navigate to where you want to save the file, and enter a file name.

Load Waveforms from Saved Files

Use this procedure to load waveforms that were saved during a previous waveform acquisition session.

1. Select **File > Open**. Navigate to and select the file or files to open. Click **Open**.



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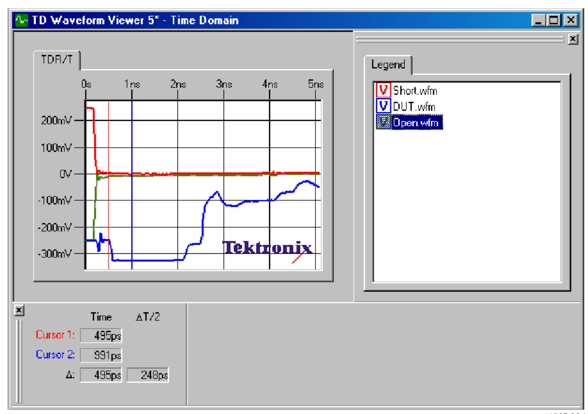
2. IConnect loads the waveforms and displays the correct viewer for the waveforms.



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Using Drag-and-Drop to Load Waveforms or Files

You can use standard Microsoft Windows drag-and-drop operations to load waveform, model, and waveform viewer files into IConnect. As you will need adequate room on a display to view both the Windows Explorer and IConnect application window, this method is recommended only when running IConnect on a PC, or when running IConnect on a Tektronix oscilloscope to which an external monitor is connected.

File Operations

File Operation	Procedure
Save a single waveform	Select the waveform in the plot or Legend tab list. Right-click to open the shortcut menu and click **Save**.
Save one or more waveforms to a new location	Select the waveform(s) in the plot or Legend tab list. Right-click to open the shortcut menu and click **Save As**. IConnect sequentially opens a **Save As** dialog box, one for each selected waveform. Use normal Windows operations to specify the location and name for the saved waveform.
Export a waveform to a CSV format file	Select the waveform in the plot or Legend tab list. Right-click to open the shortcut menu and click **Export**. Select **CSV**. Use normal Windows operations to specify the location and name for the saved waveform. Select the type of CSV file (space, comma, or tab-delimited).
Export a waveform to a Touchstone file	Right-click in the plot to open the shortcut menu and select **Export > Touchstone**. Use normal Windows operations to specify the location and name for the saved waveform. You can only export waveforms to Touchstone that are appropriate for that format.
Save the oscilloscope settings to a file	Click **File > Save Instrument Settings**. Use normal Windows operations to specify the location and name for the oscilloscope settings file. You should use a naming convention to clearly label the file with the oscilloscope to which the settings apply.
Load (restore) oscilloscope settings from a file	Click **File > Load Instrument Settings**. Use normal Windows operations to locate and select the appropriate oscilloscope settings file. Click **OK** to load the settings to the connected oscilloscope. ***NOTE.*** *Loading a settings file saved from one oscilloscope into a different type of oscilloscope will not work, and may cause unpredictable results on the target oscilloscope.*
Execute oscilloscope commands from a file	You can use a text file to send valid GPIB commands to the instrument. Create a text file that contains the correct GPIB commands and syntax for the target oscilloscope. Click **File > Load Instrument Settings**. Use normal Windows operations to locate and select the appropriate oscilloscope command file. Click **OK** to send the commands to the connected oscilloscope. ***NOTE.*** *If the oscilloscope does not respond as expected, and the communications to the oscilloscope are good, verify that the GPIB command syntax and values are correct in the command text file.*

Waveform Math

In general, it is better to let the oscilloscope perform waveform math, as the oscilloscope can usually do this math faster. IConnect can do addition, subtraction, multiplication, and division of two waveforms. It can also do integration, differentiation, and filtering of a waveform. Since a constant may be substituted for one of the waveforms, waveform math also allows convenient scaling and offsetting of waveforms.

Waveform math is executed from the computation window by choosing Waveform Math from the Compute list box. Select the required operator from the Operator drop-down list located in the Waveforms group. Depending on the nature of the operator, select either one or two operand waveforms in the remaining drop-down list boxes in the group. Click the **Compute** button, and the resultant waveform is placed in the selected waveform viewer. To use a constant as one of your operands, select **Constant** from one of the waveform selection boxes, and enter the value of the constant in the field at the bottom of the Computation window.

Integration and Differentiation

Integration is performed as the running sum of the waveform data points, multiplied by the time step between data points. For this reason, the magnitude of the integrated waveform will typically be several orders of magnitude smaller than that of the original waveform. Differentiation is performed as the difference between consecutive waveform data points, divided by the time step between data points. For this reason, the magnitude of the differentiated waveform will typically be several orders of magnitude larger than that of the original waveform.

NOTE. *Differentiation attenuates low-frequency components and amplifies high-frequency components. Therefore, it is not uncommon for high-frequency noise to be visibly present in a differentiated waveform.*

Application Examples

Eye Diagram Compliance Testing

A compliance test consists of a series of Eye Diagram tests (eye setups) as defined for a standard such as SATA, HDMI, or PCI Express. Each standard defines the number of Eye Diagram tests and the characteristics of each Eye Diagram that are required to meet compliance.

Prerequisite:

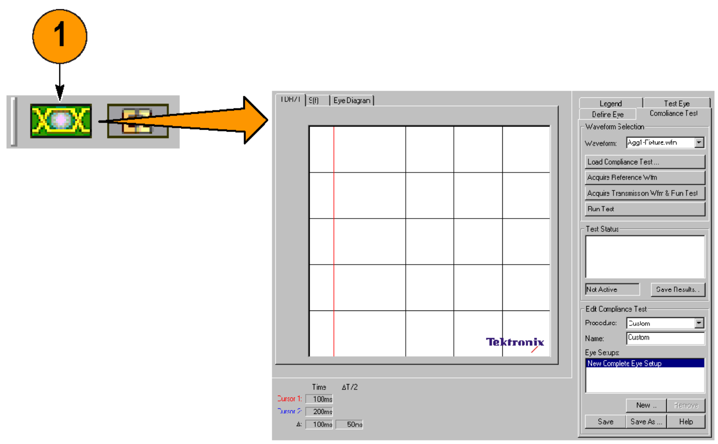
- Compliance test setups (SATA, HDMI, and PCI-Express setups are supplied with IConnect)

Eye Diagram Compliance Test Procedure

Prerequisites

- Follow measurement best practices. (See page 12, *Measurement Best Practices*.)
- Set the oscilloscope to display the correct waveforms. (See page 13, *Displaying the Correct TDR Waveform*.)
- Set IConnect to acquire the necessary waveforms. (See page 18, *Acquiring, Saving, and Loading Waveforms*.)

1. Click the **Eye Diagram Viewer** button.



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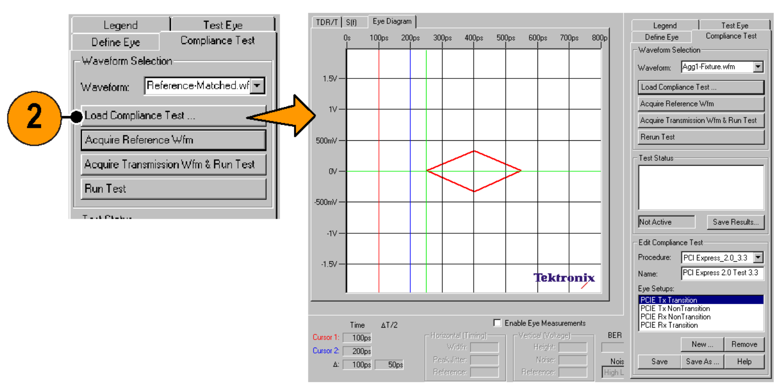
2. On the Compliance Test tab, click the **Load Compliance Test** button. Navigate to and select the compliance test file (*.cts). IConnect lists the eye setup tests in the **Edit Compliance Test** area and loads required masks in the Eye Diagram viewer.



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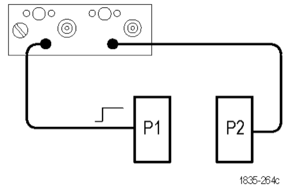
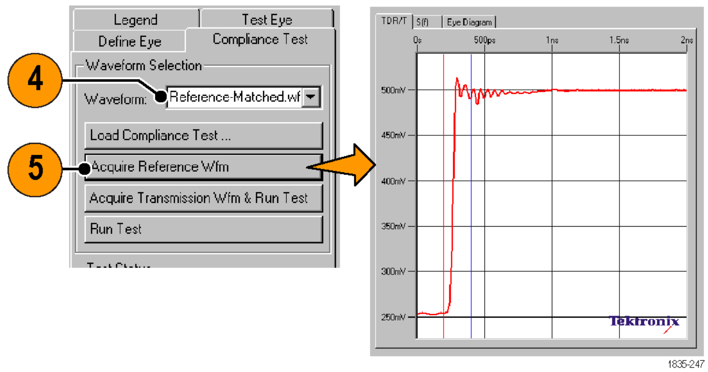
3. Connect cables and fixtures to the oscilloscope. Do not connect the DUT.

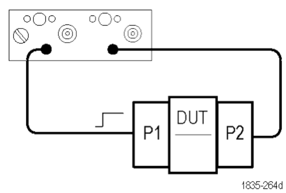


4. Select the reference waveform from the **Waveform** list.

5. Click the **Acquire Reference Wfm** button. IConnect acquires and plots the reference waveform on the TDR/T viewer tab.



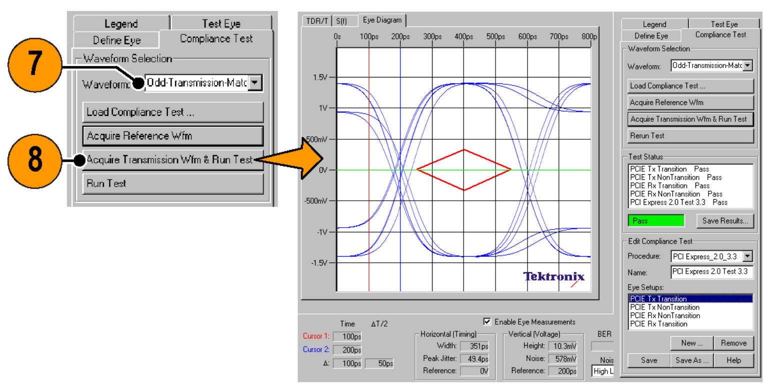
6. Connect cables, fixtures, and the DUT to the oscilloscope.



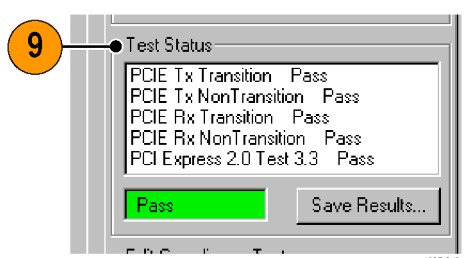
7. Select the transmission waveform from the **Waveform** list.

8. Click the **Acquire Transmission Wfm & Run Test** button. IConnect acquires the transmission waveform, runs all eye tests, and plots the results of the last test on the Eye Diagram viewer tab.

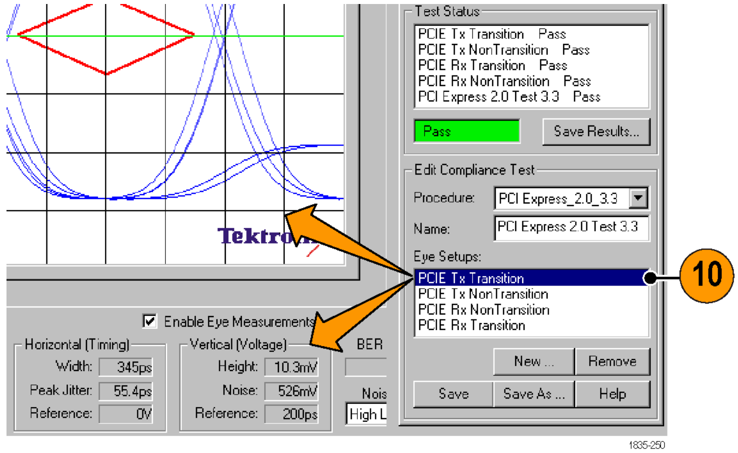
   IConnect first runs theTx tests, then runs the Rx tests.



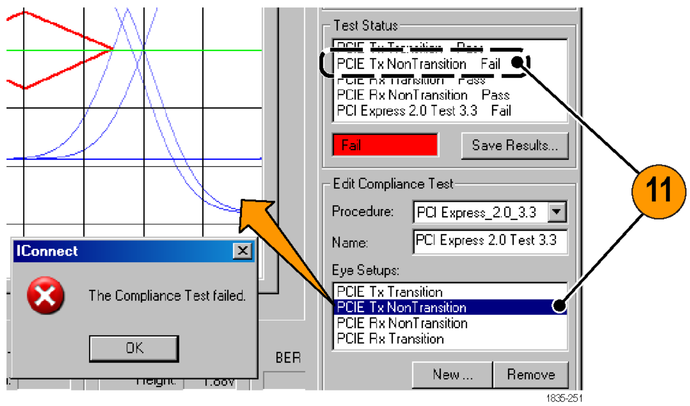
9. The **Test Status** area lists the pass/fail status of each test, and shows a color-coded Pass/Fail field to show the overall test status. The last line of the test status is the name of the compliance test that was run.



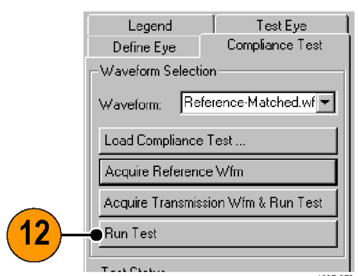
10. Select the **Eye Diagram** viewer tab and click an item in the **Eye Setups** list to show the Eye Diagram plot and the Eye Measurements (if enabled) for that eye test.



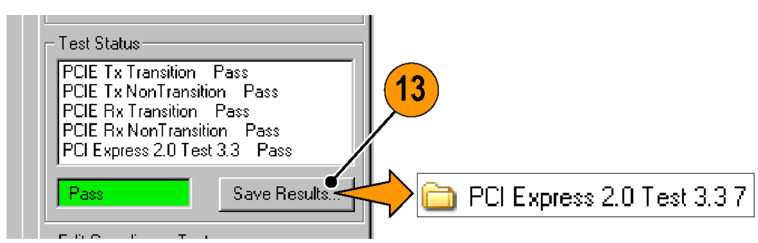
11. If one or more tests fail, IConnect displays an error message and shows which tests failed in the **Test Status** area list. You can then select the failed test item in the **Eye Setups** list to show the eye diagram for that test.



12. Click **Run Test** to run the test again. Note that the test may fail on occasion because IConnect applies random values to some parameters (such as jitter) to simulate real-signal conditions.



13. To save results, click the **Save Results** button. Navigate to and select a directory in which to store results. IConnect creates a folder in that directory and names it with the compliance test name (as listed in the Name field) appended with a number (starting with 1).



NOTE. *In the Eye Diagram Options dialog box, the **Save as Default** button saves the eye setup parameters to the IConnect registry on the PC. These settings now become the new default settings when you select the **New** button in the Compliance Test tab (bottom of the tab, below the Eye Setups list), and is also used in the default New Compliance Eye Setup entry listed in the Eye Setups field.*

The test result folder contains:

- A PNG-format screen shot of the entire Eye Diagram viewer, for each eye setup test
- A copy of the source .cts file used by that test, but modified by IConnect during runtime for such things as the jitter insertion parameters for the Rx eye test, which are generated as part of the test run
- A text file with overall test results
- A text file with the test results for each eye setup

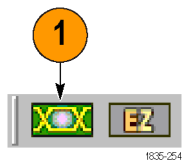
Creating a Standard-Based Custom Eye Diagram Test

IConnect lets you create custom eye diagram tests based on the application-supplied standards (SATA, HDMI, or PCI-Express). Each standard defines the number and type of eye diagrams (eye setups) needed to pass the requirements of that standard.

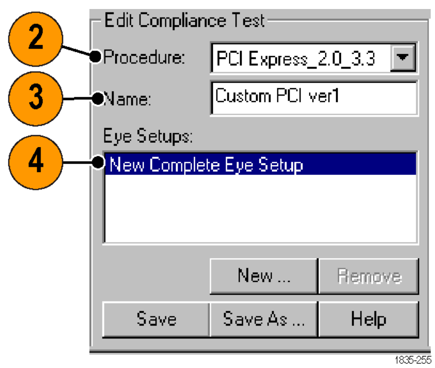
***NOTE.** IConnect cannot automatically run all tests in a custom Eye Diagram test setup; you must select a test, click the **Test Eye** tab, and click the **Display Eye** button.*

Part of an eye diagram computation is setting up the eye diagram options, such as input sequence, data rate and rise time. If you are computing an eye diagram without any crosstalk effects, you only need to set parameters for the DUT (victim) line. If you are including crosstalk effects in your eye diagram, you will need to set parameters for each aggressor line.

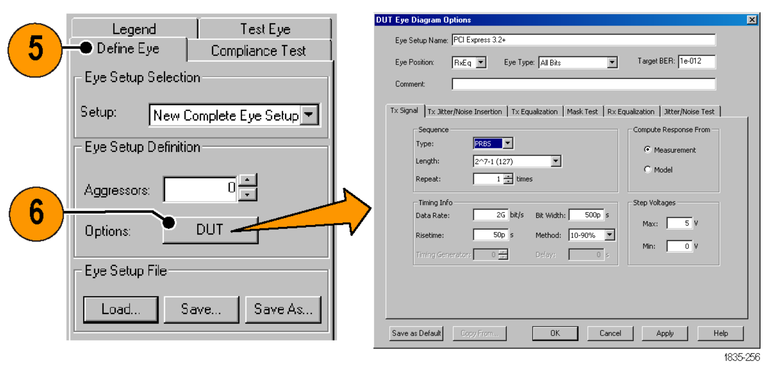
1. Click the **Eye Diagram** button to open a new Eye Diagram viewer.



2. On the **Compliance Test** tab, select the standard against which to test from the **Procedure** list.
3. Enter a name for your custom test in the **Name** field.
4. Select the **New Complete Eye Setup** item in the **Eye Setups** list. This is a default eye setup.

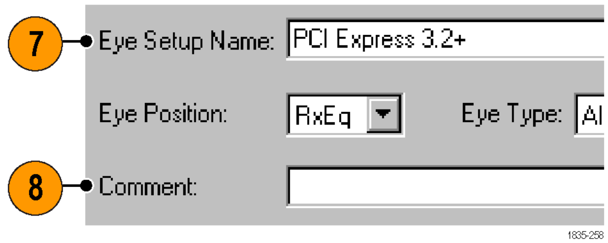


5. Click the **Define Eye** tab.
6. Click the **DUT** button and use the tabs and controls on the **Eye Diagram Options** dialog box to define the DUT Eye Diagram parameters such as input sequence, data rate, jitter, mask test, and risetime. Click the **Help** button for information on the various parameters.

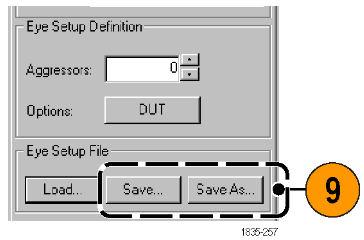


7. Enter the new name for the eye setup test in the **Eye Setup Name** field.

8. Use the **Comment** field to add additional information about the eye setup. Comments can contain up to 30,000 characters.



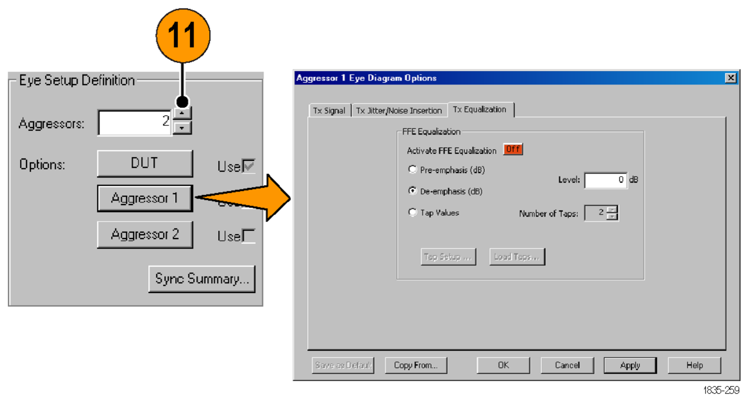
9. To save an eye setup to a file (*.mts), click the **Save** or **Save As** button and navigate to a folder and enter the name of the setup file.



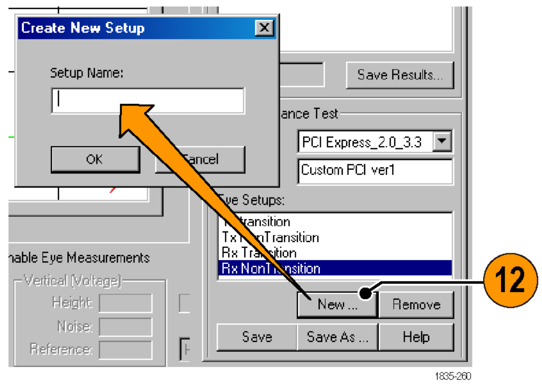
10. Click **OK** to apply the settings, close the dialog box, and return to the Define Eye tab.

11. To add aggressors to the eye setup test, click the arrow buttons in the **Aggressors** field to set the number of aggressors (up to eight). IConnect adds a button for each aggressor, which you click to set the parameters for each aggressor.

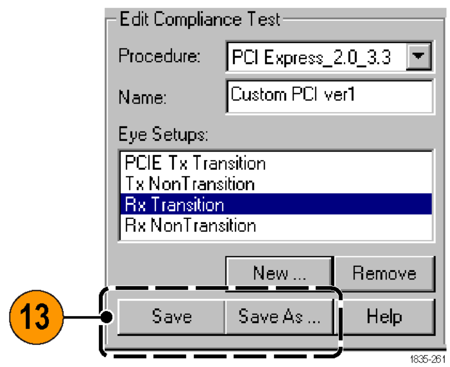
*NOTE. If you cannot select the **Use** check box next to the Aggressor buttons, then the aggressor does not have all its required waveforms loaded on the Legend page.*



12. To add more eye setups to the compliance test, click the **New** button on the Compliance Test tab and enter the name of the eye setup in the **Create New Setup** dialog box. Click the **Define Eye** tab and use the controls to define the DUT and aggressor parameters for that eye setup.



13. To save the entire test (all eye setup files) to a single compliance test file (.cts), click the **Save** or **Save As** button on the Compliance Test tab, navigate to a folder, and enter the name of the setup file. IConnect verifies that the test contains all required eye setups and eye types, and will not save a file until the eye setup tests meet the requirements for the specified standard.



***NOTE.** You can load a saved eye setup file (*.mts) into your current Eye Diagram test. Click the **Load** button and navigate to and select the eye setup file to load.*

When Not to Run an Eye Diagram Compliance Test

- When the reference or transmission waveform is missing (IConnect requires both)
- When the number of eye setups in the test does not match what the selected standard requires
- When eye setups do not have the correct eye type or position settings for the selected standard
- When the Eye Compliance Test Procedure field has Custom selected (you must select and run each test individually)

Creating Custom Eye Diagram Tests

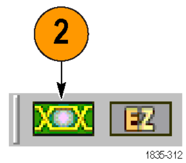
The eye diagram is a method to visualize a digital data stream, in which each consecutive clock cycle is overlaid on top of the first cycle in the data stream. The digital data pattern may be switching from 1 to 0, from 0 to 1, or stay at a 1 or 0 level. As a result, this continuously changing data stream, observed within a single cycle, produces a display resembling a human eye.

Eye diagram calculations require two measurements:

- A reference TDR measurement of all connecting cables and/or probes without the DUT, on the positive switching channel.
- A transmission TDT waveform on the positive-switching line at the far end of the DUT. Make sure to use exactly the same time base as for the reference waveform.

1. Acquire the reference and transmission waveforms. (See page 18, *Acquiring, Saving, and Loading Waveforms*.)

2. Click the **Eye** button to open the **Eye Diagram Viewer**.



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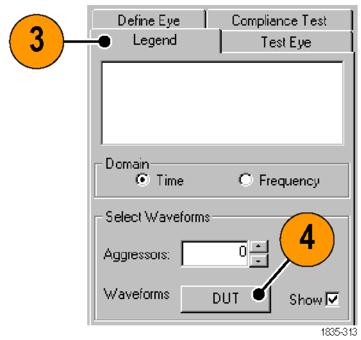
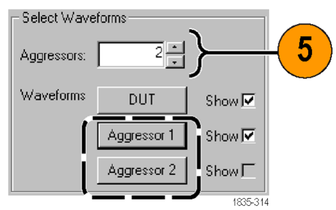
3. Click the **Legend** tab.

4. Click the **DUT** button and load the reference and transmission waveforms.



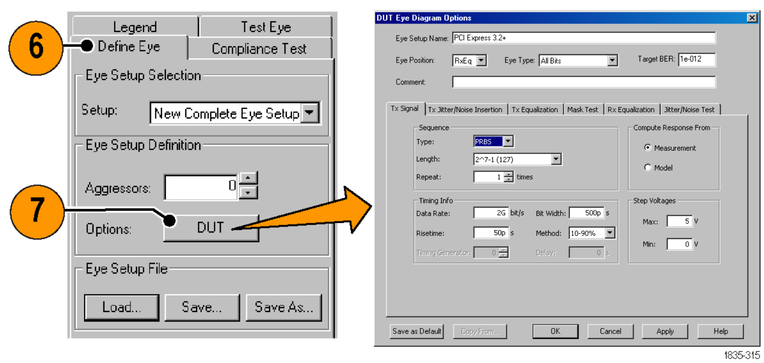
5. To add aggressors, click the arrow buttons in the **Aggressors** field to set the number of aggressors (up to eight). Click each Aggressor button to load the waveforms for that aggressor (reference, crosstalk, and optional fixture).



6. Click the **Define Eye** tab.

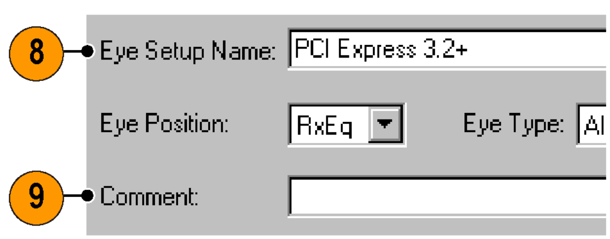
7. Click the **DUT** button and use the fields, tabs and controls on the **DUT Eye Diagram Options** dialog box to define the Eye Diagram parameters such as input sequence, data rate, jitter, mask test, and risetime.

If you have enabled aggressors, click each aggressor button and use the **Aggressor Eye Diagram Options** to set the aggressor parameters.

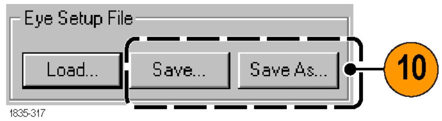


8. Enter the name of the eye diagram test setup in the **Eye Setup Name** field.

9. Use the **Comment** field to add additional information about the eye setup. Comments can contain up to 30,000 characters.

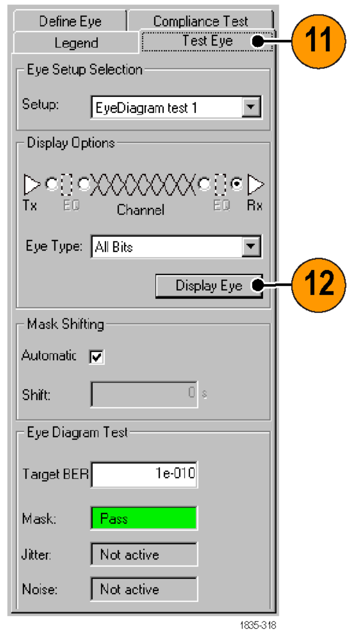


10. Click the **Save** or **Save As** button in the Define Eye tab to save the eye diagram test.

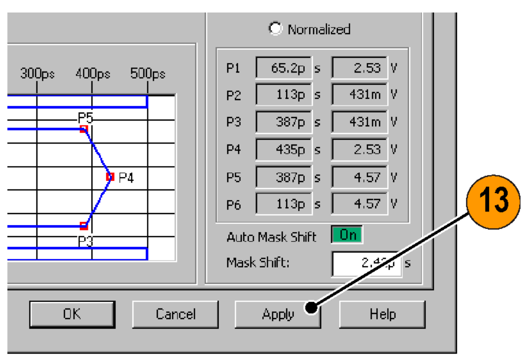


11. Click the **Test Eye** tab. Set the parameters on this tab as required for your eye test.

12. Click the **Display Eye** button to display the eye diagram in the viewer. If you enabled mask, jitter, or noise testing, the Eye Diagram Test area displays the pass/fail status of each test.



13. To evaluate different settings with the same signals, click the **Define Eye** tab, click the **DUT** or **Aggressor** buttons, make changes to the test settings, and click the **Apply** button. IConnect redraws the eye diagram based on the new settings.



EZ Z-Line DUT Testing

The IConnect EZ Z-Line viewer is specifically designed to do quick, single-button Z-Line computation for any number of device waveforms. The EZ Z-Line viewer lets you:

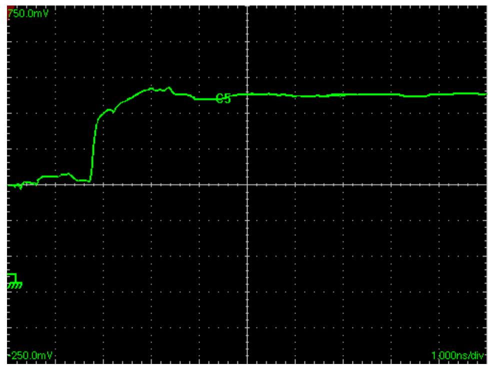
- Measure and store waveforms and instrument settings from a known good device and test cable assembly to create a Golden Setup file
- Use a single-button click to quickly acquire successive device waveforms, generate Z-Line impedance plots, and compare the device impedance plots against the Golden Setup

Prerequisites

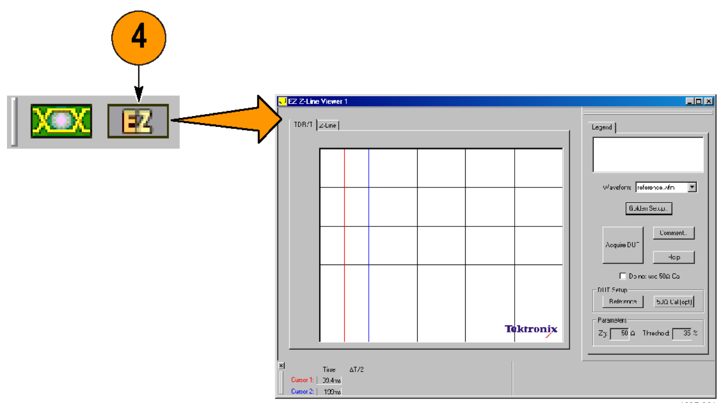
- Follow measurement best practices. (See page 12, *Measurement Best Practices*.)
- Set the oscilloscope to display the correct waveforms. (See page 13, *Displaying the Correct TDR Waveform*.)
- Set IConnect to acquire the necessary waveforms. (See page 18, *Acquiring, Saving, and Loading Waveforms*.)

Create a Golden Setup File

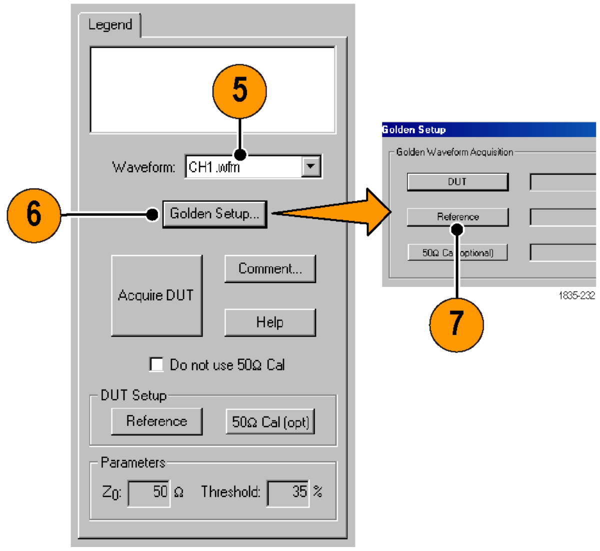
1. Use a **golden DUT** to display a correct TDR waveform. The golden DUT is a DUT with known good impedance characteristics. (See page 13, *Displaying the Correct TDR Waveform*.)
2. Disconnect the golden DUT.



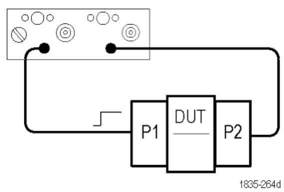
3. Start IConnect. Establish communication with the instrument. (See page 18, *Acquiring, Saving, and Loading Waveforms*.)
4. Click the **EZ** button on the toolbar to open the **EZ Z-Line Viewer**.



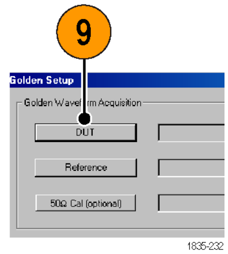
5. Select the waveform source from the **Waveform** drop-down list.
6. Click **Golden Setup**.
7. Click **Reference** to acquire and plot the reference waveform in the TDR/T tab. This waveform is labeled **Golden Reference**.



8. Reconnect the Golden DUT to the test cable assembly.



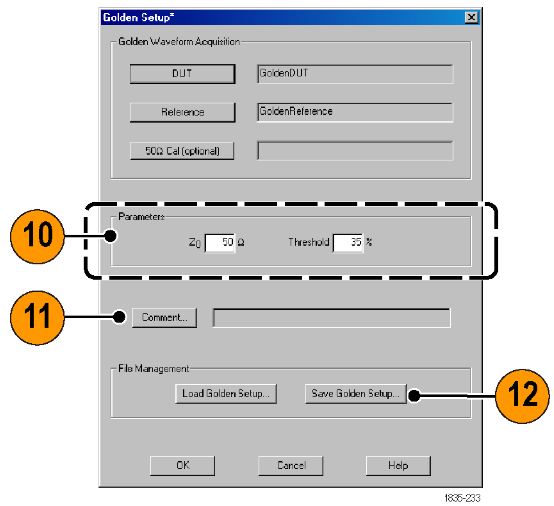
9. Click **DUT** to acquire and plot the Golden DUT waveform in the TDR/T tab. This waveform is labeled **Golden DUT**.



10. Set the measurement system impedance (Z_0) and threshold parameters if required. The default values (50 Ω and 35%) are good for most measurements, but may need adjusting to accommodate your test setup.

11. (Optional) Click **Comment** and enter comment text in the displayed dialog box. If the EZ Z-Line Viewer comment field is empty, the Golden Setup comment will be copied into it. Otherwise the two comments are independent.

12. Click **Save Golden Setup** to save the Golden Setup file to a specified location and name. Golden Setup files have the extension **.gst**.

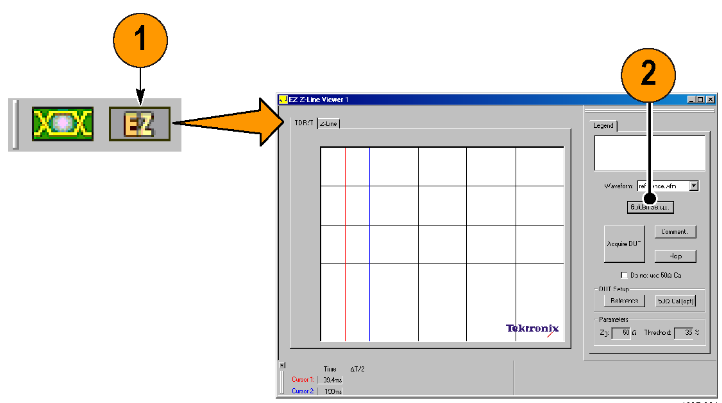


Taking DUT Z-Line Measurements with a Golden Setup

Prerequisite. Connect the test cable assembly to the oscilloscope. Make sure to use the same type of test cable assembly (cable types, lengths, TDR probes, connectors, fixtures, and so on) that was used to create the Golden Setup. Do not connect the DUT at this time. Make sure that IConnect can communicate with the instrument. (See page 18, *Acquiring, Saving, and Loading Waveforms*.)

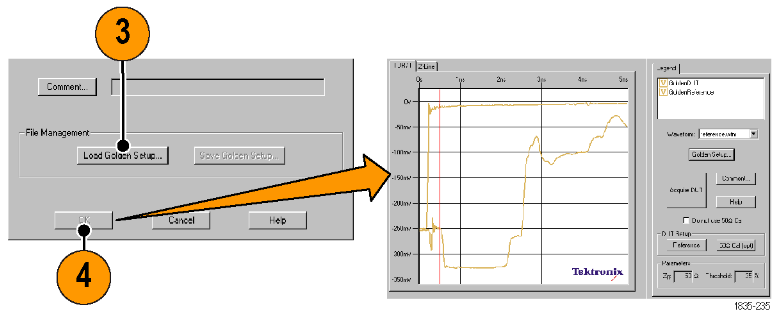
1. Click the **EZ** toolbar button to open the EZ Z-Line Viewer.

2. Click **Golden Setup**.

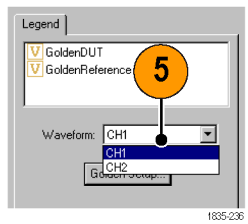


3. Click **Load Golden Setup**. Navigate to and select the Golden Setup file that you want to load. Make sure to load a Golden Setup file that was created for the instrument to which you are connected, and that the same test cable assembly and instrument settings are being used to take the current set of measurements.

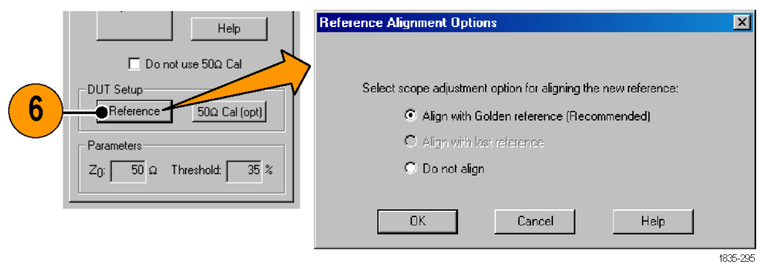
4. Click **OK** to close the dialog box and set IConnect to use this golden setup with this EZ Z-Line viewer.



5. Disconnect the DUT. Click in the **Waveform** list and select the oscilloscope waveform source or channel to which the DUT will later be connected.

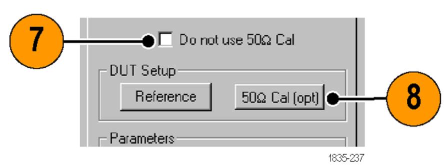


6. Click **Reference** in the **DUT Setup** area. IConnect displays a message asking whether and how to align the new reference. Click **OK** to accept the recommended selection. IConnect adjusts the instrument settings to align the waveforms, acquires the new reference waveform, and plots the new reference waveform in silver on the TDR/T tab, with the label **Reference**.

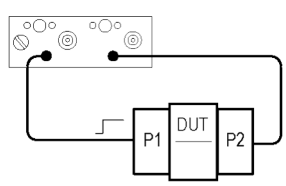


7. If you are not using a calibration waveform, select the **Do not use 50 Ω Cal** check box.

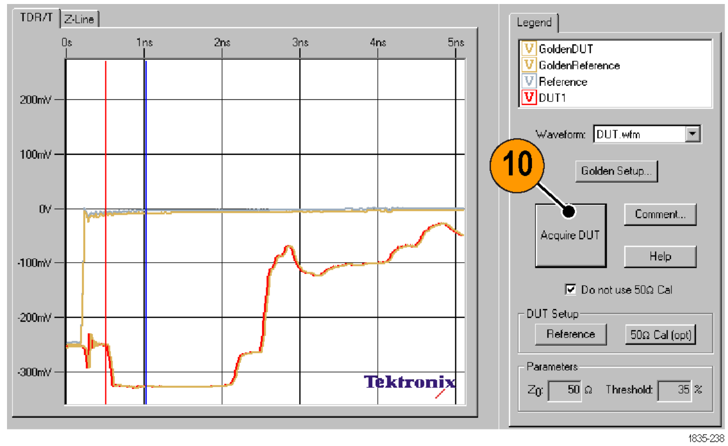
8. If you are using a calibration waveform, acquire a new calibration waveform by connecting a 50 Ω termination to the end of the test fixture assembly and clicking **50 Ω Cal (opt)**. IConnect acquires and plots the new calibration waveform in silver. Remove the 50 Ω termination.



9. Connect the (nongolden) DUT to the test fixture assembly.

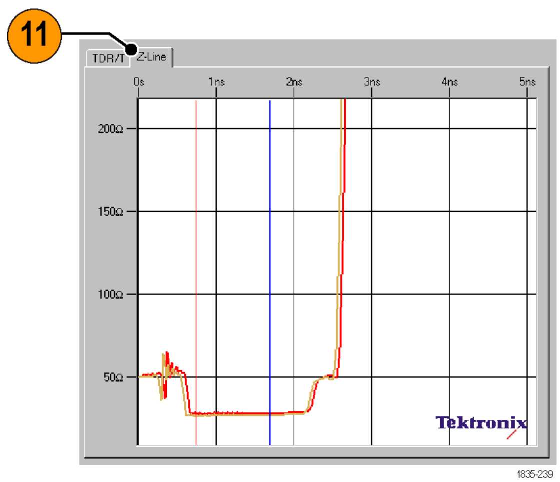


10. Click **Acquire DUT**. IConnect acquires the DUT waveform and plots it on the TDR/T and Z-Line tabs. The DUT plot is labeled **DUT*n*** on the TDR/T tab, and **Z*n*** on the Z-Line tab, where *n* is an integer that increments for each DUT waveform acquired.



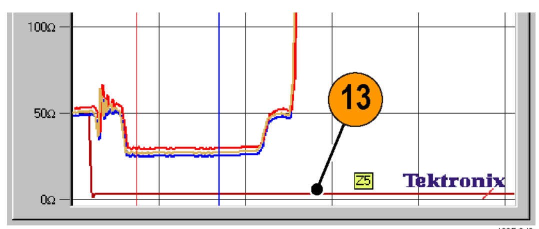
11. Click the **Z-Line** tab to compare the **DUT** impedance waveform with the **GoldenZ** impedance waveform. Determine if the DUT matches the Golden DUT waveform characteristics.

12. Disconnect the DUT.



13. Repeat steps 9 through 12 for each DUT that you want to test and compare against the Golden DUT. This example shows that the plot from DUT acquisition five (labeled Z5 in the figure) does not match the Golden Z-Line plot.

Repeat steps 6 through 8 (with the DUT disconnected) at regular intervals during prolonged DUT testing to acquire a new reference waveform. Acquiring a new reference waveform at regular intervals helps compensate for oscilloscope measurement drift.



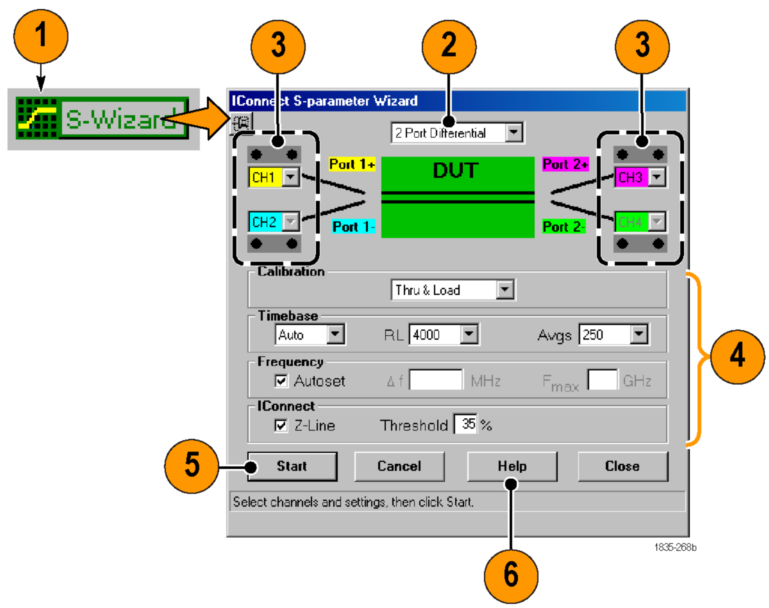
Automatically Creating S-Parameter Files (S-Parameter Wizard)

The IConnect S-parameter Wizard makes aquiring one-, two-, or four-port S-parameter waveform files fast, easy, and accurate when using a Tektronix sampling oscilloscope. The S-parameter wizard displays dialog boxes and messages to guide you through setting up and acquiring the necessary TDR and TDT measurements. The wizard uses the TDR/T waveforms and IConnect to generate S-parameter, Touchstone, Z-Line, and log files. You can load the files into IConnect or other tools for further analysis or modeling.

***NOTE.** The S-parameter Wizard runs on Tektronix 8000 Series sampling oscilloscopes on which IConnect is installed, or on a pC with IConnect installed and a GPIB or LAN connection to a Tektronix 8000 Series sampling oscilloscope. If the oscilloscope or IConnect are not available, the S-parameter Wizard runs in demo mode. For other oscilloscopes, you will need to manually acquire and save the necessary TDR/T waveforms and use the IConnect S-parameter computation function to create S-parameter files. (See page 39, Manually Creating S-Parameter Files.)*

Prerequisites

- Follow measurement best practices. (See page 12, *Measurement Best Practices*.)
- Differential measurements and long record acquisitions require that your signals arrive at the DUT at the same time. Follow the deskew procedure in your oscilloscope manual, observe the difference in delays between the two channels in differential mode, and adjust for half of that difference by using the delta TDR function in the oscilloscope.



1. Click the **S-parameter Wizard** button.
2. Select the **measurement mode** (number of ports and type of measurement).
3. Assign the **ports** to the oscilloscope channels. The S-parameter Wizard labels the waveforms with the port numbers.
4. Set the measurement **parameters**. The fields displayed depends on the selected measurement mode.
5. Click **Start**. The S-parameter Wizard displays dialog boxes and messages to guide you through setting up and acquiring S-parameter measurements. Follow the displayed instructions.

   See the *Data Files Saved* topic in the S-parameter Wizard online help for a list of the output files generated for each measurement mode.
6. Click **Help** to get more information on setting parameters, using the S-parameter Wizard, and the output files generated for each measurement mode.

NOTE. *The S-parameter Wizard controls all oscilloscope settings during measurement sequences. Do not change any oscilloscope settings while the S-parameter Wizard is running.*

The S-parameter Wizard invokes a copy of IConnect in the background to generate the S-parameter, Touchstone, and Z-Line waveform files.

NOTE. *It is recommended that you use the S-parameter Wizard to acquire S-parameter waveforms for IConnect. The S-parameter Wizard automates acquiring S-parameter waveform data, which significantly reduces the time it takes to acquire data. The S-parameter Wizard also reduces the chance of errors in setting up the instrument or in forgetting to take a set of port measurements.*

Manually Creating S-Parameter Files

Frequency-domain scattering parameters (S-parameters) are a useful way to visualize the electrical properties of a system. They are a dual representation of TDR and TDT data in the frequency domain. Although S-parameters have historically been measured in the frequency domain using a network analyzer, you can use TDR and TDT measurements to obtain differential and mixed mode S-parameter data.

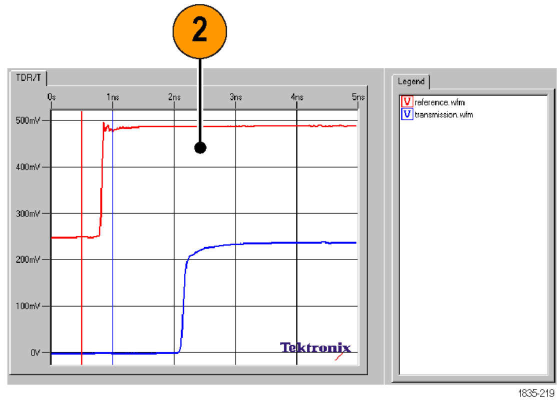
S-parameter calculations require a reference waveform and a DUT waveform. The DUT waveform can be either a reflection or transmission measurement.

Prerequisites

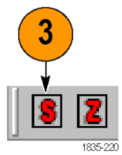
- Follow measurement best practices. (See page 12, *Measurement Best Practices*.)
- Set the oscilloscope to display the correct waveforms. (See page 13, *Displaying the Correct TDR Waveform*.)
- Set IConnect to acquire the necessary waveforms. (See page 18, *Acquiring, Saving, and Loading Waveforms*.)
- Differential measurements and long record acquisitions require that your signals arrive at the DUT at the same time. Follow the deskew procedure in your oscilloscope manual, observe the difference in delays between the two channels in differential mode, and adjust for half of that difference by using the delta TDR function in the oscilloscope.

1. Acquire the necessary TDR and/or TDT DUT and reference waveforms. The number of waveforms to acquire depends on the measurement mode (one-, two, or four-port) and type (single-ended or differential). See the *Data Files Saved* topic in the S-parameter Wizard online help for the number and type of DUT and reference measurements needed for each mode.

2. Load the S-parameter waveform files into IConnect. (See page 18, *Acquiring, Saving, and Loading Waveforms*.)

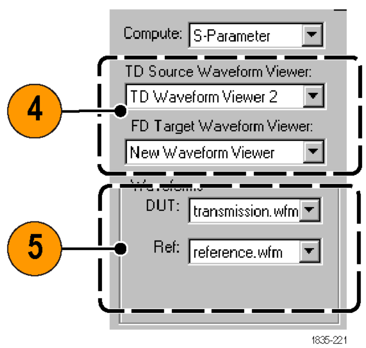


3. Click the **S** button to open the S-parameter task tab.

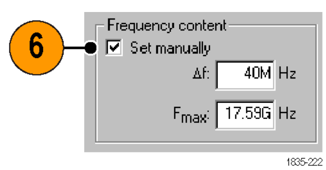


4. Set the Source and Target waveform viewers.

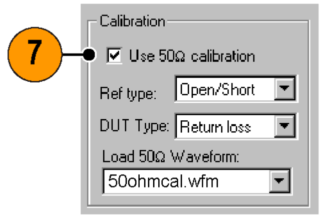
5. Select the **DUT** and **Ref** (reference) waveforms in the **Waveforms** fields.



6. (Optional) Manually set the highest frequency content parameters. If not selected, IConnect calculates the highest frequency content from the waveforms.

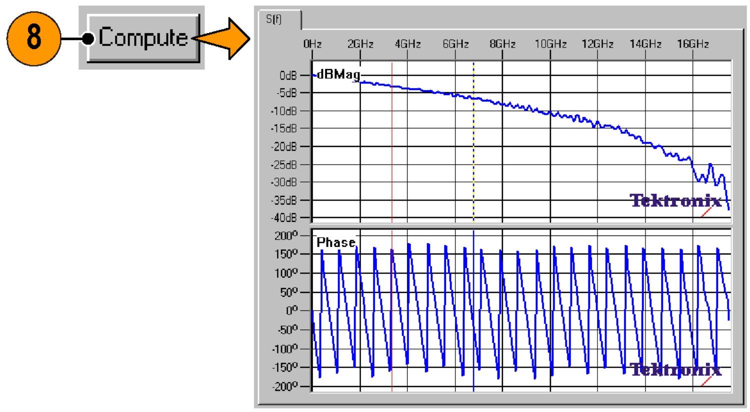


7. (Optional) Use a 50 Ω calibration waveform created using a precision 50 Ω standard at the DUT reference plane. You also have a choice between open, short, and through reference calibration. (See page 41, *S-Parameter Calibration Settings*.)



1835-223

8. Click the **Compute** button to open the specified viewer and plot the S-parameter values using the default display format (dB (Mag)/Phase). Right-click in the viewer and select **Plot** to view the data in a different format (Magnitude/Phase or Real/Imaginary).



1835-224

S-Parameter Calibration Settings

- In the Calibration settings, when Ref type is set to **Thru**, and DUT Type is set to **Insertion loss/xtalk**, IConnect ignores the 50 Ω calibration waveform.
- The Ref type field specifies what type of waveform to use in the waveform's **Ref** menu.
- When Ref type is set to **Open/Short**, you must load a 50 Ω calibration waveform. To create a 50 Ω calibration waveform for a two-port transmission measurement, remove the DUT and connect a reference 50 Ω termination to the port to which the pulse will be applied from the TDR module, acquire and save the reflected waveform, and then enter that file name in the **Load 50 Ω Waveform** field.

Differential and Common Mode Measurements

Differential (odd) and common (even) mode S-parameter measurements require different stimulus waveforms:

- Differential mode measurements: The oscilloscope must have the two stimuli switching in opposite directions (180° out of phase). For differential responses, subtract one response channel from the other.
- Common mode measurements: The oscilloscope must have the stimuli switching in the same direction (in phase). For common mode responses, add the two response channels together.

True Impedance Profile (Z-Line) Measurement

The IConnect Z-Line impedance measurement analyzes the TDR waveforms to accurately determine the true impedance profile of the device. An impedance profile lets you observe the type and position of discontinuities along a line. You can also use the impedance profile for signal integrity modeling.

The impedance profile is the characteristic impedance of a PCB trace, package lead, or other transmission-line-type structure, measured as a function of distance. Transmission lines tend to have multiple discontinuities which cause reflections that superimpose on each other. TDR oscilloscope impedance measurements do not take these multiple reflections into account, resulting in possibly significant impedance measurement errors for multiple-segment interconnects.

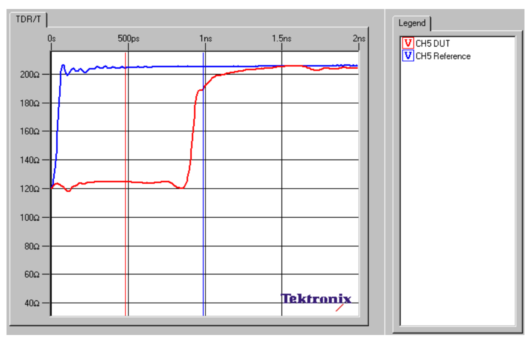
Z-Line impedance calculations require at least two TDR measurements:

- A reference measurement of all connecting cables and/or probes without the DUT. If there are no interconnecting cables or probes to the DUT, the reference measurement is to the connector on the TDR measurement module.
- A measurement with all interconnecting cables/probes and the DUT.

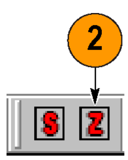
Prerequisites

- Follow measurement best practices. (See page 12, *Measurement Best Practices*.)
- Set the oscilloscope to display the correct waveforms. (See page 13, *Displaying the Correct TDR Waveform*.)
- Set IConnect to acquire the necessary waveforms. (See page 18, *Acquiring, Saving, and Loading Waveforms*.)

1. Acquire the appropriate waveforms from the instrument or saved files. (See page 18, *Acquiring, Saving, and Loading Waveforms*.)

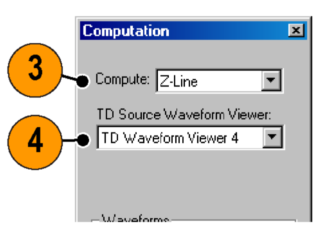


2. Click the **Z** button to open the **Z-Line Computation** task tab.



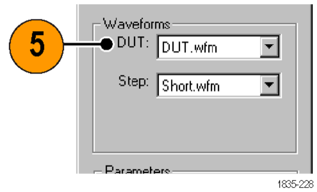
1835-226

3. Verify that Z-Line is already selected in the **Compute** field.
4. Select the TD Waveform Viewer window in which you acquired the waveforms in step 1.



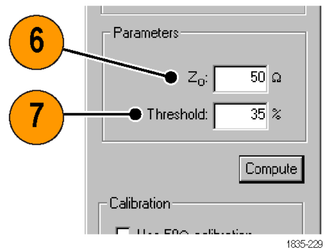
1835-227

5. In the Waveforms group, select the measured DUT TDR waveform in the **DUT** field, and the step waveform in the **Step** field.

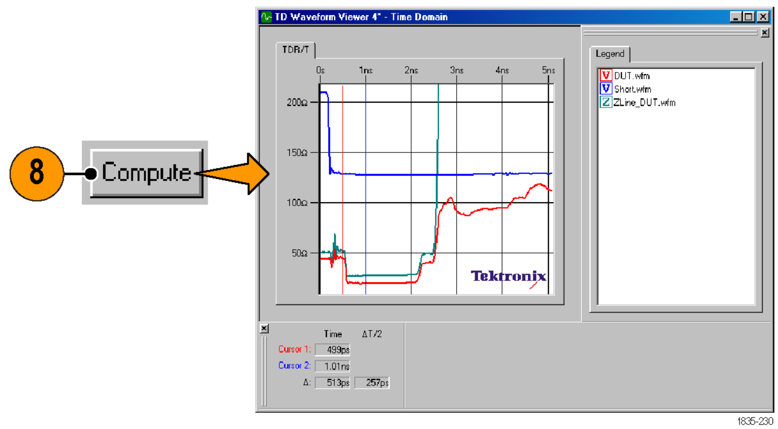


6. In the Parameters group, verify that the Z_o field (instrument impedance) is **50 Ω** (default).

7. Leave the Threshold field at **35%** (default).



8. Click the **Compute** button. IConnect calculates the true DUT impedance and adds the Z-Line plot to the TD Waveform Viewer window.



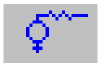
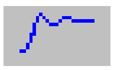
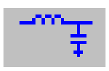
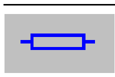
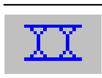
Standard Modeling

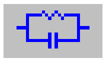
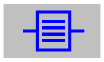
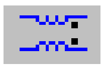
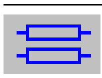
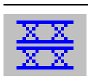
IConnect and MeasureXtractor TDR software helps you extract many different types of interconnect models from measurements. Model extraction in IConnect is a cooperative effort between IConnect's underlying algorithms and the different model viewers available for creating, editing, and saving various types of models. Models are accessible both from the Model menu and from the Model toolbar buttons (toggled on or off from **View > Toolbars > Model Toolbar**).

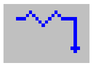
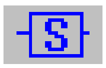
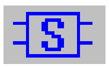
Many of the model viewers have the ability to take measurements, extract a model, and validate it on your simulator, without having to open another window. For more complex modeling tasks, you can cascade individual models by using the editor in the Composite model viewer.

Model files are typically saved with .cir extensions, and may be loaded from the main menu using the **File > Open** command. More typically, they are loaded from the Composite model viewer.

Model Descriptions

Toolbar icon	Model	Description
	Source	The Source model is an excitation model for launching an incident step into a DUT model. The model parameters are step delay, step rise time, and step amplitude. The delay is the time elapsed from t=0 before the ramp begins, and the risetime is the 0%-100% rise time of the ramp. The amplitude is that of the incident voltage step injected into the DUT model, so in model verification applications it should be the same as the step launched into the DUT during measurement. For example, ~200 mV for HP TDRs, ~250 mV for Tektronix TDRs. The Source model offers a quick, but less accurate, way to simulate a step input. The accuracy is reduced because the sharp corners at the transitions are likely to inject more high-frequency content into your DUT model than your real-world drivers will be injecting into your DUT. Simulation results should be interpreted accordingly.
	Piecewise-Linear (PWL) Source	The PWL (piecewise-linear) source model is an excitation model for launching an incident step into a DUT model. The model consists of a set of time-voltage pairs, which describe a time-domain voltage waveform. The data points from which the waveform is built are defined through a graphical user interface, and are built from a measured voltage waveform to accurately represent the excitation conditions present during measurement.
	Lumped	The Lumped model is built up from RLGC, RLC, RC, or LC sections. The LC sections may be of pi, T, LC, or CL topology. The model may be used as a valid low-frequency approximation to an ideal single transmission line, or as a model for electrically small structures such as packages and connectors which are well represented by such a topology. The potential parameters to the model are the inductance L, the capacitance C, the resistance R, and the conductance G. A picture shows graphically the selected topology and how the R, L, G and C parameters are distributed in that topology. If a more distributed model is desired, you may increase the number of subsegments, in which case each of the values shown in the picture is divided by that number and the subsegments are cascaded. Although this will not typically change the transmission characteristics of your model, it will generally improve the reflection characteristics to look more like those of a distributed transmission line.
	Single Line	The Single Line model consists of nonuniform cascaded RLGC and/or transmission line sections, and is useful for characterizing structures that are well represented as a single conducting path. Examples would be microstrip traces and some package leads. The graphical user interface of the single line model editor determines the parameters and topology of each of the sections, although R and G values must be determined manually if desired.
	Lossy Line	As digital circuit speeds continue to rise, transmission line loss plays an increasingly important role in signal integrity analysis. Transmission line loss is caused in large part by two factors: skin loss in the conductors, and dielectric loss. The primary results are rise time and amplitude degradation. Propagation delay becomes dependent on rise time, and amplitude degradation becomes dependent on clock frequency and bit sequences. The combination of these effects is eye closure at increased clock frequencies.

Toolbar icon	Model	Description
	Passive Equalizer	The Passive Equalizer model is built up from RLC or RC sections to model a passive equalizer used in a communication channel. The model opens the eye by applying a high pass filter characteristic (reducing signal loss at high frequencies) to the data stream of the transmission line. The potential parameters to the model are the inductance L, the capacitance C, and the resistance R. A picture shows graphically which topology has been chosen, and how the R, L, and C parameters are distributed in that topology.
	Two-port Subcircuit	The Two-port Subcircuit model lets IConnect incorporate SPICE-based modeling results into the overall model. Any SPICE model with input, output, and ground nodes may be included as part of a composite IConnect model. All two-port subcircuit node definitions must be in the following order: input node, output node, and model ground node.
	Lumped Coupled	The Lumped Coupled models the crosstalk energy coupling between adjacent lines. The signal propagating on the offender line transfers part of its energy onto the victim line. The IConnect lumped coupled model is built up from RLCG, RLC, RC, or LC sections. The LC sections may be of pi, T, LC, or CL topology. Because it models two structures with inductive and capacitive coupling between them, it may be used as a valid low-frequency approximation to an ideal set of two coupled transmission lines, or as a model for electrically small coupled structures such as packages and which are well represented by such a model. The potential parameters to the model are the self and mutual inductance L1, L2, and L12, and the self and mutual capacitance C1, C2, and C12, the resistance R, and the conductance G. Although the picture in the modeling window shows the RLGC topology, the various LC topologies available are equivalent to the analogous topologies shown in the Lumped (uncoupled) model. If a more distributed model is desired, you may increase the number of subsegments, in which case each of the values shown in the picture is divided by that number and the subsegments are cascaded.
	Symmetric Coupled Lines	The Symmetric Coupled Lines model consists of nonuniform cascaded coupled RLGC and/or transmission line sections, and is useful for characterizing structures that are well represented as dual symmetric conducting paths. Examples are coupled microstrip traces and some coupled package leads or connector lines. The graphical user interface of the symmetric coupled lines model editor assists the user in determining the parameters and topology of each of the sections, although R and G values must be determined manually if desired.
	Symmetric Coupled Lossy Lines	The Symmetric Coupled Lossy Line model allows you to simulate skin effect and dielectric loss, together with intersymbol interference (ISI) and crosstalk effects. It also allows you to predict the Eye Diagram degradation due to losses and ISI in the interconnects. You may also incorporate Eye Diagram closure effects due to crosstalk from neighboring line pairs.

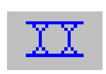
Toolbar icon	Model	Description
	Termination	The termination model replicates the passive termination conditions of the DUT. The only model parameter is resistance, since the model consists of a resistor to ground. To emulate an open circuit, use a resistance value that is large compared to the characteristic impedance, while for a short circuit, use a resistance value that is small compared to the characteristic impedance of the measurement system. For a 50 Ω system, for example, a typical open circuit termination resistance value would be 5k Ω and a short circuit termination resistance value would be 1Ω.
 	Data Driven Models (Single and Coupled)	The data-driven models allow you to bypass any manual intervention in the modeling process using IConnect's MeasureXtractor modeling technology. IConnect supports automatic model extraction for two-port and four-port models, which correspond to single-line and coupled-line circuits. (See page 49, *Advanced Modeling (MeasureXtractor™)*.) Data driven model extraction results in a SPICE netlist which very accurately replicates the behavior of the measured device. The passivity of the model is guaranteed by the extraction process. The resulting netlist cannot be adjusted, and will not be structurally recognizable. As a result, you should not use data-driven models if you intend to adjust parameters in the resulting model.

Example Standard Model Process

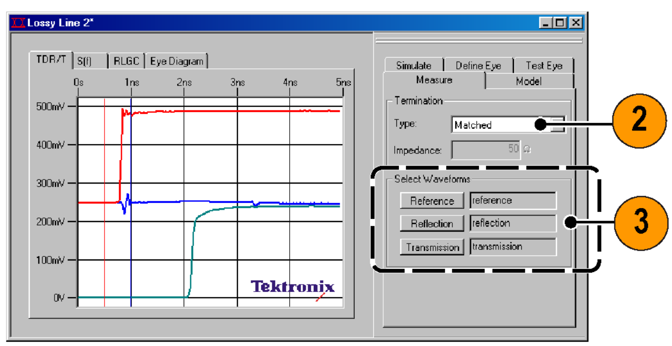
Prerequisites

- Follow measurement best practices. (See page 12, *Measurement Best Practices*.)
- Set the oscilloscope to display the correct waveforms. (See page 13, *Displaying the Correct TDR Waveform*.)
- Set IConnect to acquire the necessary waveforms. (See page 18, *Acquiring, Saving, and Loading Waveforms*.)

1. Click the **Lossy Line** button.

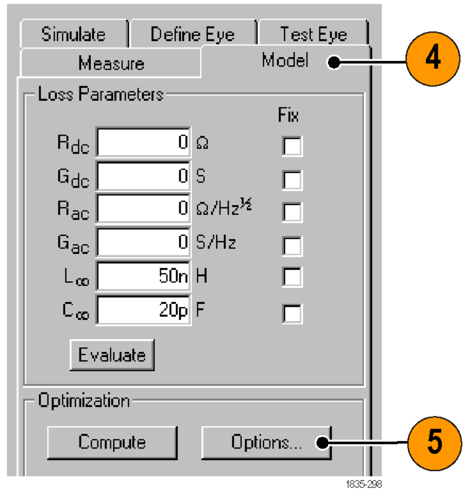


2. Select the termination **Type** (Open or Matched) on the Measure tab.
3. Click the buttons in the **Select Waveforms** area to select and load the required waveforms.



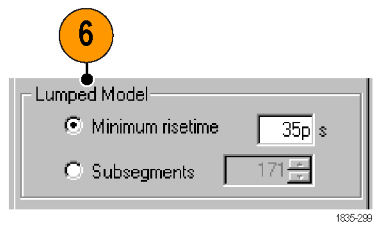
4. Select the **Model** tab.

5. (Optional) Click the **Options** button and set the **Max. Iterations** that IConnect performs before calculations stop, and the measurement **Precision** setting at which to stop calculations (calculations stop when IConnect reaches the precision value setting).

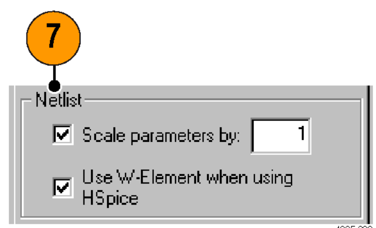


6. Set the **Lumped Model** parameters. Lumped Model settings affect how the Lossy Line model is written to a file.

   Enter a realistic rise time number to decrease the required number of subsegments for the model to be accurate to that rise time. Alternatively, you can manually decrease the number of subsegments. You need to have at least three segments per length of TDR rise time.

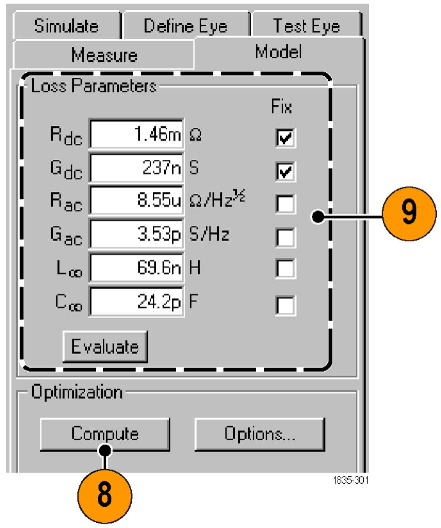


7. Set the **Netlist** parameters. Netlist settings affect how the Lossy Line model is written to a file. Use the **Scale parameters by** field to generate a per-unit length model, or to easily scale the length of the model.



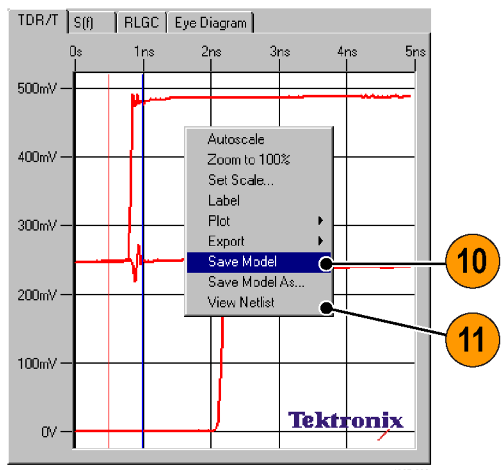
8. Click the **Compute** button. IConnect calculates the DUT Loss Parameter characteristics and plots the simulated waveforms.

9. (optional) Change one or more **Loss Parameter** fields and click the **Evaluate** button to test how different values change the simulated waveforms. Use the **Fix** check boxes to prevent the current value from changing.

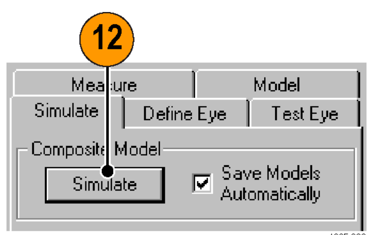


10. To save the model, right-click in the waveform plot and select **Save Model**.

11. To view the model netlist, right-click in the waveform plot and select **View Netlist**.



12. To simulate the model, select the **Simulate** tab and click the **Simulate** button. IConnect generates new viewer windows as needed and prompts you to enter the location at which to save the simulation files.



Model Extraction Tips

Keep models as simple as possible. Simple models are faster to simulate, easier to troubleshoot, and easier to explain to a colleague or customer. One effective way to create a simple model is to filter your measured data prior to model extraction to be sure that you are modeling for the rise time at which your circuit is intended to operate, and not modeling an order of magnitude higher than necessary. Also, be certain that you are modeling your DUT, and not the parasitics associated with your measurement system.

Work with models directly in the composite model viewer. Working directly in the composite model viewer will save you the intermediate step of writing a model to disk and later having to reload it into the composite viewer for verification.

Know which models are most effective for which modeling tasks. Some assistance is available in the reference material, but a certain amount of expertise must be gained through experience and through physical understanding of the problem at hand. Tektronix is also available to give advice on modeling issues.

Make sure that your measured data is accurate. Your models can only be as accurate as your measurements, so taking the time to do it right will pay off later. Ensuring that shorts are shorts, that opens are opens, and performing other checks on measured data will save time and headache in troubleshooting later.

Advanced Modeling (MeasureXtractor™)

Whereas standard modeling provides an engineer with the tools to create a detailed topological model of an interconnect, MeasureXtractor provides a fast way to create a data-driven model based on the measurements through a known good interconnect. You can use this “black box” model in the IConnect Link Simulator to test and verify the interconnect functionality. MeasureXtractor data-driven models let you simulate any interconnect structure, and include both time dependent (reflection, ringing, crosstalk) and frequency dependent (frequency loss) interconnect behavior.

MeasureXtractor modeling can use time domain reflectometry and transmission (TDR/T) measurements or frequency dependent S-parameter data. The size of the model is proportional to the interconnect size and complexity. The passivity, stability and causality of the models are guaranteed.

Waveform Acquisition and Setup

Review measurement techniques if necessary. (See page 12, *Measurement Best Practices*.) In addition to the best practices given in that section, it is particularly important when taking MeasureXtractor measurements to select a window that is long enough to allow the DUT waveforms to completely settle to their steady state DC levels. High-frequency DUT analysis requires the signal to settle to make an accurate analysis.

When to Use Data-Driven Models

Data Driven models are best used for devices which are electrically short or medium-sized. A rough rule of thumb is that the device should be fewer than 20 wavelengths in length. Longer devices may take too long to extract. Another equivalent rule of thumb is that the electrical length of the device shouldn’t be more than 100 times the rise time of the signal you will use to excite the model. This is because the extraction time increases for waveforms with a large number of data points. Furthermore, simulation time of the resultant model will also increase.

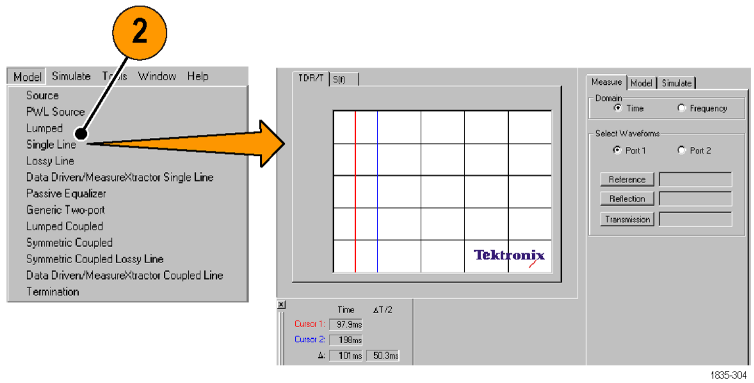
Prerequisites

- Follow measurement best practices. (See page 12, *Measurement Best Practices*.)
- Set the oscilloscope to display the correct waveforms. (See page 13, *Displaying the Correct TDR Waveform*.)

- Set IConnect to acquire the necessary waveforms. (See page 18, *Acquiring, Saving, and Loading Waveforms*.)
- All the waveforms must be acquired with 50 Ω probes, fixtures, or cables connected to all the DUT ports.
- The cables, probes, and fixtures used to connect the DUT to both channels of the TDR oscilloscope must be of the same length.
- Reference waveforms must be acquired at each port, with the cables, probes, and fixtures disconnected from the DUT and left open-ended.

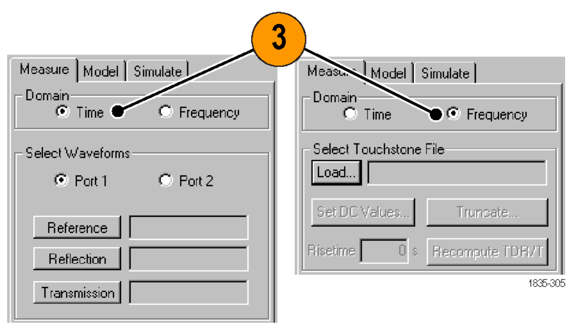
1. Determine the type of model that you want to extract (single or coupled line).
2. Select the appropriate type model to open the Data Driven viewers and task tabs (the example shows the data-driven Single Line Viewer and Task tabs).

   You can also select the MeasureXtractor model from the Model toolbar.

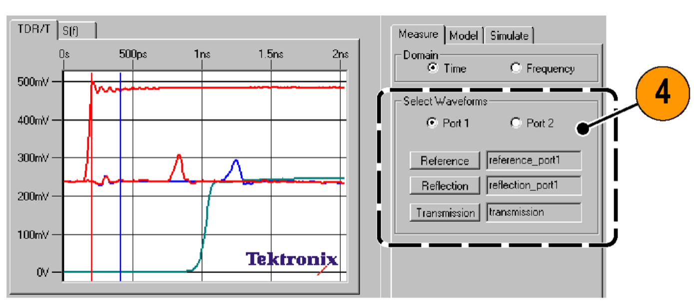


3. Select **Time** or **Frequency** domain data for MeasureXtractor data driven modeling. The parameters displayed depend on the selected domain type.

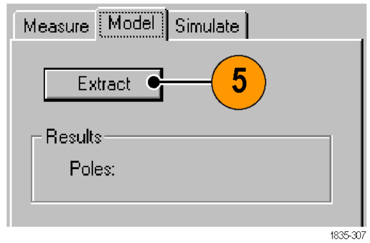
   If you select Time domain, you can acquire the data directly from a TDR oscilloscope, load saved waveform files, or select waveforms from an open Viewer window. If you select Frequency domain, you will need to acquire and save the waveform data as frequency-dependent Touchstone files beforehand, with port 1 (and 3 for coupled line) as inputs, and 2 (and 4 for coupled line) as outputs.



4. Load or acquire the necessary waveforms for each port.

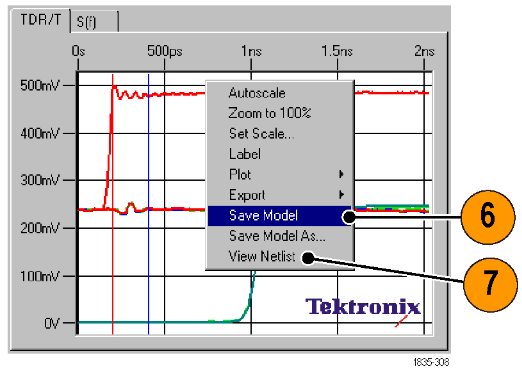


5. Select the **Model** tab and click the **Extract** button. The Results area lists the number of poles and any errors encountered during the extraction.



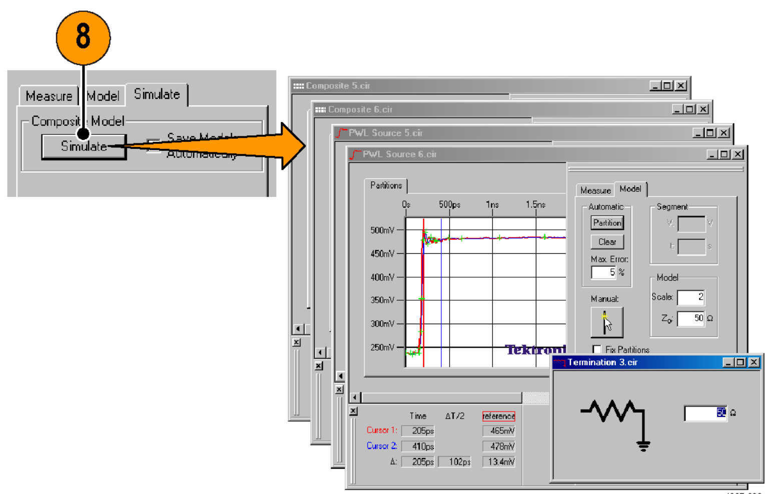
6. To save the model, right-click in the **TDR/T** viewer and select **Save Model**. Use the **Syntax** field in the Save dialog box to set the model file syntax (variations on SPICE, or the IConnect Linear Simulator).

7. To view the model netlist, right-click in the **TDR/T** viewer and select **View Netlist**.

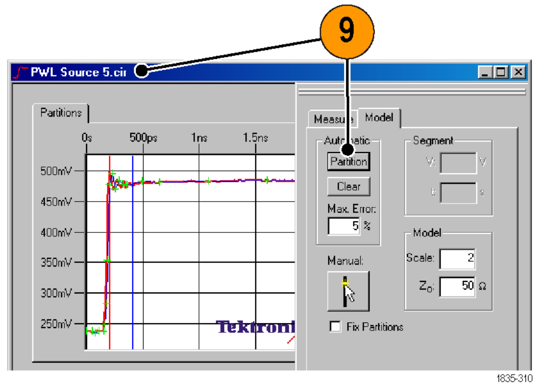


8. To simulate the model, select the **Simulate** tab and click the **Simulate** button. IConnect generates and displays associated viewers during the simulation, and also prompts you for the location to store the simulation results.

   The simulator specified in the Tools/Options menu on the Simulate tab must match the Syntax field entry in step 6.

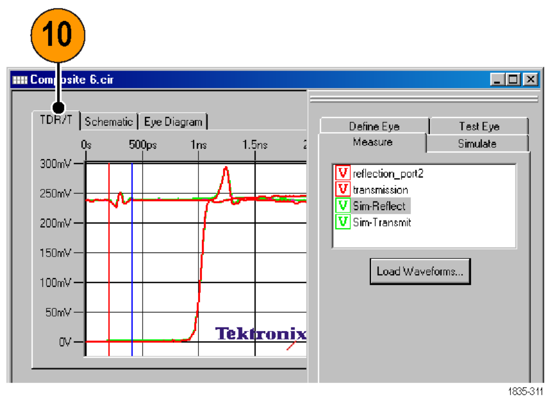


9. If you need to increase the precision with which IConnect models the TDR reference port data, open the appropriate **PWL Source** window, decrease the Max Error value and click **Partition** to repartition the PWL Source model. Make sure to save it before continuing.



10. After the simulation is complete, the simulated waveforms are placed in the **Composite** model waveform viewers. Click the **TDR/T** or **S(f)** tabs to view the correlation. The correlation is exact in both time and frequency domains.

When using Touchstone files, note that IConnect uses ports 1 and 3 as the input ports, and ports 2 and 4 as the output ports. Use the Port Mapping option when reading the Touchstone file if the file uses a different port numbering scheme.



See the Online help for more information on MeasureXtractor functions and the Model Composite Editor.

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