



**TekExpress® FRL Solution**  
**Printable Application Help**







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- In North America, call 1-800-833-9200.
- Worldwide, visit [www.tek.com](http://www.tek.com) to find contacts in your area.

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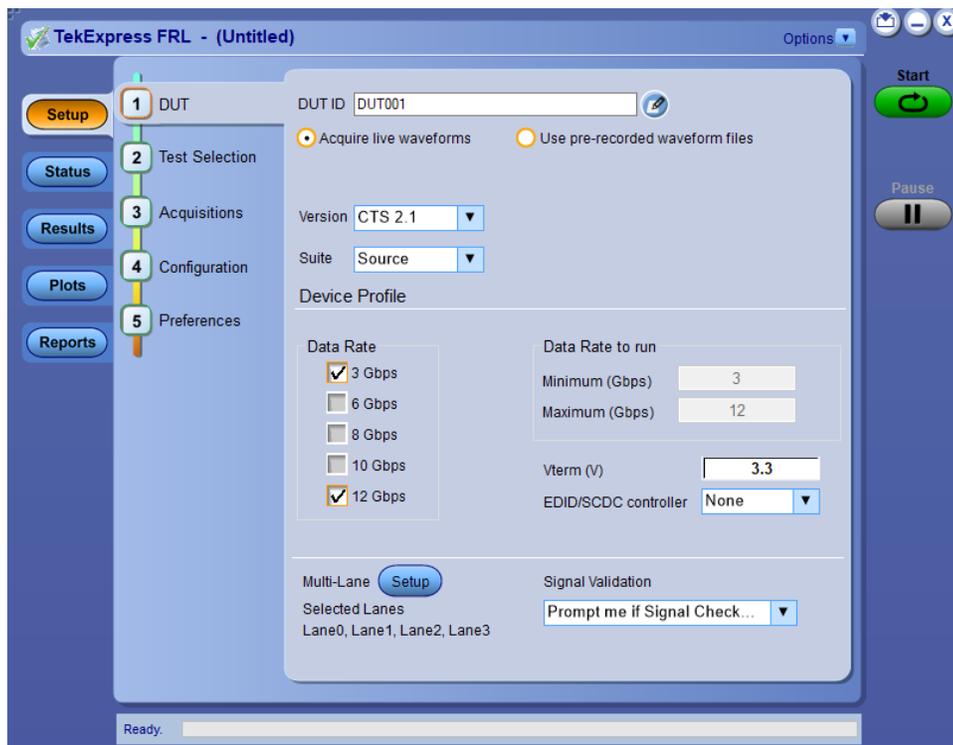
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# Welcome



The FRL (Fixed Rate Link) is a video signaling technology supported in the HDMI 2.1 Specification. FRL supports up to 4 K at 120 Hz and 8 K at 60 Hz - for compressed and uncompressed video content. FRL supports only predefined discrete data rates (3 Gbps, 6 Gbps, 8 Gbps, 10 Gbps, and 12 Gbps) on each of its 4 lanes which means that the FRL supports post encoded link bandwidth of up to 48 Gbps.

The TekExpress FRL compliance application gives you the tools to easily run the High Definition Multimedia Interface (HDMI) tests under the HDMI compliance test specification 2.1. It displays a complete and reliable solution for quick testing.

The TekExpress FRL supports the following **Source** and **Sink** measurements:

**Source measurements**

1. HFR1-1: DC Common Mode Voltage
2. HFR1-2: Vse\_max, Vse\_min
3. HFR1-3: Rise/Fall Slew Rate
4. HFR1-4: Inter-Pair Skew
5. HFR1-5: FRL Rates
6. HFR1-6: Data Jitter (Rj)
7. HFR1-7: Data Eye Diagram
8. HFR1-8: AC Common Mode Voltage
9. HFR1-9: FFE Monotonicity-Method 1
10. HFR1-9: FFE Monotonicity-Method 2

**Sink measurements**

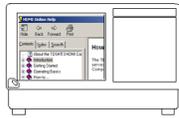
1. HFR2-1: Max Differential Swing Tolerance
2. HFR2-2: Intra-Pair Skew
3. HFR2-3: Inter-Pair Skew
4. HFR2-4: Minimum Link Rate Tolerance
5. HFR2-5: Jitter Tolerance

# Getting help and support

## Related documentation

The following documentation is available as part of the TekExpress® FRL application.

**Table 1: Product documentation**

| Item            | Purpose                                       | Location   |
|-----------------|---|--|
| Help            | Application operation and User Interface help |   |
| PDF of the help | Printable version of the compiled help        | <br>PDF file that ships with FRL application distribution ( <i>TekExpress FRL-Automated-Test-application-Software-Printable-Help-EN-US.pdf</i> ). |

**See also** [Technical support](#) on page 2

## Conventions

Help uses the following conventions:

- The term "Application," and "Software" refers to the TekExpress FRL application.
- The term “DUT” is an abbreviation for Device Under Test.
- The term “select” is a generic term that applies to the two methods of choosing a screen item (button, control, list item): using a mouse or using the touch screen.

**Table 2: Icon descriptions**

| Icon  | Meaning  |
|---|--|
|  | This icon identifies important information.  |
|  | This icon identifies conditions or practices that could result in loss of data.                      |
|  | This icon identifies additional information that will help you use the application more efficiently. |

## Technical support

Tektronix values your feedback on our products. To help us serve you better, please send us your suggestions, ideas, or comments on your application or oscilloscope. Contact Tektronix through mail, telephone, or the Web site, [www.tek.com](http://www.tek.com).

When you contact Tektronix Technical Support, please include the following information (be as specific as possible):

### General Information

- All instrument model numbers
- Hardware options, if any
- Probes used
- Your name, company, mailing address, phone number, FAX number
- Please indicate if you would like to be contacted by Tektronix about your suggestion or comments.

**Application Specific Information**

- Software version number
- Description of the problem such that technical support can duplicate the problem
- If possible, save the setup files for all the instruments used and the application.
- If possible, save the TekExpress setup files, log.xml, \*.TekX (session files and folders), and status messages text file.
- If possible, save the waveform on which you are performing the measurement as a .wfm file.



# Getting started

## Required Oscilloscopes

DPO70000SX/DX Series Real Time Oscilloscopes with Bandwidth  $\geq$  20 GHz

## Recommended accessories

**Table 3: Recommended accessories**

| Instruments/Accessories                         | Description   | Quantity |
|---|---|----------|
| Arbitrary Waveform Generator                    | AWG70001A/B   | 4        |
| Sync Hub  | Synchronizes the signal outputs of up to four AWG70001A/B series instruments (AWGs). One instrument becomes the master and three instruments become slaves. | 1        |
| AWG-HD  | Performs amplification, sets the skew on positive and negative legs and sets the bias voltage.  | 1        |
| HDMIA2-TPA-P                                    | Wilder Fixture, HDMI Type A(v2.1) Test Point Adapter  | 1        |
| HDMIA2-TPA-R                                    | Wilder Fixture, HDMI Type A(v2.1) Test Point Receptacle   | 1        |
| EDID/SCDC controller                            | HDMI_EDID2.1-EMSS (Wilder) or AJSC-1 (Allion)   | 1        |
| Synchronisation cable (for stack configuration) |   | 1        |
| SMA torque                                      |   | 1        |
| AWG Synchronization Hub                         |   | 1        |
| External box                                    |   | 1        |
| Ethernet Hub                                    |   | 1        |

## Recommended probes

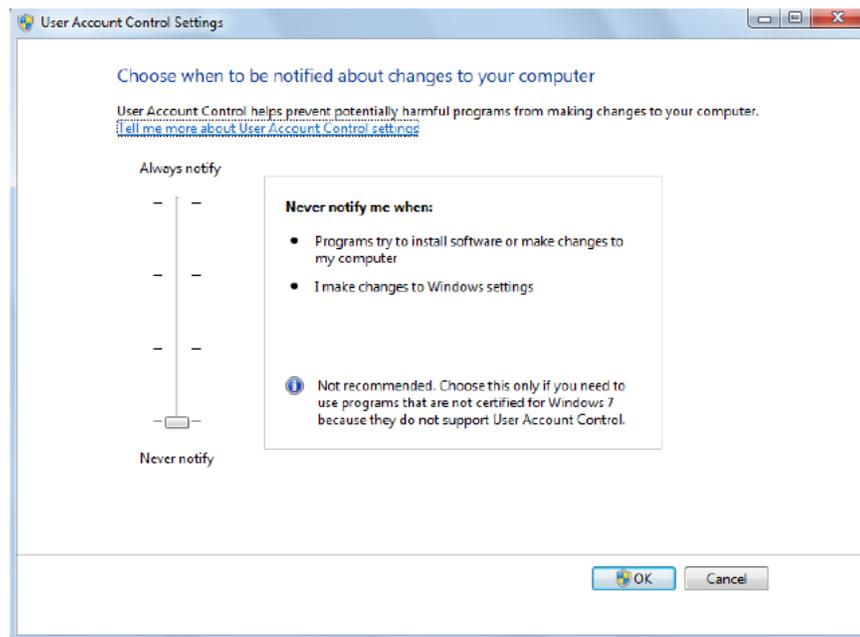
**Table 4: Recommended probes**

| Probes                                     | Quantity |
|--|----------|
| SMA Cables                                 | 10       |
| P7625/P7633 Tri-mode probe with P76CA-292C | 4        |
| P7720 Tri-mode probe with P77C292MM        |          |

## Windows 10 user accounts

Windows 10 instruments need to have the User Account Control Settings set to **Never Notify**. To set the User Account Control Settings:

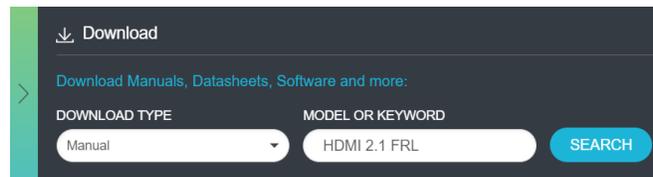
1. Go to **Control Panel > User Accounts > Change User Account Control settings**.
2. Set it to **Never Notify** as shown in the image.



## Installing the software

Complete the following steps to download and install the latest FRL application. See [Recommended accessories](#) on page 5 for compatibility.

1. Go to [www.tek.com](http://www.tek.com).
2. Click **Downloads**. In the Downloads menu, select DOWNLOAD TYPE as Software and enter *HDMI 2.1 FRL* in the MODEL OR KEYWORD field and click **SEARCH**.



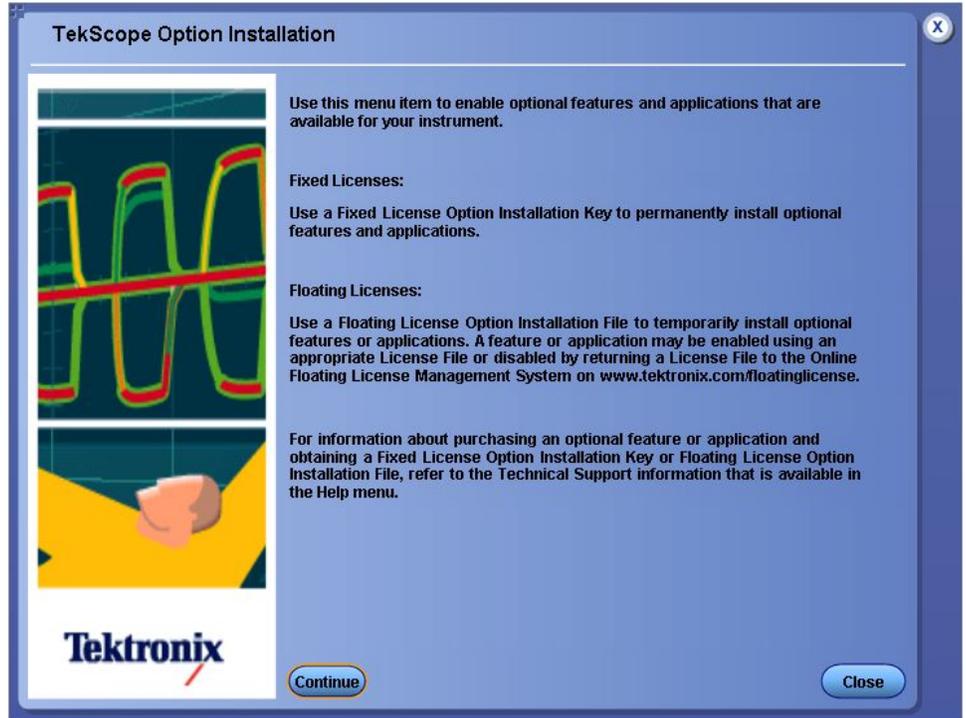
3. Select the latest version of software and follow the instructions to download. Copy the executable file to the oscilloscope.
4. Double-click the executable and follow the on-screen instructions. The software is installed at *C:\Program Files\Tektronix\TekExpress\TekExpress FRL*.
5. Select **Analyze > Tekexpress FRL** from the TekScope menu to [Run the application](#) on page 11.

## Activate the license

Activate the license using the option installation wizard on the oscilloscope. Complete the following steps to activate the TekExpress FRL license:

1. From the oscilloscope menu bar, click **Utilities > Option Installation**.

The TekScope Option Installation wizard opens.



2. Instructions for using the Options Installation window to activate licenses for installed applications is provided in the oscilloscope online help. Press the **F1** key on the oscilloscope keyboard to open the Option Installation help topic. Follow the directions in the topic to activate the license.

**See Also** [View version and license information](#) on page 9

## View version and license information

Use the following instructions to view application version information and version information for the application modules such as the Programmatic interface and the Programmatic interface client.

To view version information:

From the Options menu, select **About TekExpress**.



To view license information:

1. From the oscilloscope Help menu, select **About TekScope**.

The Options section in the dialog box displays a list of installed options, including TekExpress FRL.

2. To view the Option key, look in the Option Installation Key section. When finished, click **OK** to close the dialog box.

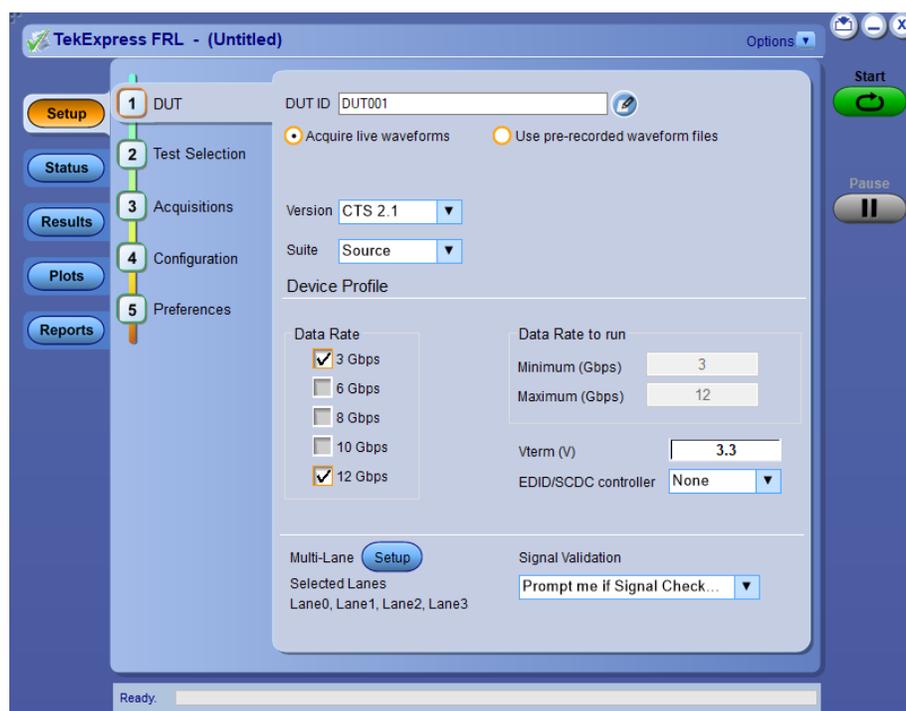
**See Also** [Activate the license](#) on page 8  
[Options menu](#) on page 15



# Application basics

## Run the application

To launch the TekExpress HDMI 2.1 FRL application, select **Analyze > TekExpress FRL** from the TekScope menu.



When you launch the application for the first time, the file C:\Users\\My Documents\My TekExpress\FRL\Resource.xml is mapped to drive X:. This file contains information about the available network-connected instruments. The session files are stored in X:\FRL\. If this file is not found, then the application runs Instrument Discovery Program to detect the network-connected instruments before launching FRL application.

If the application is behind the oscilloscope application, click **Analyze > TekExpress FRL** to bring it to the front. To keep the TekExpress FRL application window on top, select **Keep On Top** from the TekExpress FRL *Options menu* on page 15.

See also [Application controls](#) on page 14  
[Application panels overview](#) on page 12

## Application panels overview

The FRL application uses panels to group Configuration, Results, and Reports settings. Click any button to open the associated panel. A panel may have one or more tabs that list the selections available in that panel. The configurations in a tab changes depending on the settings made in the same tab or another tab.

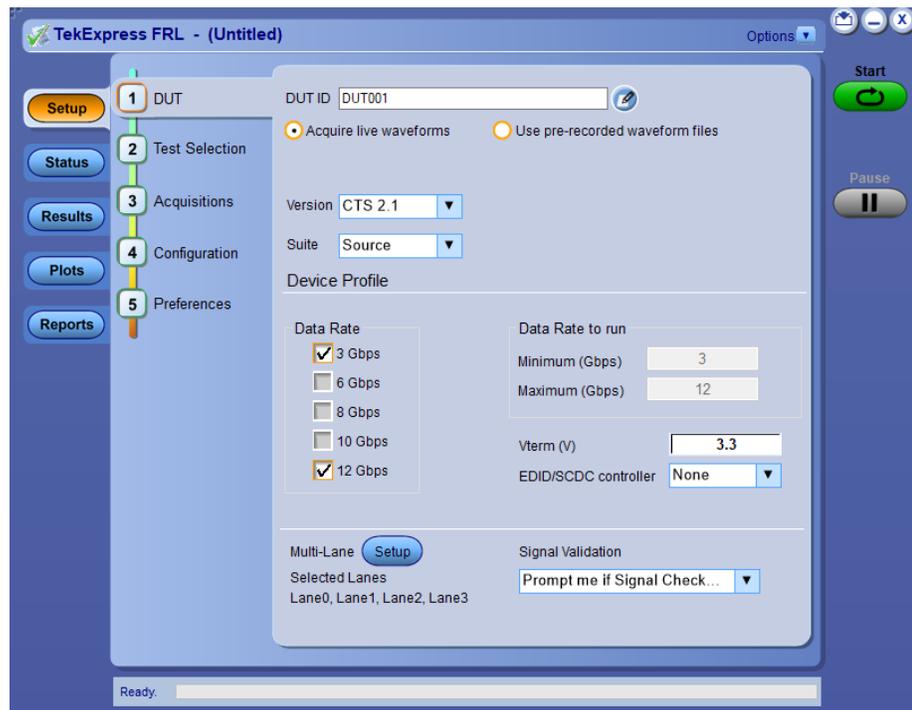


Table 5: Application panels overview

| Panel Name  | Purpose  |
|---|--|
| <a href="#">Setup panel overview</a> on page 21   | <p>The Setup panel shows the test setup controls. Click the <b>Setup</b> button to open this panel. Use this panel to:</p> <ul style="list-style-type: none"> <li>■ <a href="#">Set DUT parameters</a> on page 22</li> <li>■ <a href="#">Select tests</a> on page 28</li> <li>■ <a href="#">Set acquisition parameters</a> on page 29 (Only available when <b>Suite=Source</b> )</li> <li>■ <a href="#">Set configuration tab parameters</a> on page 32</li> <li>■ <a href="#">Set test notification preferences</a> on page 38</li> </ul> |
| <a href="#">Status panel overview</a> on page 39  | View the progress, analysis status of the selected tests, and view test logs.  |
| <a href="#">Results panel overview</a> on page 41 | View the summary of test results and select result viewing preferences.  |
| <a href="#">Reports panel overview</a> on page 44 | Browse for reports, save reports as specific file types, specify report naming conventions, select report content to include (summary information, detailed information, user comments, setup configuration, application configuration), and select report viewing options.  |

**See also** [Application controls](#) on page 14

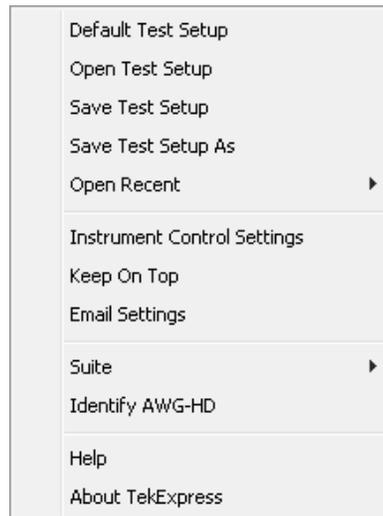
## Global application controls

Application controls **Table 6: Application control descriptions**

| Item   | Description   |
|--|---|
| <a href="#">Options menu</a> on page 15  | Opens the Options menu for access to global controls.   |
| Panels   | Visual frames with sets of related options.   |
| Command buttons  | Buttons that initiate an immediate action such as the Start, Stop, Pause, Continue, and Clear command buttons.  |
| Start button<br>              | Starts continuous measurement acquisition and analysis. If prior acquired measurements have not been cleared, the new measurements are added to the existing set. |
| Stop button<br>               | Stops (aborts) the current execution.   |
| Pause \ Continue button<br> | Use the Pause button to temporarily interrupt the current acquisition. When a test is paused, the button name changes to Continue.                                |
| Clear button<br>            | Clears all existing measurement results. This button is available only on the <a href="#">Results panel overview</a> on page 41.                                  |
| Clear Log<br>               | This button is available only on the <a href="#">Status panel overview</a> on page 39 and it is used to clear all the status log.                                 |
| Save<br>                    | This button is available only on the <a href="#">Status panel overview</a> on page 39 and it is used to save the status log locally for the future use.           |

| Item  | Description   |
|---|---|
| Application window move icon<br> | Place the cursor over the three-dot pattern in the upper left corner of the application window. When the cursor changes to a hand, drag the window to the desired location.   |
| Mini view / Normal view<br>      | Toggles the application between mini view and normal view.<br><br><br>Mini view displays the run messages with the time stamp, progress bar, Start / Stop button, and Pause / Continue button. The application moves to mini view when you click the Start button. |

**Options menu** The Options menu is located in the upper right corner of the application. The Options menu has the following selections:



| Menu               | Function   |
|--------------------|--|
| Default Test Setup | Opens an untitled test setup with defaults selected.                 |
| Open Test Setup    | Opens a saved test setup.  |
| Save Test Setup    | Saves the current test setup selections.                             |
| Save Test Setup As | Creates a new test setup based on an existing one.                   |
| Open Recent        | Displays a menu of recently opened test setups from which to select. |

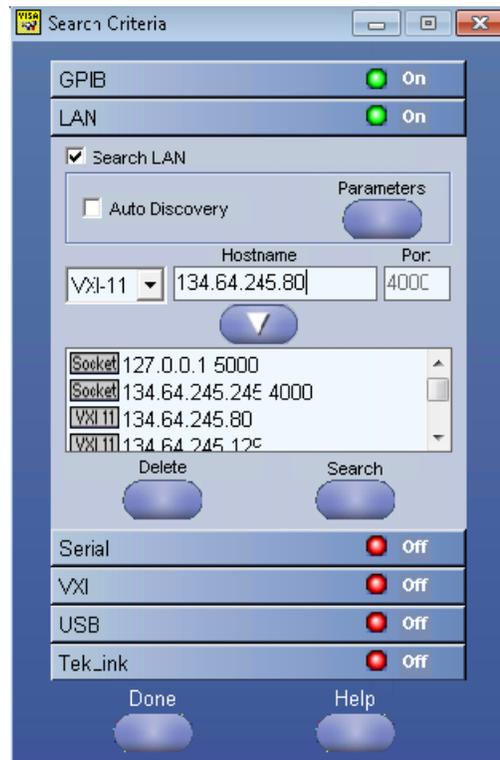
| Menu   | Function  |
|--|---|
| <a href="#">Instrument control settings</a> on page 17 | Shows the list of instruments connected to the test setup and allows you to locate and refresh connections to connected instruments.  |
| Keep On Top  | Keeps the TekExpress FRL utility on top of other open windows on the desktop.   |
| Email Settings   | Displays configure email options for test run and results notifications.  |
| Suite  | Displays the suite selected as 'Source' or 'Sink'.  |
| Identify AWG-HD  | <p><b>(Only available when Suite = Sink)</b><br/>                     Identifies the AWG-HD through MAC address</p>   |
| Help   | Displays TekExpress FRL application Help document (This document).  |
| About TekExpress                                       | <ul style="list-style-type: none"> <li>■ Displays application details such as software name, version number, and copyright.</li> <li>■ Provides access to <a href="#">View version and license information</a> on page 9 for your TekExpress FRL application installation.</li> <li>■ Provides a link to the Tektronix site.</li> </ul> |

**See also.**

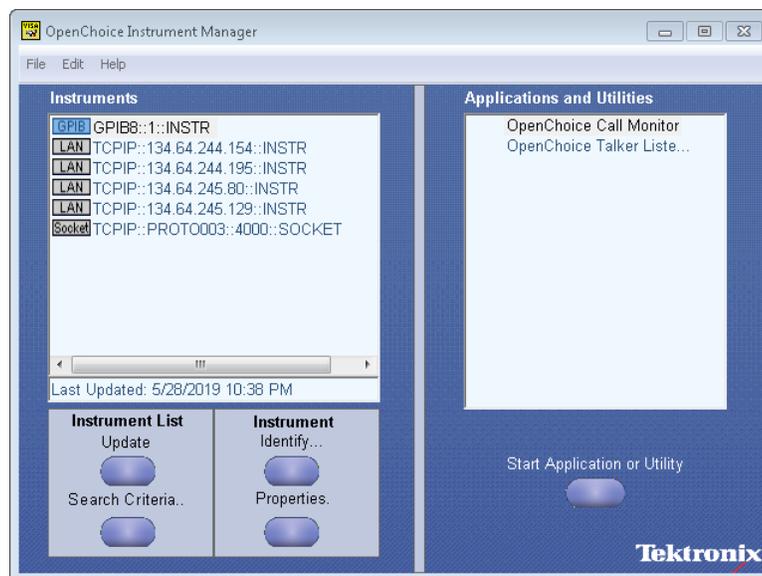
[Application controls](#) on page 14

## Instrument control settings

Use the TekExpress Instrument Control Settings dialog box to search and list the connected resources (instruments) found on specified connections (LAN, GPIB, USB, and so on) and each instruments connection information.



Identify all the instruments through VISA resource manager, before discovering the instruments in "Instrument control settings" and can access this dialog box from the Options menu.



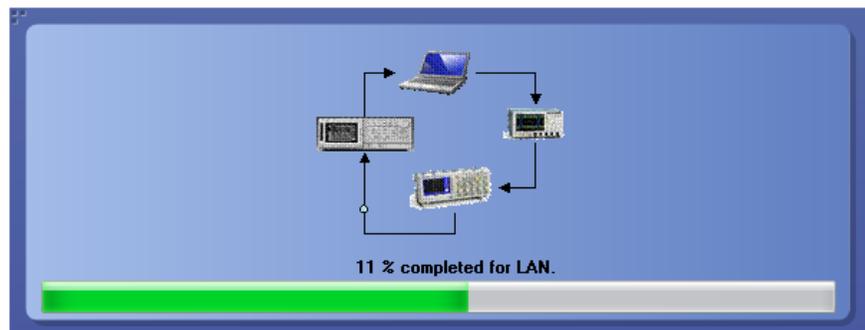
Use the Instrument Control Settings feature to view instrument connection details. Connected instruments displayed here and are selected for use in the Global Settings tab in the configuration section. See [Set configuration tab parameters](#) on page 32 for details.

To refresh the list of connected instruments:

1. From the Options menu, select **Instrument Control Settings**
2. In the **Search Criteria** section of the Instrument Control Settings dialog box, select the connection types of the instruments for which to search.

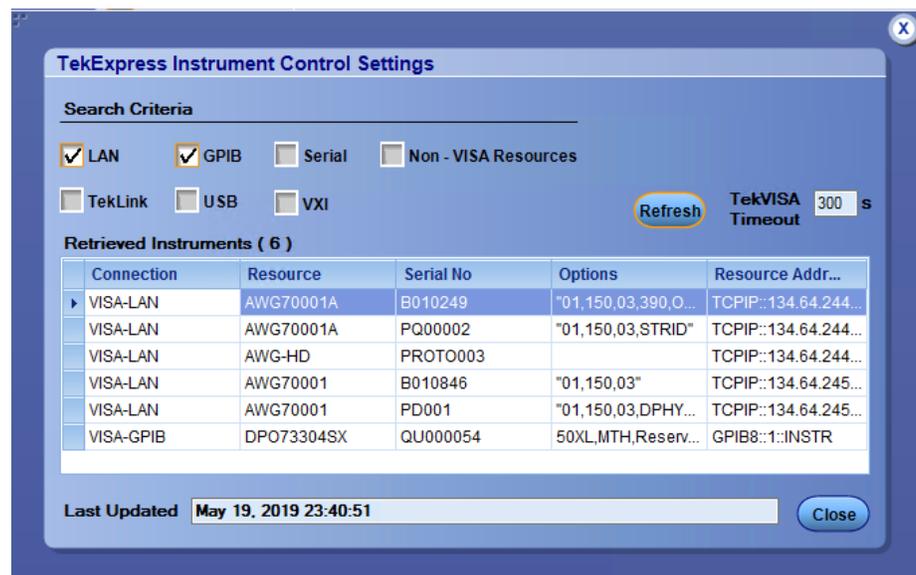
Instrument search is based on the VISA layer, but different connections determine the resource type, such as LAN, GPIB, and USB. For example, if you choose LAN, the search will include all the instruments supported by TekExpress that are communicating over the LAN.

3. Click **Refresh**. TekExpress searches for connected instruments.



4. After searching, the dialog box lists the instrument-related details based on the search criteria you selected. For example, if you selected LAN and GPIB as the search criteria, the application checks for the availability of instruments over LAN, then GPIB, and then lists detected instruments on those connection types.

The Retrieved Instruments table lists instrument details. The time and date of the last time this table was updated is displayed in the Last Updated field.



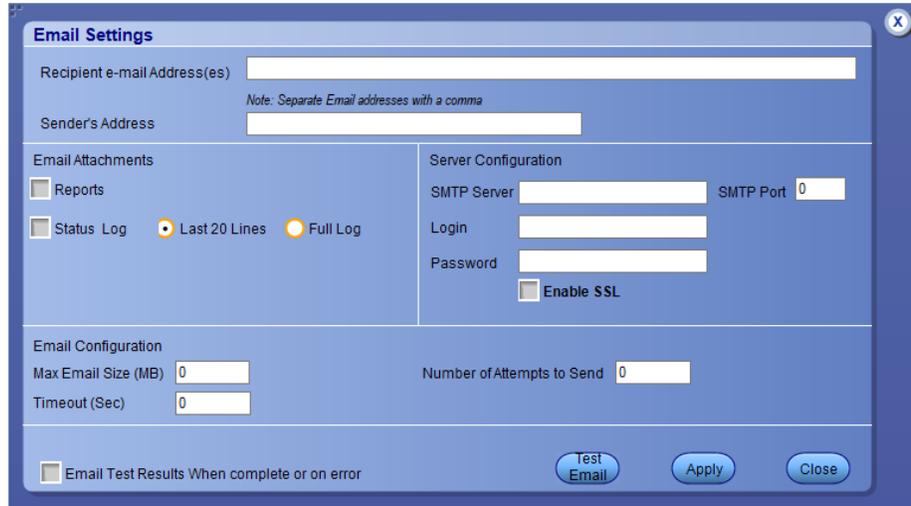
**See also.**

*Options menu* on page 15

**Configure email settings**

To be notified by email when a test completes, fails, or produces an error, configure the email settings.

1. Select **Options > Email Settings** to open the Email settings dialog box.



2. (Required) For Recipient email Address(es), enter one or more email addresses to which to send the test notification. To include multiple addresses, separate the addresses with commas.
3. (Required) For Sender's Address, enter the email address used by the instrument. This address consists of the instrument name, followed by an underscore, followed by the instrument serial number, the @ symbol and then the email server used. For example:  
DPO72004C\_B130099@yourcompany.com.
4. (Required) In the Server Configuration section, type the SMTP Server address of the Mail server configured at the client location, and the SMTP Port number, in the corresponding fields.

If this server requires password authentication, enter a valid login name, password, and host name in the corresponding fields.

---

**NOTE.** *If any of the above required fields are left blank, the settings will not be saved and email notifications will not be sent.*

---

5. In the Email Attachments section, select from the following options:
  - **Reports:** Attach the test report to the notification email.
  - **Status Log:** Attach the test status log to the notification email. If you select this option, then also select whether you want to receive the full log or just the last 20 lines.

6. In the Email Configuration section:
  - Select the message file format to send: HTML (default) or plain text.
  - Enter a maximum file size for the email message (message plus attachment files). Messages with attachments larger than this limit will be truncated. The default is 5 MB.
  - Enter the number in the Number of Attempts to Send field, to limit the number of attempts that the system makes to send a notification. The default is 1. You can also specify a timeout period.
7. Select the **Email Test Results When complete or on error** check box. Use this check box to quickly enable or disable email notifications.
8. To test your email settings, click **Test Email**.
9. To save your settings, click **Apply**.
10. Click **Close** when finished.

## Setup panel

### Setup panel overview

The Setup panel contains sequentially ordered tabs that you guides through the test setup and execution process. The configurations in the Setup panel changes depending on the **Suite** selection as **Source** or **Sink**.

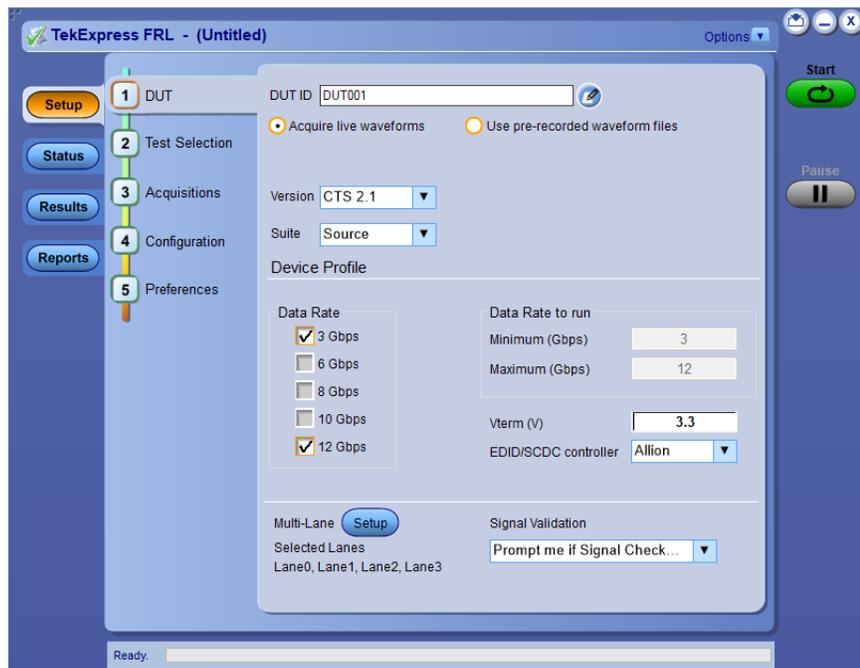


Figure 1: Setup panel for Source

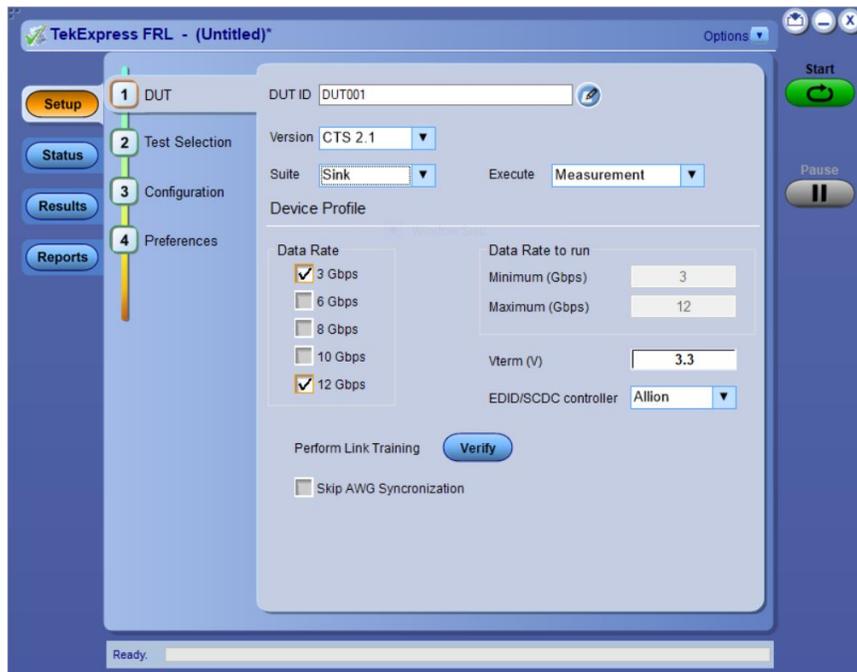


Figure 2: Setup panel for Sink

### Set DUT parameters

Use the DUT tab to select the parameters for the device under test. The settings are global and apply to all tests for the current session. The configurations available in other tabs may depend on the settings in the DUT tab.

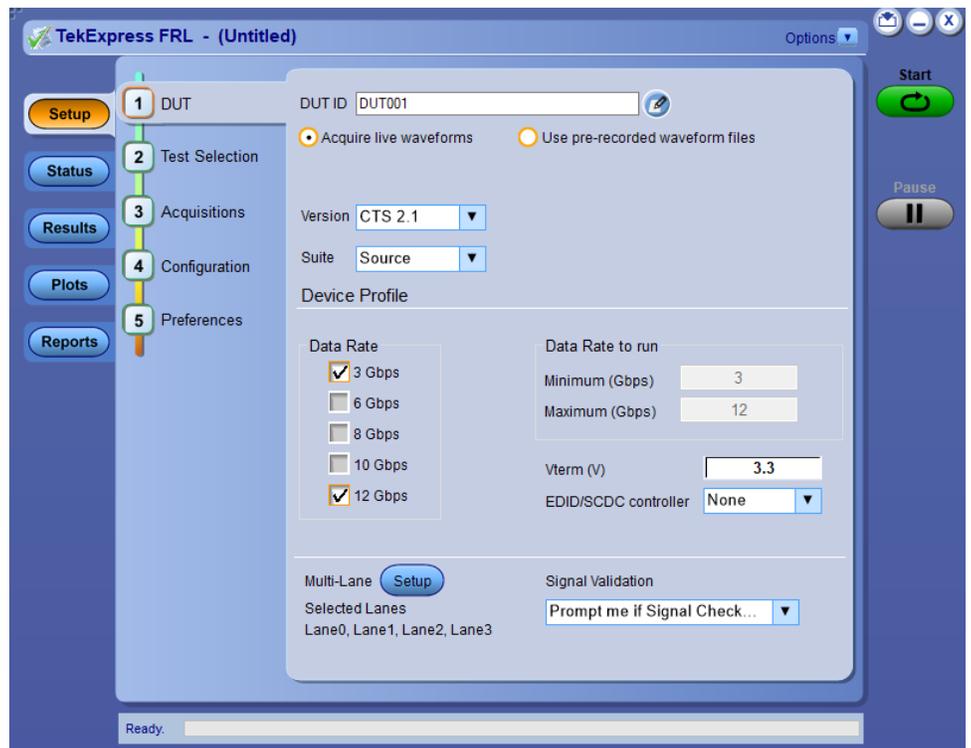


Figure 3: DUT tab for Source

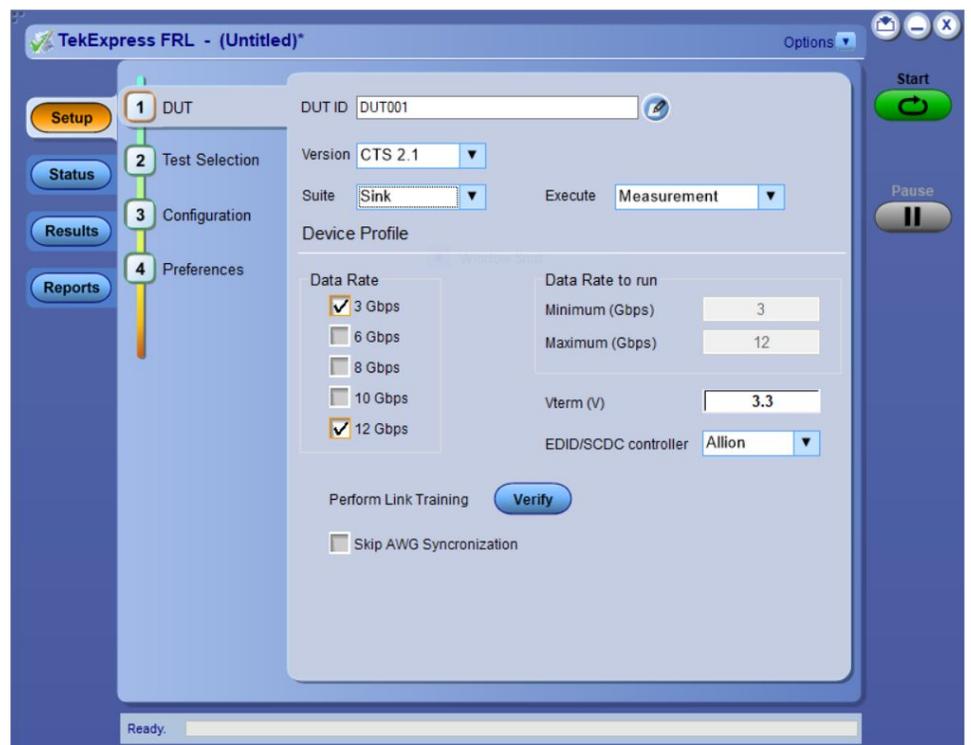
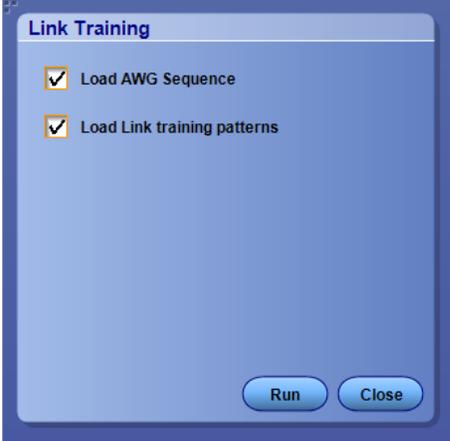
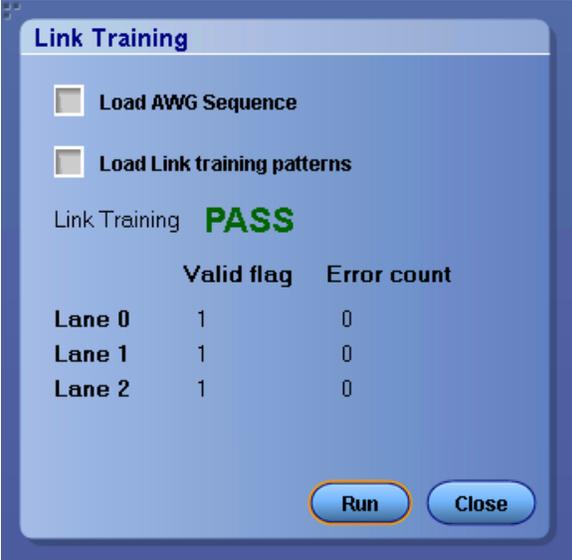
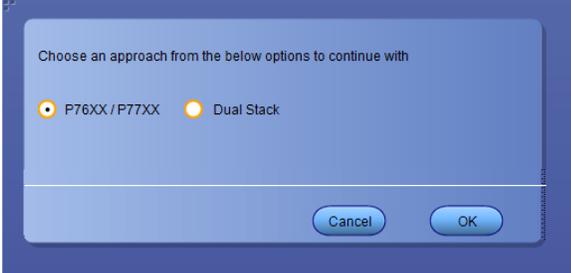
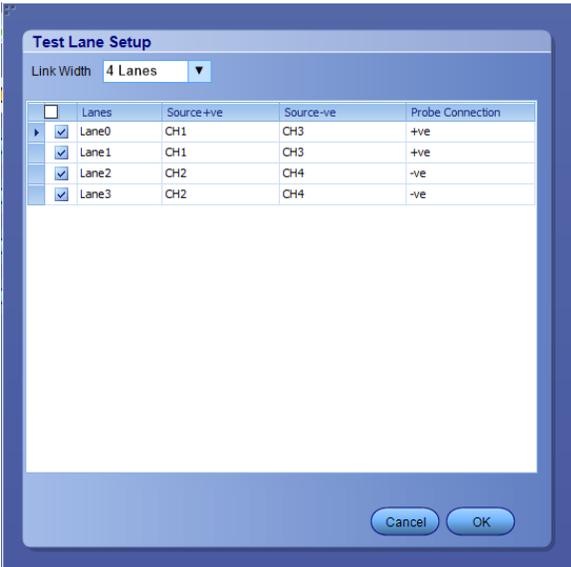
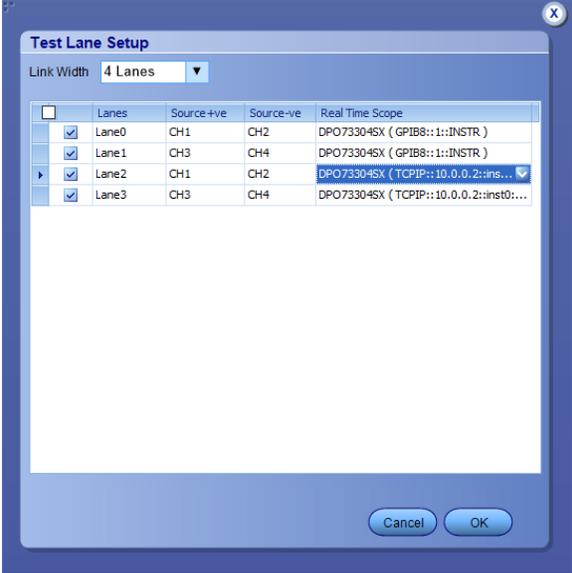


Figure 4: DUT tab for Sink



| Setting   | Description   |
|---|---|
| Verify<br> | <p>Select <b>Load AWG sequence</b> to load the sequences on all AWGs.<br/>           Select <b>Load link training patters</b> to load the appropriate patters in AWGs.</p>  <p>Click <b>Run</b>. Depending upon the selections made in the Link Training window, the application loads sequence, waveforms and performs link training on the patterns.</p>  <p><b>NOTE.</b> If you want to perform link training on selected patterns, you can load sequence and nominal waveforms manually in AWG and you can run by unselecting load sequence and waveforms.</p> |
| Skip AWG Synchronization  | <p><b>(Only available when Suite = Sink)</b><br/>           Select to skip the synchronization of AWG(s).</p>   |

| Setting          | Description   |
|------------------|---|
| Multi-Lane Setup | <p><b>(Only available when Suite=Source)</b><br/>                     Click <b>Setup</b> to configure the multi-lane setup for the test.</p>  <p>Select <b>P76XX/P77XX</b> configuration.</p> <ol style="list-style-type: none"> <li>1. Select <b>P76XX/P77XX</b> and click <b>OK</b>.</li> <li>2. In the Test Lane Setup menu, select the number of lanes selected, the Source, and the Probe connection for each lane and click <b>OK</b>.</li> </ol>  <p>Select <b>Dual Stack</b> configuration.</p> <ul style="list-style-type: none"> <li>■ Select <b>Dual Stack</b> and click <b>OK</b>.</li> <li>■ In the Test Lane Setup menu, select the number of lanes selected, the Source, and the IP address of the oscilloscope for each lane and click <b>OK</b>.</li> </ul> |

| Setting           | Description  |
|-------------------|--|
|                   | <p>The default IP address for oscilloscope and the extension oscilloscope is GPIB8::1::INSTR &amp; 10.0.0.2 respectively.</p>    |
| Signal Validation | <p><b>(Only available when Suite = Source)</b><br/>Validation of the Signal can be done by three options and they can be selected from the drop-down list provided:</p> <ul style="list-style-type: none"> <li>■ <b>Prompt me if Signal Check Fails</b><br/>When selected, user is prompted if Signal validation fails. The user will be given the option to Reacquire, Use Anyway, Skip and Abort the execution.</li> <li>■ <b>Skip Test if Signal Check Fails</b><br/>When selected, signal validation fails for the selected test is skipped.</li> <li>■ <b>Turn Off Signal Check</b><br/>When selected, FRL application does not perform any signal validation.</li> </ul> |

**Select tests** Use the Test Selection tab to select the tests to run on the connected DUT.

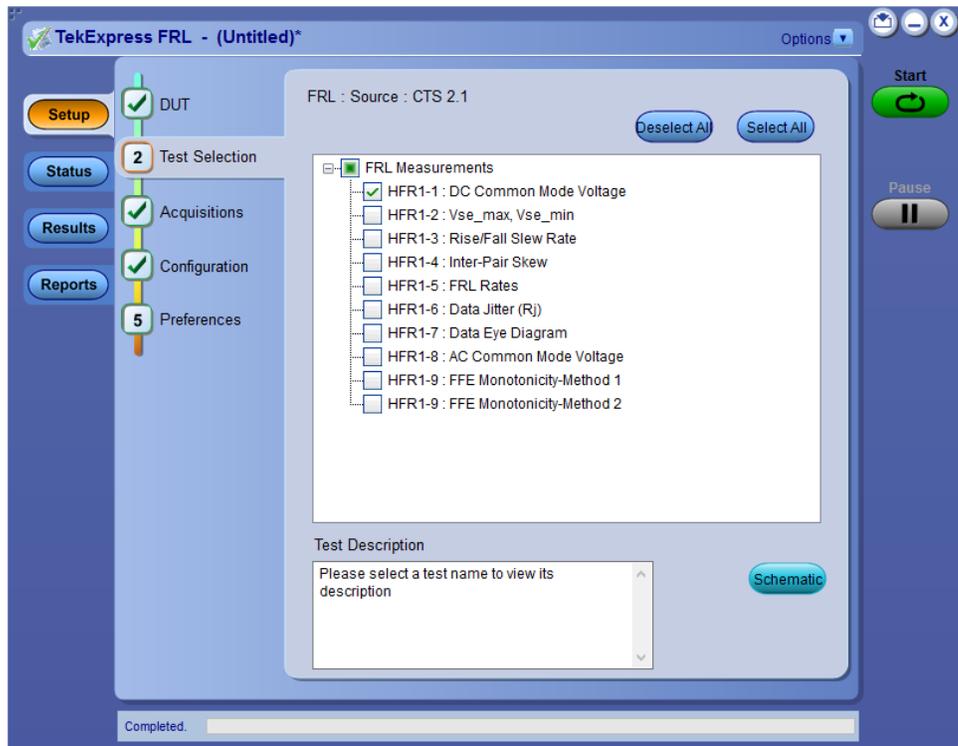


Figure 5: Test selections tab for Source

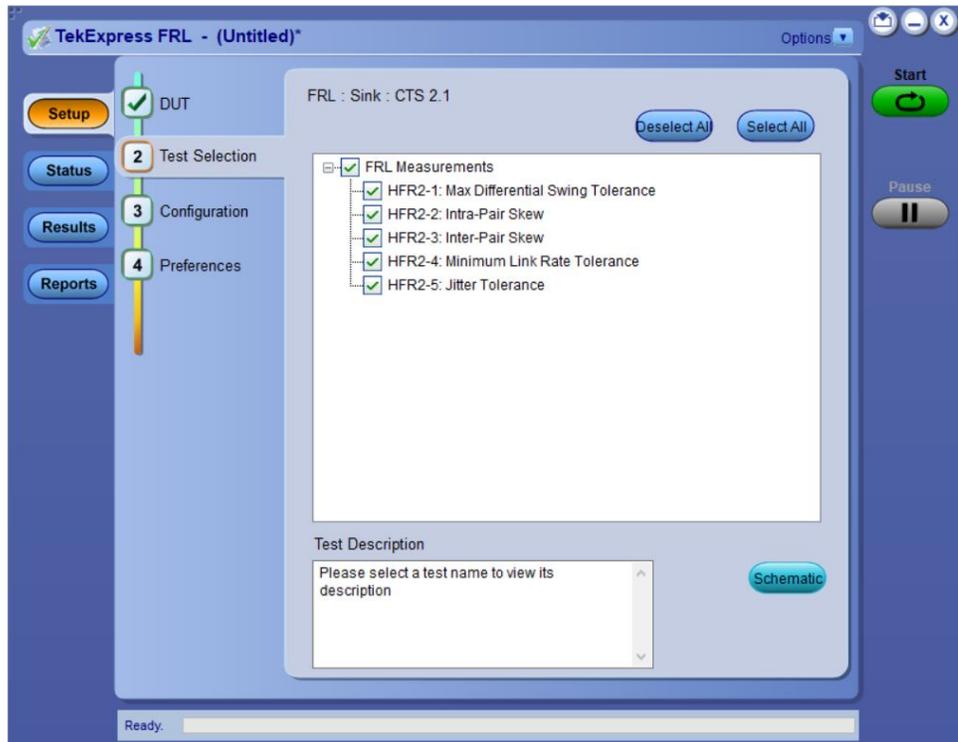


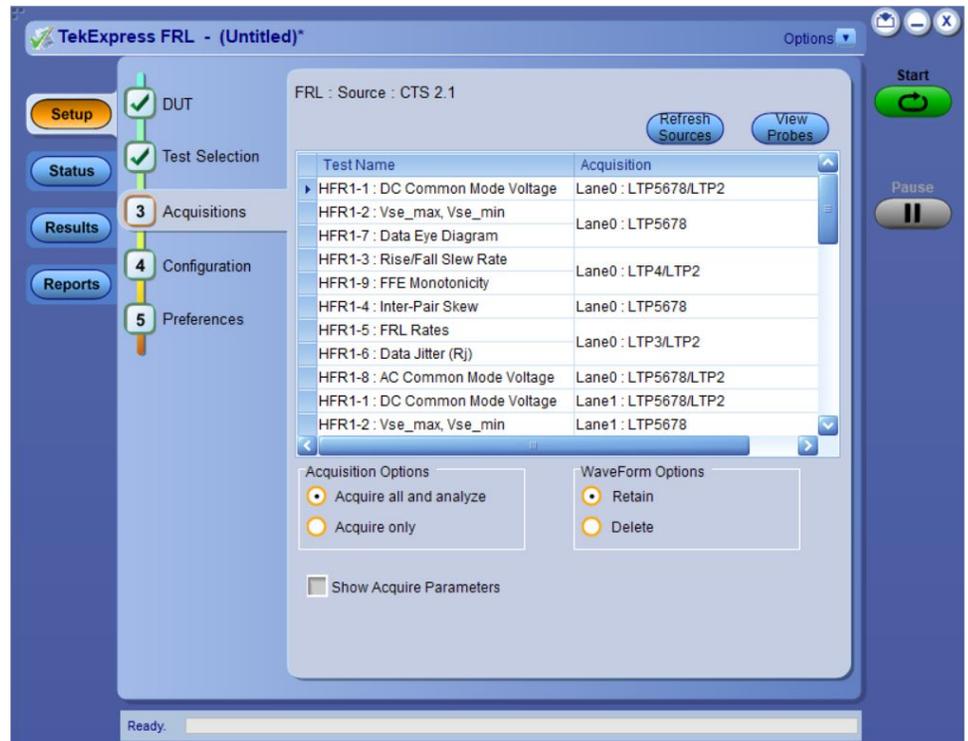
Figure 6: Test selection tab for Sink

See also. [FRL Source tests](#) on page 61

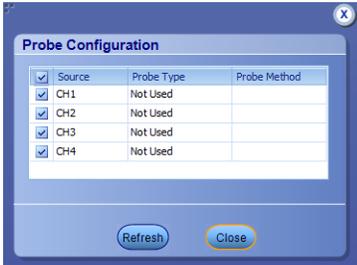
[FRL Sink Tests](#) on page 71

### Set acquisition parameters

Use the Acquisitions tab to view the test acquisition parameters. The contents displayed in this tab depends on the DUT type and the tests selected. This tab is available when the Suite in the DUT tab is selected as **Source**.

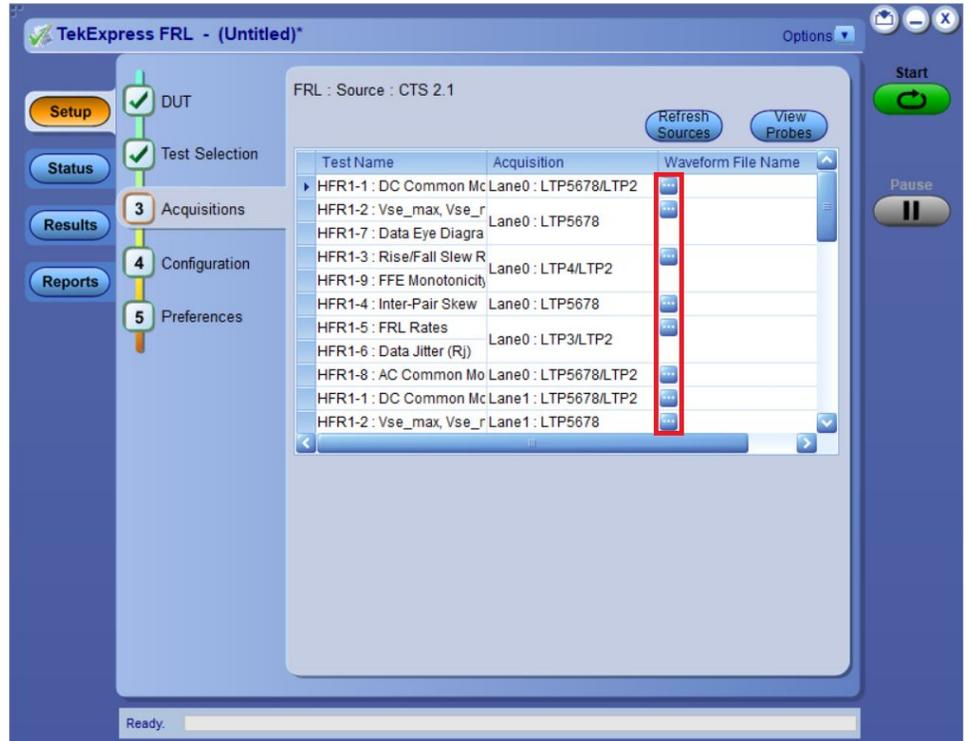


**Table 8: Acquisition tab settings**

| Settings                | Description   |
|-------------------------|---|
| Refresh Sources         | <p>Displays the sources connected to the different channels of the oscilloscope. Updates the list of available channel sources as used by the Source fields in the Device list. Click this button when you change the channel connections in the test setup.</p>                                  |
| View Probes             | <p>Displays the probes connected to the different channels of the oscilloscope. Click to view the detected probes and enable or disable the probe signal source access in the application.</p>                  |
| Acquisition Options     | <ul style="list-style-type: none"> <li>■ <b>Acquire all and analyze</b><br/>Acquire waveforms for all the valid acquisitions and analyzes using the saved waveforms.</li> <li>■ <b>Acquire only</b><br/>Acquires waveforms for all the valid acquisitions.</li> </ul>                             |
| Waveform Options        | <ul style="list-style-type: none"> <li>■ <b>Retain</b><br/>The <b>Retain</b> is enabled only when <b>acquire all and analyze</b> is selected and it retains the saved waveforms for offline analysis.</li> <li>■ <b>Delete</b><br/>Deletes the saved waveforms at the end of analysis.</li> </ul> |
| Show Acquire Parameters | <p>Select to review the acquire parameters.</p>   |

**Running tests on prerecorded (saved) waveforms.** To load a saved waveform file:

1. Click **DUT**.
2. Click **Use pre-recorded waveform files**.
3. Click **Acquisitions**. The Waveform Filename column now shows browse buttons.



4. Click the browse button (⋮) for each test acquisition type (Lane 0, Lane 1, Lane 2, Lane 3)
5. Navigate to and select the appropriate waveform file(s). You must select all waveforms required for the acquisition type.
6. To change, remove, or add a file to the list, click the browse button next to the file name to change, and use the menu items to replace, remove (delete) or add a file in the list.
7. Click **Start**.

---

**NOTE.**

*Waveform naming based on the Acquire Parameters.*

*Data Rate: 12 Gbps*

*Target Lane: Lane0*

*Victim Lane Pattern : LTP5678*

*Quite Lane Pattern : LTP5678(When Quite lane not present, Quite Lane Pattern = Victim Lane Pattern)*

*FFE Level: 0*

*Run no: 1*

*Example 1:*

*FRL\_Lane0\_12Gbps\_LTP5678\_LTP5678\_FFE0\_SE\_Pos\_R1.wfm*

*Example 2: Specific to HFR 1-4 Measurement*

*Allowed lane combination in compliance Mode:*

*Stack: L0L1,L0L2,L0L3*

*Probe: L0L2,L1L3,L0L3,L1L2*

*FRL\_Lane0\_12Gbps\_LTP5678\_LTP5678\_FFE0\_SE\_Neg\_L0L2\_R1.wfm*

---

**Set configuration tab parameters**

Use Configuration tab to configure the Global Settings and the test measurement configurations. The Global Settings and the measurements with configurations are available in this tab depend on the Standards selected in the DUT tab.

**Source configuration settings.** Use the configuration tab to configure the Global Settings and Measurement settings for the measurements. The settings described in this tab is available when Suite in the DUT tab is selected as Source.

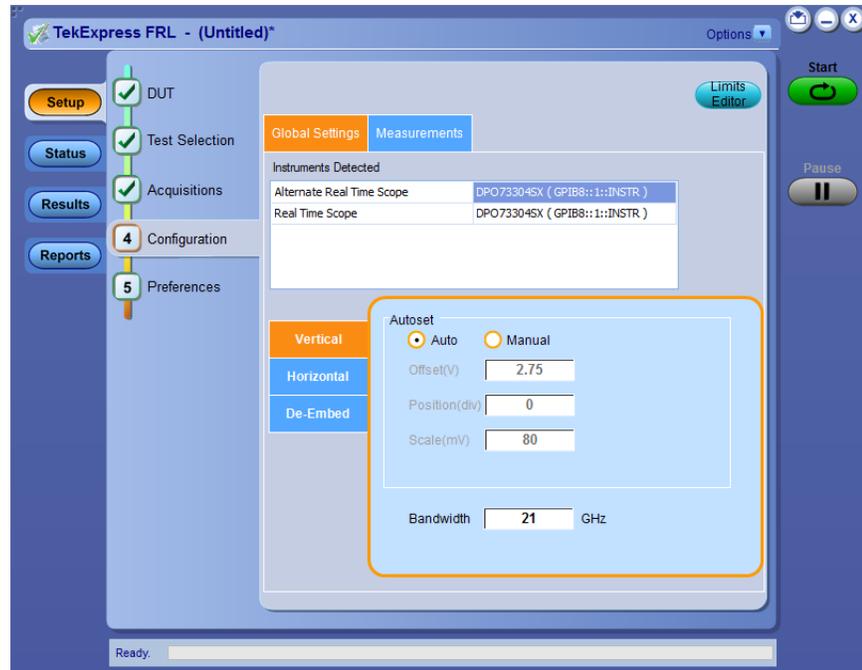


Figure 7: Source configuration: Global settings

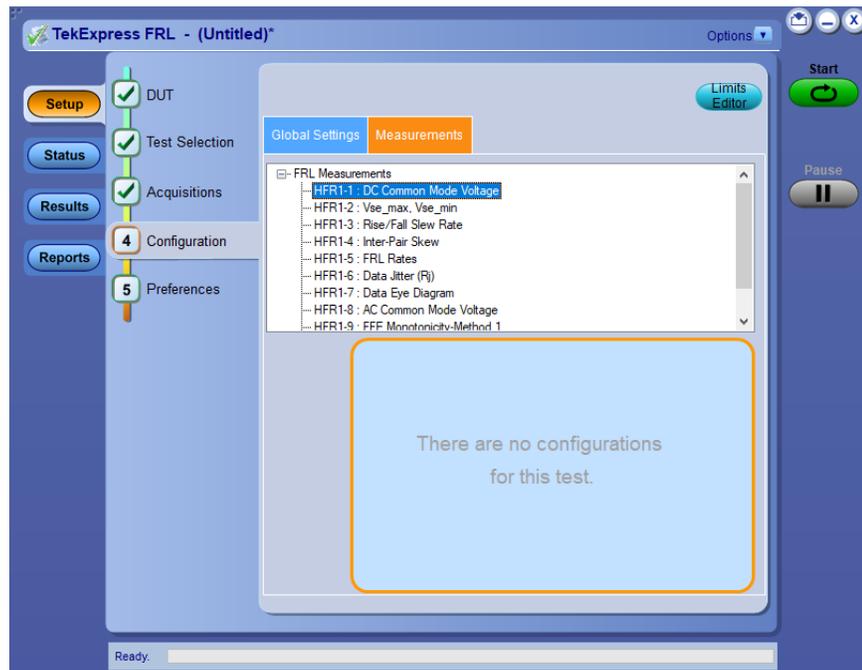


Figure 8: Source configuration: Measurement settings

**Table 9: Source Configuration tab settings**

| Settings                        | Description   |   |
|---------------------------------|---|---|
| <b>Compliance mode settings</b> |   |   |
| <b>Global settings</b>          |   |   |
| Instruments Detected            | Displays the instruments connected to this application. Click on the instrument name to open a list of available (detected) instruments. Select <b>Options &gt; Instrument Control Settings</b> and click <b>Refresh</b> to update the instrument list. |   |
|                                 | <i><b>NOTE.</b> Verify that the <b>GPIOB</b> search criteria (default setting) in the Instrument Control Settings is selected when using the TekExpress FRL application.</i>  |   |
| <b>Vertical</b>                 |   |   |
| Autoset                         | <b>Auto</b> (Default value)   | <b>Manual</b>   |
| Offset (V)                      | 2.75 V  | -5 V to 5 V   |
| Position (div)                  | 0   | -4 to 4   |
| Scale(mV)                       | 80 mV   | 3.48 mV to 5350 mV  |
| Bandwidth                       | Values changes from 2.5 GHz to 21 GHz.  |   |
| De-Embed Filter                 | Apply De-Embed  | Select to apply the de-embed filter file. Click Browse and select the de-embedding filter files (.flt). |
|                                 |   | <i><b>NOTE.</b> Browse option is enabled only when you select <b>Apply De-Embed</b> checkbox.</i>       |

**Table 10: Measurement configurations for Source**

| Measurement Name         | Configuration  |               |                                 | Default value |
|--------------------------|----------------|---------------|---------------------------------|---------------|
| HFR1-6: Data Jitter (RJ) | Clock Recovery | PLL Custom BW | PLL Model: Type I Loop BW (MHz) | -             |
|                          |                |               | 3 Gbps                          | 4             |
|                          |                |               | 6 Gbps                          | 4             |
|                          |                |               | 8 Gbps                          | 5.333         |
|                          |                |               | 10 Gbps                         | 6.666         |
|                          |                |               | 12 Gbps                         | 8             |
|                          | Cable Settings | Cable Model   |                                 | Both          |

| Measurement Name         | Configuration                  |               |                                 | Default value  |
|--------------------------|--------------------------------|---------------|---------------------------------|--|
| HFR1-7: Data Eye Diagram | Clock Recovery                 | PLL Custom BW | PLL Model: Type I Loop BW (MHz) | -  |
|                          |                                |               | 3 Gbps                          | 4  |
|                          |                                |               | 6 Gbps                          | 4  |
|                          |                                |               | 8 Gbps                          | 5.333  |
|                          |                                |               | 10 Gbps                         | 6.666  |
|                          | Cable Settings                 |               | Cable Model                     | Both   |
|                          |                                |               | Crosstalk                       | With   |
|                          |                                |               | Equalizer Options               | CTLE+DFE   |
|                          |                                |               | Apply Custom Mask File          | Select to apply the custom mask file. Click Browse and select the custom mask files. |
|                          | HFR1-8: AC Common Mode Voltage | Acquire       | Bandwidth (GHz)                 | 3 Gbps   |
| 6 Gbps                   |                                |               |                                 | 3  |
| 8 Gbps                   |                                |               |                                 | 4  |
| 10 Gbps                  |                                |               |                                 | 5  |
| 12 Gbps                  |                                |               |                                 | 6  |

**Sink configuration settings.** Use the configuration tab to configure the Global Settings and Measurement settings for the measurements. The settings described in this tab is available when Suite in the DUT tab is selected as Sink.

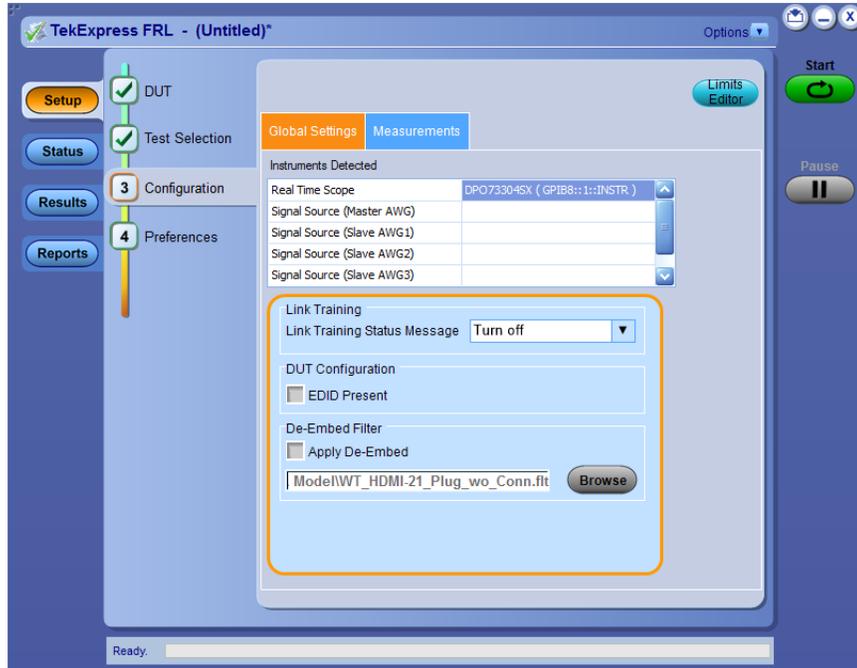


Figure 9: Global settings tab for Sink configuration

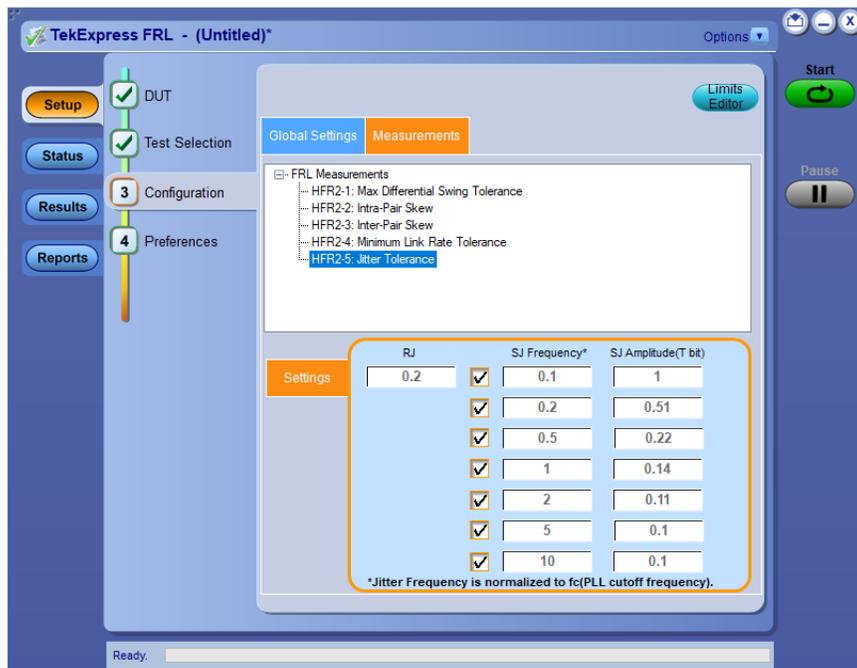


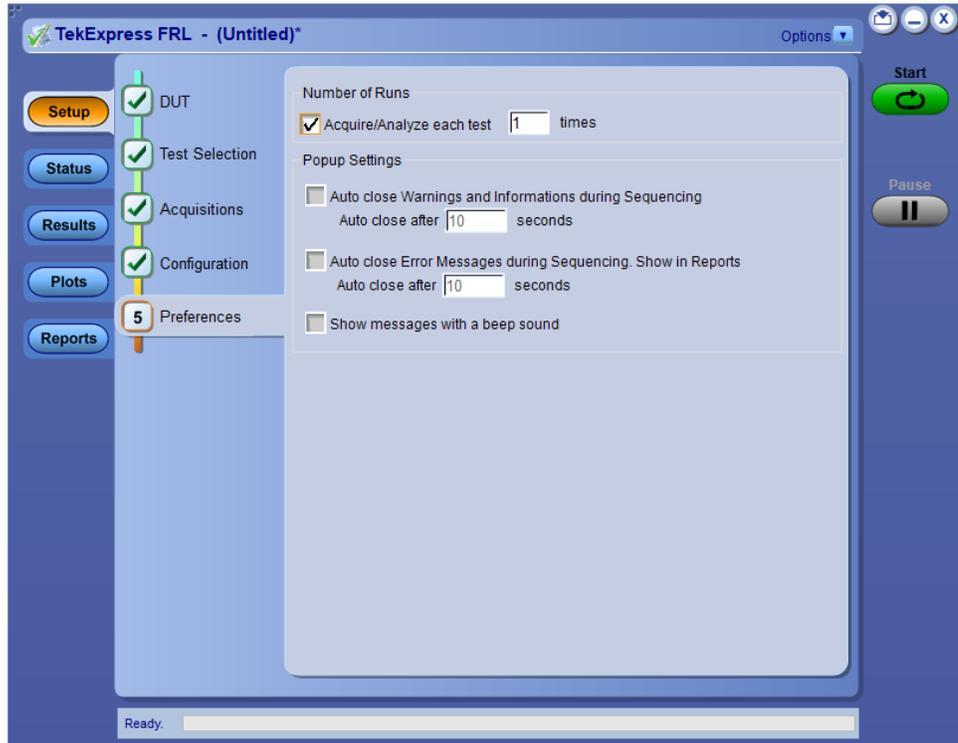
Figure 10: Measurement tab for Sink configuration

Table 11: Sink configuration tab settings

| Setting                         | Description  |                                     |   |
|---------------------------------|--|-------------------------------------|---|
| <b>Compliance mode settings</b> |  |                                     |   |
| <b>Global Settings</b>          |  |                                     |   |
| Instruments Detected            | <p>Displays the instruments connected. Click on the instrument IP to open a list of available (detected) instruments and assign the appropriate IP address of corresponding instruments connected . Select <b>Options &gt; Instrument Control Settings</b> and click <b>Refresh</b> to update the instrument list.</p> <p><b>NOTE.</b> Verify that the <b>GPIB</b> search criteria (default setting) in the Instrument Control Settings is selected when using the TekExpress FRL application.</p> |                                     |   |
| <b>Link Training</b>            |  |                                     |   |
| Link Training Status Message    | <ul style="list-style-type: none"> <li>■ <b>Turn off</b><br/>When selected, link training status messages are not displayed.</li> <li>■ <b>Prompt always</b><br/>When selected, displays the status (either pass or fail) of link training status messages.</li> <li>■ <b>Prompt on failure</b><br/>When selected, only failure link training status messages are displayed.</li> </ul>  |                                     |   |
| <b>DUT Configuration</b>        |  |                                     |   |
| EDID Present                    | The selection of <b>EDID Present</b> is dependent on the presence of EDID on the Sink DUT.   |                                     |   |
| <b>De-embed filter</b>          |  |                                     |   |
| Apply De-embed                  | <p>Select to apply the de-embed filter file. Click <b>Browse</b> and select the de-embedding filter files (.flt).</p> <p><b>NOTE.</b> <b>Browse</b> option is enabled only when you select <b>Use filter file for de-embedding</b>.</p>  |                                     |   |
| <b>Measurements</b>             |  |                                     |   |
| HFR2-5: Jitter Tolerance        | Settings   | RJ T <sub>bit</sub>                 | Default value (0.2)                                   |
|                                 |  | <b>SJ Frequency</b> (Default value) | <b>SJ Amplitude (T<sub>bit</sub>)</b> (Default value) |
|                                 |  | 0.1                                 | 1   |
|                                 |  | 0.2                                 | 0.51  |
|                                 |  | 0.5                                 | 0.22  |
|                                 |  | 1                                   | 0.14  |
|                                 |  | 2                                   | 0.11  |
|                                 |  | 5                                   | 0.1   |
|                                 | 10   | 0.1                                 |   |

**Set test notification preferences**

Use the Preferences tab to set the application to send a notification when a test measurement completes:



**Table 12: Preferences tab settings**

| Setting   | Description  |
|---|--|
| <b>Number of Runs</b>   |  |
| Acquire/Analyze each test <number> times  | Select to repeat the test run by setting the number of times. By default, it is selected with 1 run. The number of run feature is available only during the live mode. |
| <b>Popup Settings</b>   |  |
| Auto Close Warnings and information during Sequencing<br>Auto close after <number> Seconds        | Select to auto close warnings/information during sequencing. Set the Auto close time. By default it is unselected.   |
| Auto Close Error Messages during Sequencing, Show in Reports<br>Auto close after <number> Seconds | Select to auto close Error Messages during Sequencing. Set the Auto close time. By default it is unselected.   |
| Show messages with a beep sound   | Select to display the messages with a beep sound. By default it is unselected.   |
| Read Error Counter  | <b>Only available when Suite = Sink</b><br>Enter the number of times the Error count needs to be read.   |

**See also.**

*Select report options* on page 44

## Status panel overview

The Status panel provides status on test acquisition and analysis (Test Status tab) and a listing of test tasks performed (Log View tab). The application opens the Test Status tab when you start a test run. You can select the Test Status or the Log View tab to view these items while tests are running.

The Test Status tab lists a high level status for each test.

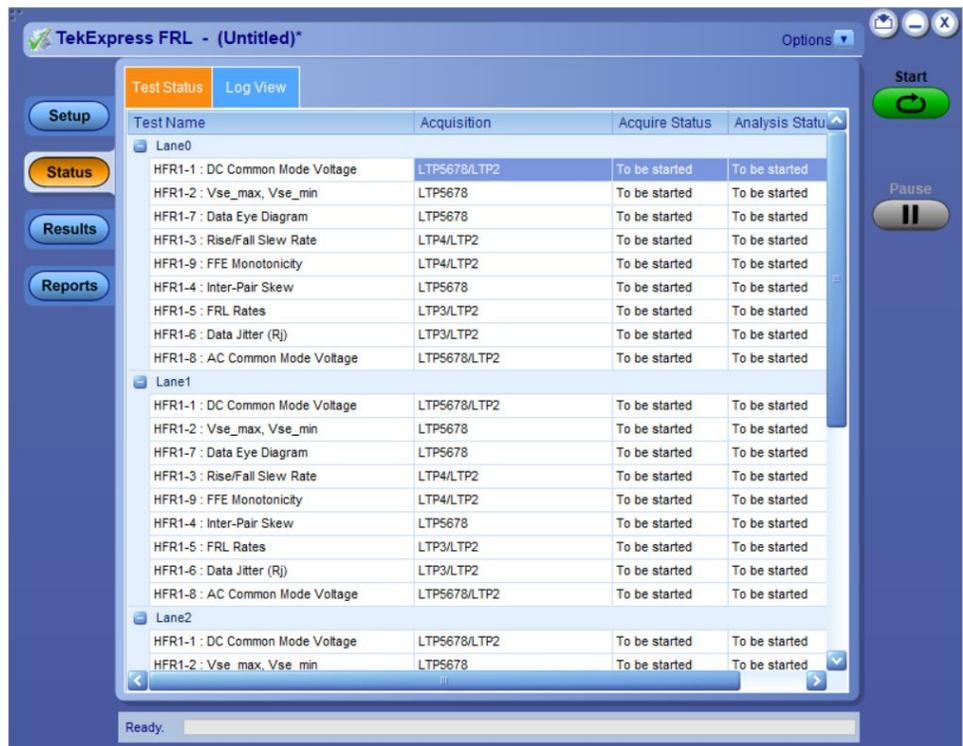


Table 13: Test Status tab

| Column                       | Description   |
|------------------------------|---|
| Test Name                    | Name of the test  |
| Acquisition, Analysis Status | Status of the signal acquisition or test analysis <ul style="list-style-type: none"> <li>■ To be started</li> <li>■ In progress</li> <li>■ Completed</li> </ul> |

The Log View tab provides a list of the actions executed during the test. Use this information to review or troubleshoot tests.

### Log View tab

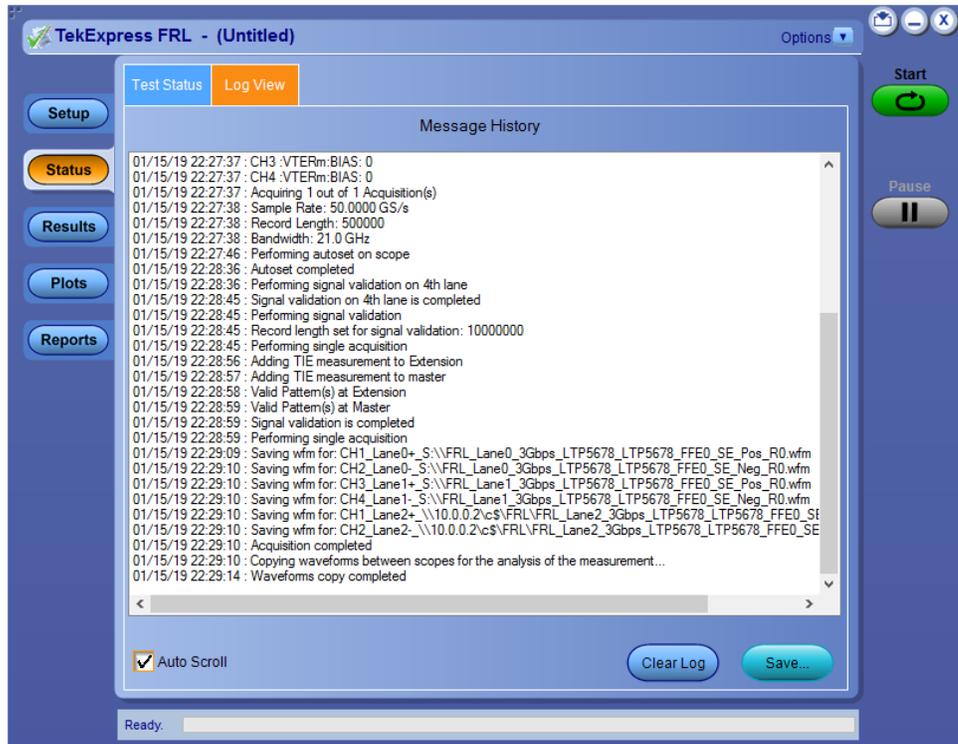


Table 14: Log View fields

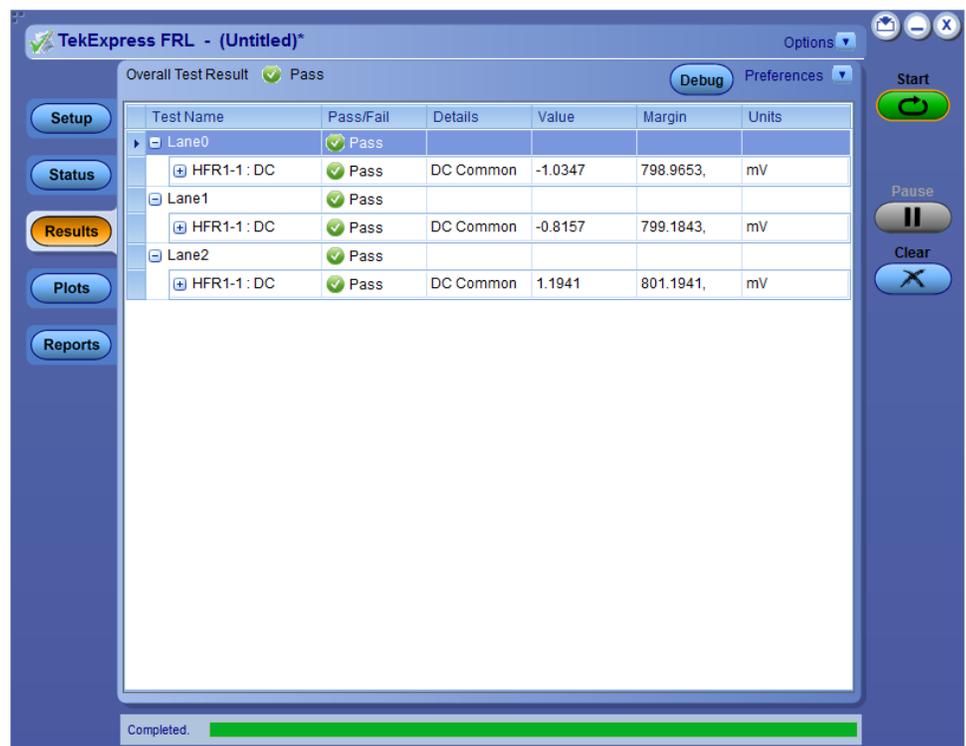
| Item            | Description  |
|-----------------|--|
| Message History | Displays all run messages with timestamp information   |
| Auto Scroll     | Sets the program to automatically scroll down the Message History window as information is added to the log during the test.                           |
| Clear Log       | Clears all messages in the Message History window.   |
| Save            | Saves the log file as a text file for examination. Displays a standard Save As File window and saves the status messages in the file that you specify. |

See also [View test results](#) on page 42

## Results panel

### Results panel overview

When a test finishes, the application switches to the Results panel to display a summary of test results. Set viewing preferences for this panel from the Preferences menu in the upper right corner. Viewing preferences include showing whether a test passed or failed, summary results or detailed results, and enabling wordwrap. For information on using this panel, see [View test results](#) on page 42.



The screenshot displays the TekExpress FRL Results panel. The overall test result is 'Pass'. The results are summarized in the following table:

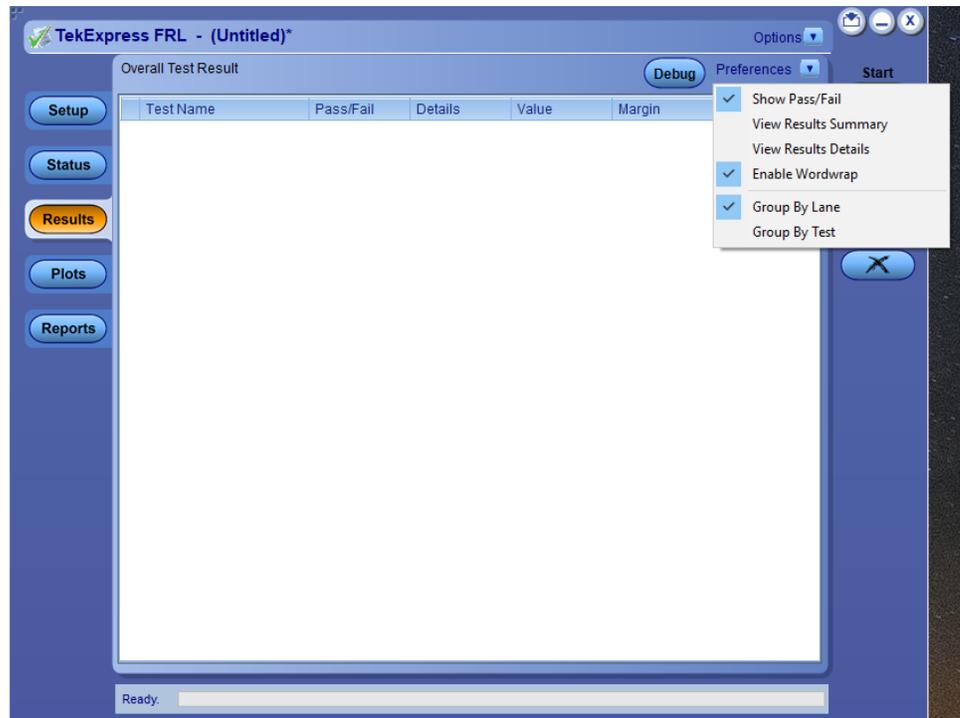
| Test Name   | Pass/Fail | Details   | Value   | Margin    | Units |
|-------------|-----------|-----------|---------|-----------|-------|
| Lane0       | Pass      |           |         |           |       |
| HFR1-1 : DC | Pass      | DC Common | -1.0347 | 798.9653, | mV    |
| Lane1       | Pass      |           |         |           |       |
| HFR1-1 : DC | Pass      | DC Common | -0.8157 | 799.1843, | mV    |
| Lane2       | Pass      |           |         |           |       |
| HFR1-1 : DC | Pass      | DC Common | 1.1941  | 801.1941, | mV    |

The interface includes a left sidebar with buttons for Setup, Status, Results (highlighted), Plots, and Reports. The top right has buttons for Start, Pause, and Clear. A status bar at the bottom indicates 'Completed.' with a green progress bar.

## View test results

When a test finishes, the application switches to the *Results panel* on page 41, which displays a summary of test results. The overall test result is displayed at the top left of the Results table. If all of the tests for the session pass, the overall test result will be Pass. If one or more tests fail, the overall test result will show Fail.

Each test result occupies a row in the Results table. By default, results are displayed in summary format with the measurement details collapsed and with the Pass/Fail column visible. Change the view in the following ways:



- To expand all tests listed, select **View Results Details** from the Preferences menu in the upper right corner.
- To expand and collapse tests, click the plus and minus buttons.
- To collapse all expanded tests, select **Preferences > View Results Summary**.
- To remove or restore the Pass/Fail column, select **Preferences > Show Pass/Fail**.
- To enable or disable the wordwrap feature, select **Preferences > Enable Wordwrap**.
- To expand the width of a column, place the cursor over the vertical line that separates the column from the column to the right. When the cursor changes to a double-ended arrow, hold down the mouse button and drag the column to the desired width.
- To sort the test information by column, click the column head. When sorted in ascending order, a small up arrow is displayed. When sorted in descending order, a small down arrow is displayed.
- To clear all test results displayed, click **Clear**.

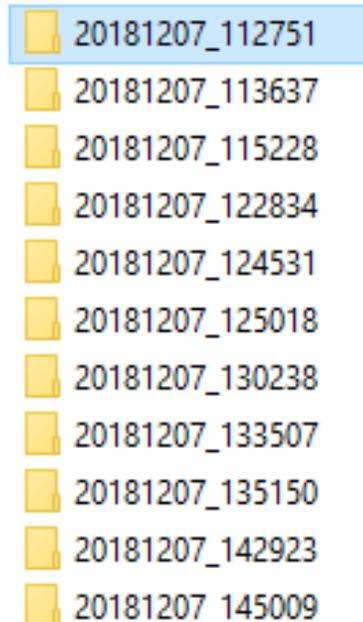
**See also.**

[View a report](#) on page 46

**View test- related files**

Files related to tests are stored in the Documents\My TekExpress\FRL folder. In the FRL folder, each test setup has a test setup file and a test setup folder, both with the test setup name. The test setup file is preceded by the FRL icon and usually has no visible file extension.

Inside the test setup folder is another folder named for the DUT ID used in the test sessions. The default is DUT001.



Inside the DUT001 folder are the session folders and files. Each session has a folder and file pair, both named for the test session using the naming convention (date)\_(time). Each session file is stored outside its matching session folder.

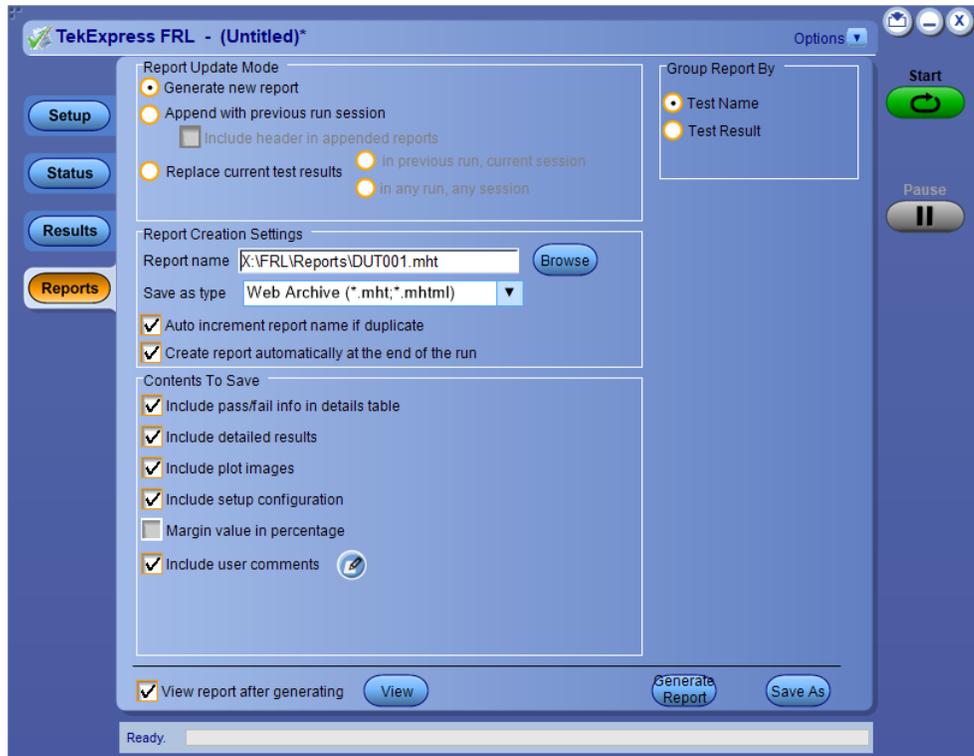
The first time you run a new, unsaved session, the session files are stored in the Untitled Session folder located at ..\My TekExpress\FRL. When you name and save the session, the files are placed in a folder with the name that you specify.

## Reports panel

### Reports panel overview

Use the Reports panel to save reports, select report content to include, and select report viewing options.

For information on setting up reports, see [Select report options](#) on page 44. For information on viewing reports, see [View a report](#) on page 46.



### Select report options

Use the [Reports panel](#) on page 44 to select which test information to include in the report, and the naming conventions to use for the report. For example, always give the report a unique name or select to have the same name increment each time you run a particular test. Generally, you would select report options before running a test or when creating and saving test setups. Report settings are included in saved test setups.

In the Reports panel, select from the following options:

**Table 15: Report options**

| Setting   | Description   |
|---|---|
| <b>Report Update Mode</b>                         |   |
| Generate new report                               | Creates a new report. The report can be in either .mht or html or .pdf file formats   |
| Append with previous run session                  | Appends the latest test results to the end of the current test results report.  |
| Include header in appended reports                | Includes header in appended reports.  |
| Replace current test in previous run session      | Replaces the previous test results with the latest test results.  |
| <b>Report Creation Settings</b>                   |   |
| Report name                                       | <p>Displays the name and location from which to open a FRL report. The default location is at \My TekExpress\ FRL \Untitled Session. The report file in this folder gets overwritten each time you run a test unless you specify a unique name or select to auto increment the report name. Change the report name or location. Do one of the following:</p> <ul style="list-style-type: none"> <li>■ In the Report Path field, type over the current folder path and name.</li> <li>■ Double-click in the Report Path field and then make selections from the popup keyboard and click the Enter button.</li> </ul> <p>Be sure to include the entire folder path, the file name, and the file extension. For example: C: \Documents and Settings\your user name \My Documents\My TekExpress\ FRL\&lt;Username&gt; \DUT001.mht. This folder (C: \Documents and Settings\&lt;user name&gt; \MyDocuments\My TekExpress) is mapped as X drive in the scope. Open an existing report. Click Browse, locate and select the report file and then click View at the bottom of the panel.</p> |
| Save as type                                      | <p>Saves a report in the specified file type, selected from the dropdown list.</p> <p><b>NOTE.</b> If you select a file type different from the default, be sure to change the report file name extension in the Report Name field to match.</p>  |
| Auto increment report name if duplicate           | Sets the application to automatically increment the name of the report file if the application finds a file with the same name as the one being generated. For example: DUT001, DUT002, DUT003. This option is enabled by default.  |
| Create report automatically at the end of the run | Creates report at the end of the run.   |
| <b>Contents To Save</b>                           |   |

| Setting                                    | Description  |
|--|--|
| Include pass/fail info in details Table    | Includes pass/fail info in the details table of the report.  |
| Include detailed results                   | Includes detailed results in the report.   |
| Include plot images                        | Includes plot images in the report.  |
| Include setup configuration                | Sets the application to include hardware and software information in the summary box at the top of the report. Information includes: the oscilloscope model and serial number, the oscilloscope firmware version, and software versions for applications used in the measurements. |
| Margin value in percentage                 | Enable to Display the margin value in percentage   |
| Include user comments                      | Select to include any comments about the test that you or another user added in the DUT tab of the Setup panel. Comments appear in the Comments Section, under the summary box at the beginning of each report.  |
| View report after generating               | Automatically opens the report in a Web browser when the test completes. This option is selected by default.   |
| View                                       | Click to view the most current report.   |
| Generate Report                            | Generates a new report based on the current analysis results   |
| Save As                                    | Specify a name for the report.   |
| Include complete application configuration | Displays the general and measurement specific parameters in the report   |

**See also.**

[View a report](#) on page 46

**View a report**

The application automatically generates a report when test analysis is completed and displays the report in your default Web browser (unless you cleared the **View Report After Generating** check box in the Reports panel before running the test). If you cleared this check box, or if you want to view a different test report, do the following:

1. Click the **Reports > Browse** button and locate and select the report file to view.

---

**NOTE.** *If you did not save the test setup after running the test and you either closed the application or you ran another test, the report file was not saved.*

---

2. At the bottom of the Reports panel, click **View**.

For information on changing the file type, file name, and other report options, see [Select report options](#) on page 44.

**Report contents** A report shows specified test details, as defined in the Reports panel.

### Setup configuration information

Setup configuration information is listed in the summary box at the top of the report. This information includes the oscilloscope model and serial number, probe model and serial number, and software versions. To exclude this information from the report, clear the **Include setup configuration** check box in the Reports panel before running the test.

| Tektronix® TekExpress Automated Test Solution<br>TekExpress FRL |                       |                                    |                      |
|---|-----------------------|------------------------------------|----------------------|
| <b>Setup Information</b>  |                       |                                    |                      |
| DUT ID  | DUT001                | Master Scope Information           | DPO73304SX, QU000056 |
| Date/Time   | 2019-01-21 21:25:15   | SPC, Factory Calibration Master    | PASS;PASS            |
| Device Type   | FRL Source            | Scope F/W Version Master           | 10.9.1 Build 16      |
| App Version   | FRL:10.0.0.199        | DPOJET Version Master              | 10.0.8.177           |
| TekExpress Version  | Framework:4.9.0.5     | Extension Scope Information        | DPO73304SX, QU000054 |
| Execution Mode  | Live                  | SPC, Factory Calibration Extension | PASS;PASS            |
| Mode  | Compliance            | Scope F/W Version Extension        | 10.9.1 Build 16      |
| Overall Result  | Pass                  | DPOJET Version Extension           | 10.0.7.9             |
| Connector   | Standard              | Master CH1 Probe Information       | TCA-SMA, N/A         |
| CTS Version   | FRL Source v1.0       | Master CH2 Probe Information       | TCA-SMA, N/A         |
| Overall Execution Time  | 0:06:15               | Master CH3 Probe Information       | TCA-SMA, N/A         |
|   |                       | Master CH4 Probe Information       | TCA-SMA, N/A         |
|   |                       | Extension CH1 Probe Information    | TCA-SMA, N/A         |
|   |                       | Extension CH2 Probe Information    | TCA-SMA, N/A         |
|   |                       | Extension CH3 Probe Information    | TCA-SMA, N/A         |
|   |                       | Extension CH4 Probe Information    | TCA292D, N/A         |
| DUT COMMENT:  | General Comment - FRL |                                    |                      |

Figure 11: Report for Source

| HFR1-1 : DC Common Mode Voltage |           |                          |                |       |             |                    |           |            |
|---------------------------------|-----------|--------------------------|----------------|-------|-------------|--------------------|-----------|------------|
| Lane                            | Iteration | Measurement Details      | Measured Value | Units | Test Result | Margin             | Low Limit | High Limit |
| Lane0                           | Run1      | DC Common Mode at 3Gbps  | 2660.1790      | mV    | Pass        | 160.1790, 669.8210 | 2500.0    | 3330.0     |
| Lane1                           | Run1      | DC Common Mode at 3Gbps  | 2689.9866      | mV    | Pass        | 189.9866, 640.0134 | 2500.0    | 3330.0     |
| Lane2                           | Run1      | DC Common Mode at 3Gbps  | 2664.8135      | mV    | Pass        | 164.8135, 665.1865 | 2500.0    | 3330.0     |
| Lane0                           | Run1      | DC Common Mode at 12Gbps | 2662.0594      | mV    | Pass        | 162.0594, 667.9406 | 2500.0    | 3330.0     |
| Lane1                           | Run1      | DC Common Mode at 12Gbps | 2690.0634      | mV    | Pass        | 190.0634, 639.9366 | 2500.0    | 3330.0     |
| Lane2                           | Run1      | DC Common Mode at 12Gbps | 2665.3040      | mV    | Pass        | 165.3040, 664.6960 | 2500.0    | 3330.0     |
| Lane3                           | Run1      | DC Common Mode at 12Gbps | 2669.3794      | mV    | Pass        | 169.3794, 660.6206 | 2500.0    | 3330.0     |
| COMMENTS                        |           |                          |                |       |             |                    |           |            |

| Tektronix® TekExpress Automated Test Solution |                            |                        |                |                |
|---|----------------------------|------------------------|----------------|----------------|
| TekExpress FRL Sink – Calibration Report      |                            |                        |                |                |
| Setup Information                             |                            |                        |                |                |
| DUT ID  | DUT001                     | Master AWG Model       | AWG70001       |                |
| Date/Time                                     | 2019-05-24 01:08:05        | Master AWG F/W Version | 6.1.0056.0     |                |
| Device Type                                   | FRL                        | Slave AWG Model        | AWG70001       |                |
| App Version                                   | 10.1.0.90                  | Slave AWG F/W Version  | 7.1.0162.0     |                |
| TekExpress Framework Version                  | 4.10.0.35                  | Scope Model            | DPO73304DX     |                |
| Overall Execution Time                        | 0:04:58                    | Scope F/W Version      | 10.8.3 Build 3 |                |
|   |                            | DPOJET Version         | 10.0.8.149     |                |
|   |                            | EDID/SCDC controller   | Wilder         |                |
| DUT COMMENT:                                  | General Comment – FRL Sink |                        |                |                |
| Test Name Summary Table                       |                            |                        |                |                |
| HFR2-1: Max Differential Swing Tolerance      |                            |                        | Informative    |                |
| HFR2-1: Max Differential Swing Tolerance      |                            |                        |                |                |
| Data Rate                                     | Measurement Details        | Lane                   | Measured Value | Expected Value |
| 3Gbps   | Max                        | Lane0                  | 1211.400 mV    | 1200 mV        |
| 3Gbps   | Nominal                    | Lane0                  | 1005.033 mV    | 1000 mV        |
| COMMENTS                                      |                            |                        |                |                |

Figure 12: Calibration report for Sink

| TekExpress Automated Test Solution       |                            |           |                        |                   |                 |           |            |
|--|----------------------------|-----------|------------------------|-------------------|-----------------|-----------|------------|
| TekExpress FRL Sink – Measurement Report |                            |           |                        |                   |                 |           |            |
| Setup Information                        |                            |           |                        |                   |                 |           |            |
| DUT ID                                   | DUT001                     |           | Master AWG Model       | AWG70001          |                 |           |            |
| Date/Time                                | 2019-04-26 00:24:52        |           | Master AWG F/W Version | 6.1.0056.0        |                 |           |            |
| Device Type                              | FRL                        |           | Slave AWG Model        | AWG70001          |                 |           |            |
| App Version                              | 10.1.0.48                  |           | Slave AWG F/W Version  | 7.1.0162.0        |                 |           |            |
| TekExpress Framework Version             | 4.10.0.35                  |           | Scope Model            | DPO73304DX        |                 |           |            |
| Overall Test Result                      | Pass                       |           | Scope F/W Version      | 10.8.3 Build 3    |                 |           |            |
| Overall Execution Time                   | 0:05:27                    |           | DPOJET Version         | 10.0.8.149        |                 |           |            |
| DUT COMMENT:                             | General Comment – FRL Sink |           |                        |                   |                 |           |            |
| Test Name Summary Table                  |                            |           |                        |                   |                 |           |            |
| HFR2-1: Max Differential Swing Tolerance |                            |           |                        |                   |                 | Pass      |            |
| HFR2-1: Max Differential Swing Tolerance |                            |           |                        |                   |                 |           |            |
| Data Rate                                | Details                    | Lane      | Error Count            | Max Allowed Error | Max Limit (BER) | Pass/Fail | Run Number |
| 6Gbps                                    | Max                        | Lane0     | 0                      | 0                 |                 |           | 1          |
| 6Gbps                                    | Max                        | Lane1     | 0                      | 0                 |                 |           | 1          |
| 6Gbps                                    | Max                        | Lane2     | 0                      | 0                 |                 |           | 1          |
| 6Gbps                                    | Max                        | Lane3     | 0                      | 0                 |                 |           | 1          |
| 6Gbps                                    | Max                        | All Lanes | 0                      | 0                 | 1e-10           | Pass      | 1          |
| COMMENTS                                 |                            |           |                        |                   |                 |           |            |

Figure 13: Measurement report for Sink

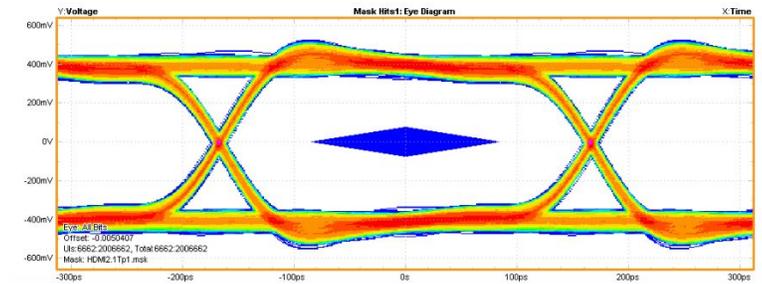
**User comments**

If you selected to include comments in the test report, any comments you added in the DUT tab of the Setup panel appear in the Comments section directly below the summary box.

**Test results**

This table lists the tests results. The contents of this table depend on the selections made in the Reports panel before running the test (Include pass/fail results summary, Include user comments, Include detailed results, Include setup configuration, and Include user comments).

If Include plots images is selected, then measurement waveform plots are shown below the test results table.



**See also.**

[View test results](#) on page 42

[View test- related files](#) on page 43

## Exit the application

Use the following method to exit the application:

1. Click  on the application title bar.
2. Do one of the following:
  - If you have an unsaved session or test setup open, you are asked to save it before exiting. To save it, click **Yes**. Otherwise click **No**. The application closes.
  - A message box appears asking if you really want to exit TekExpress. To exit, click **Yes**.

---

**NOTE.** Using other methods to exit the application results in abnormal termination of the application.

---



# Running tests

## Equipment connection setup for Source

All the tests can be performed by connecting the equipments in probe configuration or stack configuration.

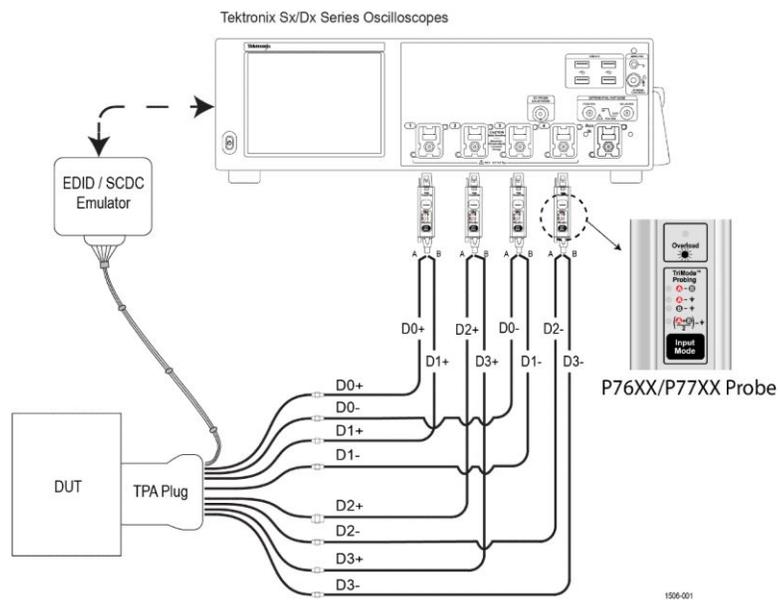


Figure 14: Probe configuration for Source

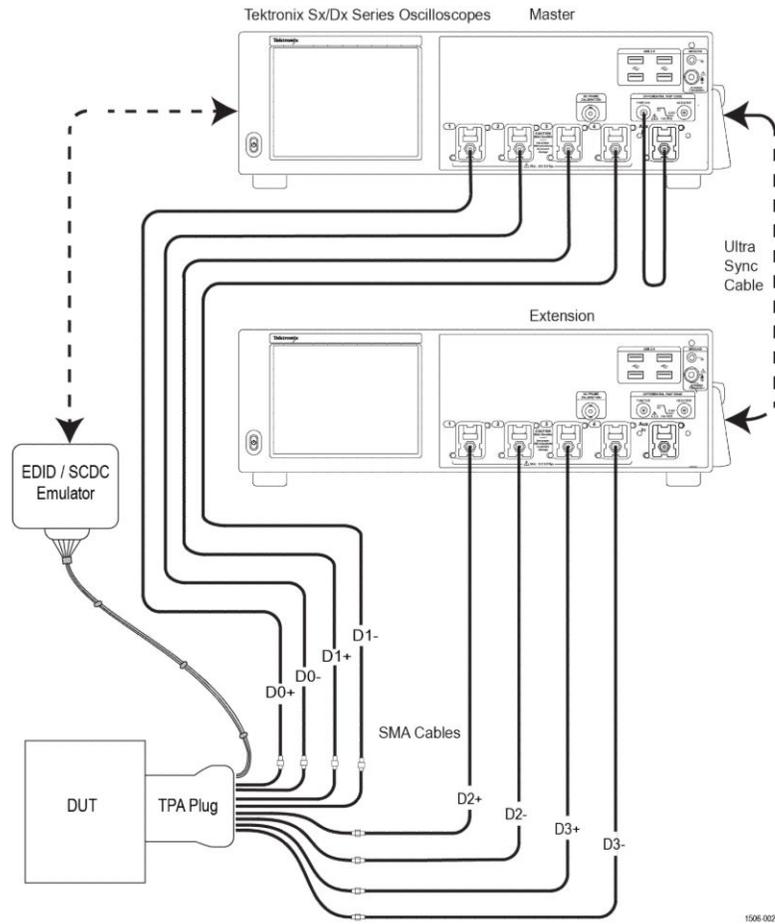


Figure 15: Stack configuration for Source

See also [Recommended accessories](#) on page 5

## Equipment connection setup for Sink

All the tests can be performed by connecting the equipments in probe configuration or stack configuration.

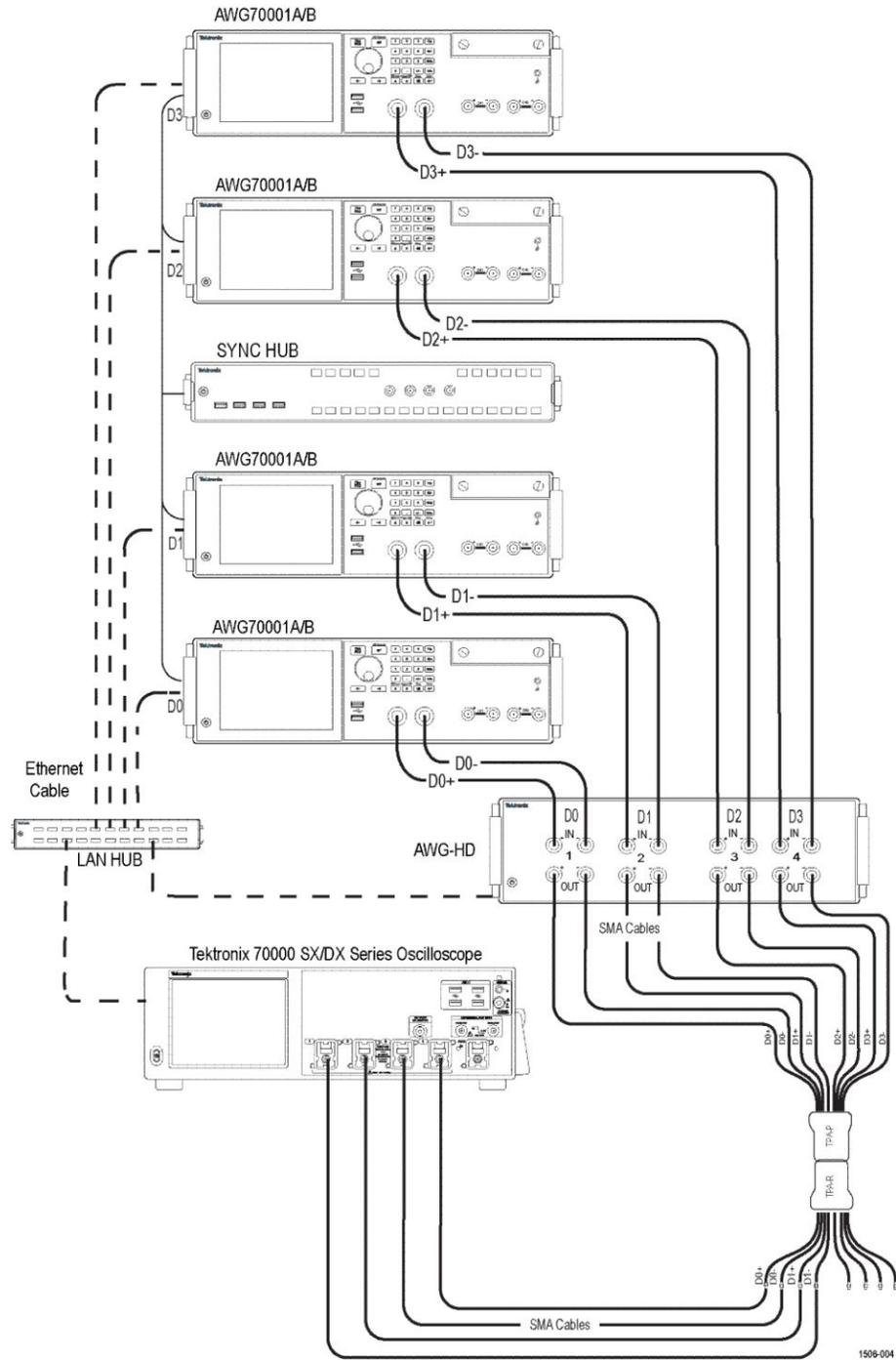


Figure 16: Calibration configuration for Sink

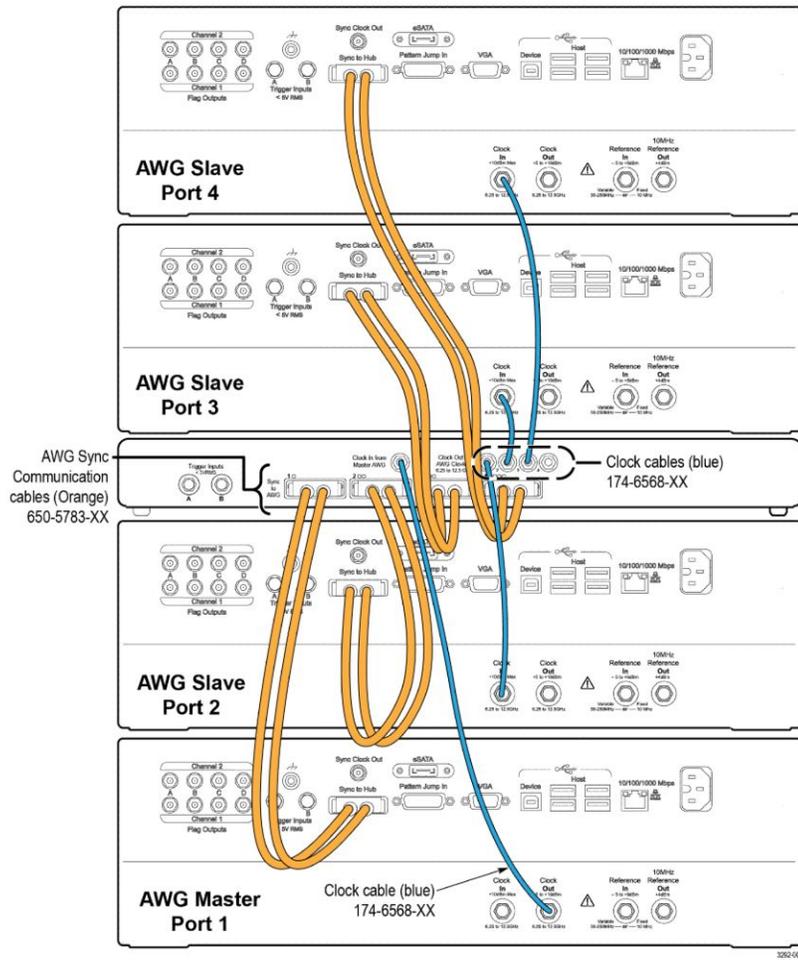


Figure 17: Sink Hub configuration setup

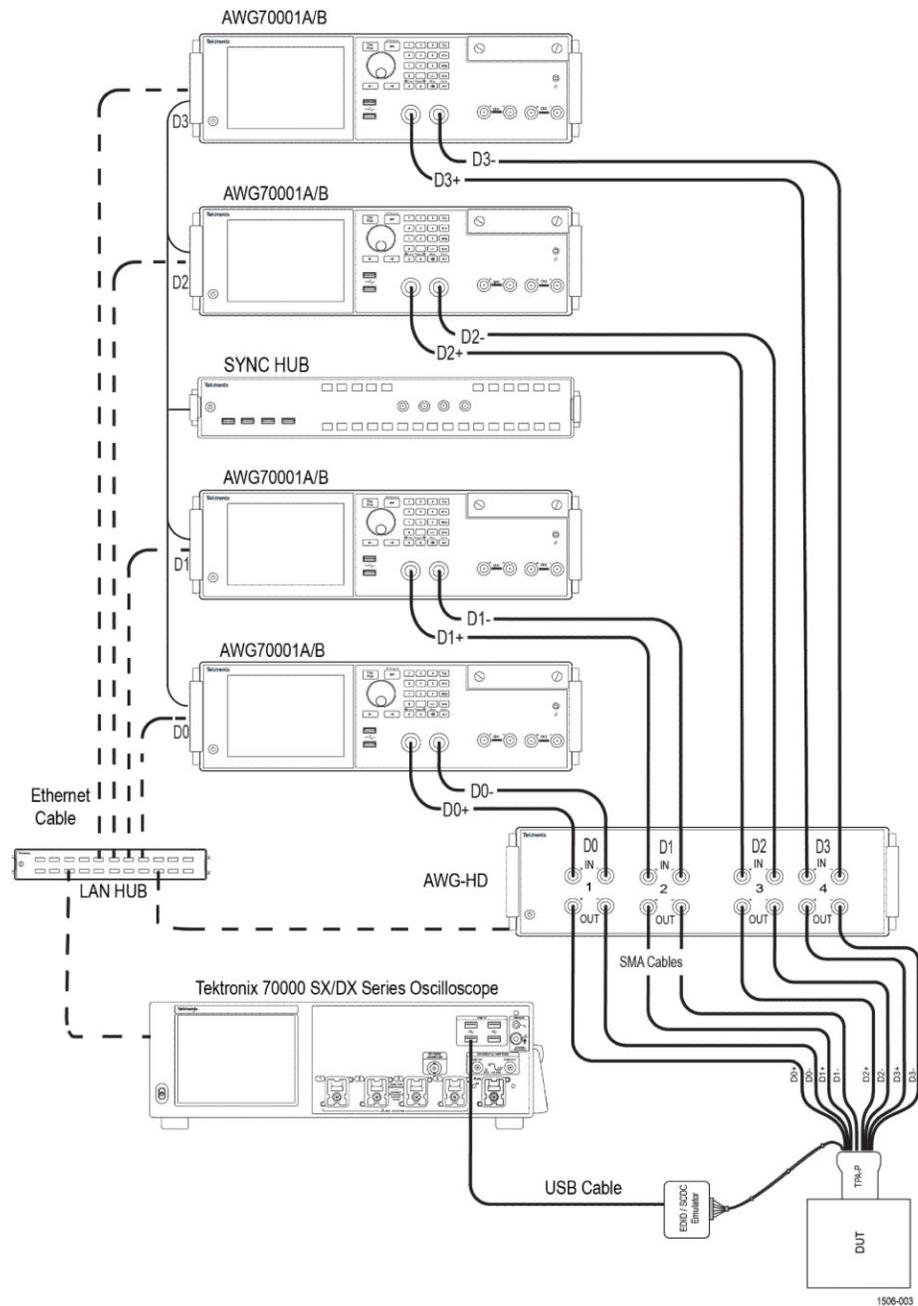


Figure 18: Measurement configuration for Sink

See also [Recommended accessories](#) on page 5

## Prerequisite

### Compensate the signal path

Use the following procedure to compensate the internal signal acquisition path. Perform this procedure if the ambient temperature has changed more than 5 °C (9 °F) since you performed the last signal path compensation. Perform the signal path compensation once a week. Failure to do so may result in the instrument not meeting warranted performance levels.

1. Power on and wait for the instrument to complete its warm up period before continuing with this procedure.
2. Disconnect any probes you have connected to the input channels.
3. Set the instrument to Menu mode.
4. Select Instrument Calibration from the Utilities menu.
5. Note any instructions that appear in the resulting control window.
6. Click Run SPC to begin the procedure. The procedure may take several minutes to complete.
7. Verify that the Status changes to Compensated after the procedure is complete. If the Calibration Status field indicates anything other than Compensated, see Signal Path Compensation Status for information on the readout and recommended action.

---

**NOTE.** *When making measurements at vertical scale settings less than or equal to 5 mV, you should perform the signal path compensation at least once a week. Failure to do so may result in the instrument not meeting warranted performance levels at those volts/div settings.*

---

### Deskew

If skew is present between positive and negative channels, then the channels need to be deskewed before being used for waveform measurements. TekExpress FRL provides support for channel deskew and attenuation using the following method:

There are no different types of deskew methods. These are the pre-requisites that need to be performed before running the measurements.

- For Source:
  1. Stack deskew :
    - a. Perform scope SPC
    - b. Perform scope channel deskew
  2. Probe deskew :
    - a. Perform scope SPC
    - b. Probe DC Compensation
- For Sink:
  - Perform Scope spc
  - Perform scope channel deskew
  - Perform WEBAC deskew
  - Perform all AWG Calibration
  - Perform Sync hub deskew

## Running tests

[Select tests](#) on page 28, [Set acquisition parameters](#) on page 29, [Set configuration tab parameters](#) on page 32, [Set test notification preferences](#) on page 38, and click **Start** to run the tests. While tests are running, you cannot access the Setup or Reports panels. To monitor the test progress, switch between the Status panel and the Results panel.

While the tests are running, other applications may display windows in the background. The TekScope application takes precedence over other applications, but you can switch to other applications by using **Alt + Tab** key combination. To keep the TekExpress FRL application on top, select **Keep On Top** from the TekExpress Options menu.

Once the test execution is completed, the application displays the report.

- Prerun checklist**
1. Make sure that the instruments are warmed up (approximately 20 minutes) and stabilized.
  2. Perform compensation: In the oscilloscope main menu, select **Utilities > Instrument Compensation**. Click **Help** in the compensation window for steps to perform instrument compensation.



---

# Saving and recalling test setup

## Test setup files overview

Saved test setup information (such as the selected oscilloscope, general parameters, acquisition parameters, measurement limits, waveforms (if applicable), and other configuration settings) are saved under the setup name at **X:\FRL**.

Use test setups to:

- Run a new session, acquiring live waveforms, using a saved test configuration.
- Create a new test setup using an existing one.
- View all the information associated with a saved test, including the log file, the history of the test status as it executed, and the results summary.
- Run a saved test using saved waveforms.

**See also** [Save a test setup](#) on page 59  
[Open \(load\) a saved test setup](#) on page 60

## Save a test setup

You can save a test setup before or after running a test. You can create a test setup from [Create a test setup using an existing one](#) on page 60, or using [Create a test setup from default settings](#) on page 60. When you select the default test setup, the parameters are set to the application's default value.

Select **Options > Save Test Setup** to save the opened setup.

Select **Options > Save Test Setup As** to save the setup with different name.

## Open (load) a saved test setup

To Open (load) a saved test setup, do the following:

1. Select **Options > Open Test Setup**.
2. Select the setup from the list and click **Open**. Setup files are located at **X:\FRL\**.

**See also** [Test setup files overview](#) on page 59  
[Create a test setup using an existing one](#) on page 60  
[Create a test setup from default settings](#) on page 60

## Create a test setup from default settings

To create a test setup using default settings, follow the steps:

1. Select **Options > Default Test Setup**. For default test setup, the parameters are set to the application's default value.
2. Click application [Setup panel](#) on page 21 and set the parameters
3. Click application [Reports panel](#) on page 44 and set the report options
4. Optional: Click **Start** to run the test and verify that it runs correctly and captures the specified test information and reports. If it does not, then edit the parameters and repeat this step until the test runs to your satisfaction
5. Select **Options > Save Test Setup**. Enter the file name and click Save. The application saves the file to X:\FRL\*<session\_name>*

## Create a test setup using an existing one

To create a test setup using an existing one, follow the steps:

1. Select **Options > Open Test Setup**
2. Select a setup from the list and then click **Open**
3. Click application [Setup panel](#) on page 21 and modify the parameters
4. Click application [Reports panel](#) on page 44 and modify the report options
5. Select **Options > Save Test Setup As**
6. Enter test setup name, and click **Save**

---

# FRL Source tests

## HFR1-1: DC Common Mode Voltage

This test measurement verify that the DC bias of each side of each Data lane.

**Required test equipment**    *Equipment connection setup for Source* on page 51  
*Recommended accessories* on page 5

- Measurement procedure**
1. Configure the DUT to transmit the lowest supported FRL data rate with TxFFE Level set to 0.
  2. Set the DUT to output LTP5, LTP6, LTP7, LTP8 pattern Lane0, Lane1, Lane2, and Lane3 respectively.
  3. Connect the L\_X\_p (+ve) and L\_X\_m (-ve) (waveforms) to Digital oscilloscope using either Tektronix recommended probe or TCA-SMA cable.
  4. Capture L\_X\_p (+ve) and L\_X\_m (-ve) single-ended signals.
  5. Set the cursor gating to 221184 unit intervals (3\*4096 FRL characters).
  6. Optionally de-embed Plug TPA using the TPA vendor's de-embed file.
  7. Calculate L\_X\_DC Common Mode Voltage as,  
$$L\_X\_DC \text{ Common Mode voltage} = \text{Average} ((L\_X\_p + L\_X\_m)/2)$$
  8. If  $L\_X\_DC \text{ Common Mode Voltage} < AV_{cc} - 800 \text{ mV}$ , then FAIL.  
Similarly if  $L\_X\_DC \text{ Common Mode Voltage} > AV_{cc} + 30 \text{ mV}$ , then FAIL.
  9. Repeat step 6 and step 7 for all FRL lanes.

## HFR1-2: Vse\_max,Vse\_min

This test measurement measures the single ended max and min voltages for each side of each data lane.

**Required test equipment**    *Equipment connection setup for Source* on page 51  
*Recommended accessories* on page 5

- Measurement procedure**
1. Configure the DUT to transmit lowest supported FRL data rate with TxFFE Level set to 0.
  2. Set the DUT to output LTP5, LTP6, LTP7, LTP8 pattern Lane0, Lane1, Lane2, and Lane3 respectively.
  3. Connect L\_X\_p (+ve) and L\_X\_m (-ve) (waveforms) to Digital oscilloscope using either Tektronix recommended probe or TCA-SMA cables.
  4. Capture L\_X\_p (+ve) and L\_X\_m (-ve) single-ended signals.
  5. Set the cursor gating to 221184 unit intervals (2\*4096 FRL characters).
  6. Optionally de-embed the Plug TPA using vendor's de-embed file.
  7. Perform the L\_X\_DC Common Mode measurement as per Test ID HFR1-1.
  8. Find the Maximum L\_X\_p voltage as  
$$\text{Max } V_{L\_X\_p} = \text{MAX}(L\_X\_p)$$
  9. Find the Minimum L\_N\_p voltage:  
$$\text{Min } V_{L\_X\_p} = \text{MIN}(L\_X\_p)$$
  10. Find the Maximum L\_N\_n voltage:  
$$\text{Max } V_{L\_X\_n} = \text{MAX}(L\_X\_n)$$
  11. Find the Minimum L\_N\_p voltage:  
$$\text{Min } V_{L\_X\_n} = \text{MIN}(L\_X\_n)$$
  12. Compare the results with the test limit.
  13. Repeat step 6 to step 12 for all FRL lanes.

## HFR1-3: Rise/Fall Slew Rate

The transition time must be more than the specified minimum because of potential for radiated emissions from transmitters with fast edges and skew. This test evaluates the transition time for an FRL Transmitter for rising and falling edges.

**Required test equipment**    *Equipment connection setup for Source* on page 51  
*Recommended accessories* on page 5

- Measurement procedure**
1. Connect the DUT to the digital oscilloscope using TPA-P fixture, in one of the configurations as shown in connection diagram.
  2. Configure the DUT to transmit highest supported FRL data rate with TxFFE Level set to 0.
  3. Set the DUT to output LTP4 pattern for the lane under test and LTP2 for all other non-target lanes.
  4. Adjust the scope vertical settings such that the signal occupies around 8 divisions on the graticule.
  5. Capture L\_X\_p (+ve) and L\_X\_m (-ve) single ended signals.
  6. Optionally de-embed Plug TPA using the TPA vendor's de-embed file.
  7. Measure the slew rate of L\_X\_p (+ve) and L\_X\_m (-ve) over 60% - 40% reference level. Consider at least 500 rising and 500 falling edges for the measurement.
  8. SlewRise=Average rising edge measurements.
  9. SlewFall=Average falling edge measurements.
  10. If either SlewRise or SlewFall is more than 16 mV/ps then FAIL.
  11. Repeat step 3 to step 10 for all FRL lanes.

## HFR1-4: Inter-Pair Skew

This test measures the difference in time between any two FRL Data Lanes.

**Required test equipment**    *Equipment connection setup for Source* on page 51  
*Recommended accessories* on page 5

- Measurement procedure**
1. Configure the DUT to transmit highest supported FRL data rate with TxFFE Level set to 0.
  2. Set the DUT to output LTP5, LTP6, LTP7, LTP8 pattern Lane0, Lane1, Lane2, and Lane3 respectively.
  3. Connect L\_X\_p (+ve) and L\_X\_m (-ve) (waveforms) to Digital oscilloscope using either Tektronix recommended probe or TCA-SMA cables.
  4. Capture L\_X\_p (+ve) and L\_X\_m (-ve) single-ended signals. Create the differential signal using Math subsystem.  
$$L\_X = L\_X\_p - L\_X\_m$$
  5. For the target lanes A and B, find the SR character in each acquisition.
  6. Evaluate time difference, InterPair Skew\_A\_B, between the SR characters of the target lanes.  
$$T_{\text{INTERPAIR\_SKEW\_A\_B}} = \text{Time Location of SR\_A} - \text{Time Location of SR\_B}$$
  7. If  $T_{\text{INTERPAIR\_SKEW\_A\_B}}$  is greater than  $4T_{\text{bit}}$  then FAIL.
  8. Repeat step 4 to step 7 for all combinations of FRL lanes A and B.

## HFR1-5: FRL Rates

This test measures the frequency or data rate accuracy to the nominal FRL data rates.

**Required test equipment**    *Equipment connection setup for Source* on page 51  
*Recommended accessories* on page 5

- Measurement procedure**
1. Configure the DUT to transmit lowest supported FRL data rate with TxFFE Level set to 0.
  2. Set the DUT to output LTP3 pattern for the lane under test and LTP2 for all other non-target lanes.
  3. Connect L\_X\_p (+ve) and L\_X\_m (-ve) (waveforms) to Digital oscilloscope using either Tektronix recommended probe or TCA-SMA cables.
  4. Set the record length to include 1 million Unit Intervals.
  5. Set the vertical scale such that the signal to noise ratio is minimized.
  6. Capture L\_X\_p (+ve) and L\_X\_m (-ve) single-ended signals. Create the differential signal using Math subsystem.  

$$L\_X = L\_X\_p - L\_X\_m$$
  7. Optionally de-embed Plug TPA using the TPA vendor's de-embed file.
  8. Measure data rate for target lane by measuring frequency of signal.  

$$L\_X\_Data\ Rate = Frequency * 2$$
  9. Calculate L\_X error from nominal bit rate targeted.
  10. 
$$L\_X\_error = 1E6 * (L\_X\_Data\ Rate - Nominal\ Data\ Rate\ Setting) / (Nominal\ Data\ Rate\ Setting)$$
  11. If L\_X\_error > 300 ppm, then FAIL.
  12. Repeat step 6 to step 11 for all FRL lanes.
  13. Repeat step 1 to step 12 for the highest supported FRL data rate.

## HFR1-6: Data Jitter (RJ)

This test evaluates Data Jitter (RJ peak-to-peak and RJ RMS) of the FRL link with a clock pattern transmitted on the target channel. Data Jitter can be used in the data eye diagram to compensate a 1E-10 BER mask to a 1E-6 BER mask.

- Required test equipment**
- Equipment connection setup for Source* on page 51
  - Recommended accessories* on page 5

- Measurement procedure**
1. Configure the DUT to transmit lowest supported FRL data rate with Tx FFE Level set to 0.
  2. Set the DUT to output LTP3 pattern for the lane under test and LTP1 for all other non-target lanes.
  3. Connect L\_X\_p (+ve) and L\_X\_m (-ve) (waveforms) to Digital oscilloscope using either Tektronix recommended probe or TCA-SMA cables.
  4. Set the record length to 1 million User Intervals.
  5. Set the vertical scale such that the signal to noise ratio is minimized.
  6. Capture L\_X\_p (+ve) and L\_X\_m (-ve) single-ended signals. Create the differential signal using Math subsystem.  
$$L\_X = L\_X\_p - L\_X\_m$$
  7. Optionally de-embed Plug TPA using the TPA vendor's de-embed file.
  8. Measure the RJ (RMS) and RJ (Pk-Pk) after applying the 8 dB CTLE and WCM3 cable model.
  9. If RJ (Pk-Pk) > 0.2 T<sub>bit</sub>, then FAIL.
  10. Repeat step 8 and step 9 with 1dB CTLE and SCM3 cable model.
  11. Repeat step 2 and step 10 for all FRL lanes.
  12. Repeat step 1 to step 11 for the highest supported FRL data rate.

## HFR1-7: Data Eye Diagram

This test evaluates that the waveform parameters over a significant interval of time to verify that with proper clock recovery there is no signal incursion into regions defined by a mask to result in correct demodulation of data.

- Required test equipment**
- Equipment connection setup for Source* on page 51
  - Recommended accessories* on page 5

**Measurement procedure**

1. Configure the DUT to transmit lowest supported FRL data rate with TxFFE Level set to 0.
2. Set the DUT to output LTP5, LTP6, LTP7, LTP8 pattern Lane0, Lane1, Lane2, and Lane3 respectively.
3. Connect L\_X\_p (+ve) and L\_X\_m (-ve) (waveforms) to Digital oscilloscope using either Tektronix recommended probe or TCA-SMA cables.
4. Set the scope sampling rate to 100 G Sa/s.
5. Set the vertical scale such that the signal to noise ratio is minimized.
6. Set the record length to 2 million User Intervals.
7. Acquire single-ended L\_X\_p (+ve) and L\_X\_m (-ve) signals for all lanes. Create the differential signal using Math subsystem.

$$L\_X = L\_X\_p - L\_X\_m$$

8. Optionally de-embed Plug TPA using the TPA vendor's de-embed file.
9. For the target lane, a channel model is applied to the acquisition waveform for that lane to comprehend the differential insertion loss for that lane.
10. Crosstalk from the non-target lanes is applied using acquisitions for each lane and applying the crosstalk transfer function derived from the channel model.
11. Apply the equalization (CTLE and DFE, if 12 Gbps; Only CTLE, for any other data rate) on the resulting summed waveform.

| FRL rate      | Cable Model | CTLE | DFE   |
|---------------|-------------|------|-------|
| 12 Gbps       | WCM3S       | 8 db | 25 mV |
| 12 Gbps       | SCM3S       | 1 db | n/a   |
| 3/6/8/10 Gbps | WCM3S       | 8 db | n/a   |
| 3/6/8/10 Gbps | SCM3S       | 1 db | n/a   |

12. Apply the PLL clock recovery with the below Loop Bandwidth.  
 Loop BW =  $(R_{bit} / 1500)$ , where  $R_{bit}$  12 Gbps, 10 Gbps, 8 Gbps and 6 Gbps  
 = 4MHz when  $R_{bit}$  3Gbps
13. Render eye diagram and verify no point incursions in mask area.
14. Repeat step 8 to step 13 for both channel models (WCM and SCM).
15. Repeat step 8 to step 14 for each data lane.
16. Repeat step 1 to step 15 for the highest supported FRL data rate.

## HFR1-8: AC Common Mode Voltage

This test verifies that the AC common mode noise of a transmitter is limited to a percentage of the nominal DC differential swing to ensure that radiated emissions due to the common mode noise are limited.

**Required test equipment**    *Equipment connection setup for Source* on page 51  
*Recommended accessories* on page 5

- Measurement procedure**
1. Configure the DUT to transmit highest supported FRL data rate with TxFFE Level set to 0.
  2. Set the DUT to output LTP5, LTP6, LTP7, LTP8 pattern Lane0, Lane1, Lane2, and Lane3 respectively.
  3. Connect L\_X\_p (+ve) and L\_X\_m (-ve) (waveforms) to Digital oscilloscope using either the recommended probe or TCA-SMA cables.
  4. Set the oscilloscope bandwidth to one half the data rate.
  5. Capture L\_X\_p (+ve) and L\_X\_m (-ve) single-ended signals.
  6. Optionally de-embed Plug TPA using the TPA vendor's de-embed file.
  7. Create Common Mode Waveform of the target lane:  
$$L\_XCM = (L\_X\_plus + L\_X\_minus)/2$$
  8. Measure  $VCM\_L\_X\_pp$  = peak to peak voltage of L\_XCM.
  9. If  $VCM\_L\_X\_pp > 150$  mV, then FAIL.
  10. Repeat step 6 to step 9 for all FRL lanes.

## HFR1-9: FFE Monotonicity-Method 1

This test verifies that the parameters of FFE, pre-shoot amplitude and de-emphasis, are monotonic from one FFE state to the next FFE state.

**Required test equipment**    *Equipment connection setup for Source* on page 51  
*Recommended accessories* on page 5

- Measurement procedure**
1. Configure the DUT to transmit highest supported FRL data rate with TxFFE Level set to 0.
  2. Set the DUT to output LTP4 pattern for the lane under test and LTP2 for all other non-target lanes.
  3. Connect L\_X\_p (+ve) and L\_X\_m (-ve) (waveforms) to Digital oscilloscope using either Tektronix recommended probe or TCA-SMA cables.
  4. Set the vertical scale such that the signal to noise ratio is minimized.
  5. Setup time scale to demonstrate ~192 UI with the positive going pulse in the middle of the screen.
  6. Optionally de-embed Plug TPA using the TPA vendor's de-embed file.
  7. Configure the DUT in de-emphasis only mode by setting xFFE\_De\_Emphasis Only bit.
  8. Capture L\_X\_p (+ve) and L\_X\_m (-ve) single-ended signals
  9. Measure Vd,
  10. Configure the DUT in pre-emphasis only mode by setting TxFFE\_Pre\_Shoot Only bit.
  11. Capture L\_X\_p (+ve) and L\_X\_m (-ve) single-ended signals.
  12. Measure Vp.
  13. Configure the DUT in Vn when FFE is in state 0.
  14. Capture L\_X\_p (+ve) and L\_X\_m (-ve) single-ended signals.
  15. Measure Vn.
  16.  $\text{dBDe-emphasis\_FFE0} = 20 * \text{Log}(Vn/Vp)$
  17.  $\text{dBPre-Shoot\_FFE0} = 20 * \text{Log}(Vd/Vn)$
  18. Repeat step 7 to step 15 for all FFE states, X and calculate dBDeemphasis\_FFEX and dBPre-Shoot\_FFEX.
  19. If the difference of pre-shoot between any two successive FFE levels is greater than 0dB then Pass. Similarly If the difference of de-emphasis between any two successive FFE levels is less than 0dB then Pass.
  20. Repeat step 7 to step 19 for all FRL lanes.

## HFR1-9: FFE Monotonicity-Method 2

This test verifies that the parameters of FFE, pre-shoot amplitude and de-emphasis, are monotonic from one FFE state to the next FFE state.

**Required test equipment** [Equipment connection setup for Source](#) on page 51  
[Recommended accessories](#) on page 5

- Measurement procedure**
1. Configure the DUT to transmit highest supported FRL data rate with TxFFE Level set to 0.
  2. Set the DUT to output LTP4 pattern for the lane under test and LTP2 for all other non-target lanes.
  3. Connect L\_X\_p (+ve) and L\_X\_m (-ve) (waveforms) to Digital oscilloscope using either Tektronix recommended probe or TCA-SMA cables.
  4. Set the vertical scale such that the signal to noise ratio is minimized.
  5. Setup time scale to demonstrate ~192 UI with the positive going pulse in the middle of the screen.
  6. Optionally de-embed Plug TPA using the TPA vendor's de-embed file.
  7. Configure the DUT in de-emphasis only mode by setting xFFE\_De\_Emphasis Only bit.
  8. Capture L\_X\_p (+ve) and L\_X\_m (-ve) single-ended signals.
  9. Measure  $V_d = V_0 - |V_{+1}|$ .
  10. Configure the DUT in pre-emphasis only mode by setting TxFFE\_Pre\_Shoot Only bit.
  11. Capture L\_X\_p (+ve) and L\_X\_m (-ve) single-ended signals.
  12. Measure  $V_p = V_0 - |V_{-1}|$
  13. Configure the DUT in No FFE mode by setting the TxFFE\_NO\_FFE bit.
  14. Capture L\_X\_p (+ve) and L\_X\_m (-ve) single-ended signals.
  15. Measure  $V_0$ .
  16. 
$$\text{dBDe-emphasis\_FFE0} = 20 \cdot \log \left( \frac{V_0 - |V_{-1}| - |V_{+1}|}{V_0 - |V_{-1}| + |V_{+1}|} \right)$$
  17. 
$$\text{dBPre-Shoot\_FFE0} = 20 \cdot \log \left( \frac{V_0 + |V_{-1}| - |V_{+1}|}{V_0 - |V_{-1}| - |V_{+1}|} \right)$$
  18. Repeat step 7 to step 15 for all FFE states, X and calculate dBDeemphasis\_FFEX and dBPre-Shoot\_FFEX.
  19. If the difference of pre-shoot between any two successive FFE levels is greater than 0dB then Pass. Similarly If the difference of de-emphasis between any two successive FFE levels is less than 0dB then Pass.
  20. Repeat step 7 to step 19 for all FRL lanes.

---

# FRL Sink Tests

## HRF2-1:Max Differential Swing Tolerance

This test confirms that the Sink supports FRL differential voltages at maximum level.

**Required test equipment**    *Equipment connection setup for Sink* on page 53  
*Recommended accessories* on page 5

- Measurement procedure**
1. Connect the AWGs (AWG70001A/AWG70001B) to the oscilloscope through AWG-HD box, Sync hub and TPA-PR fixture, as shown in the *Figure 18: Measurement configuration for Sink* on page 55.
  2. Configure the AWGs to lowest FRL rate supported by the DUT.
  3. Adjust the common mode voltage (VICM) to a level defined in HDMI version 2.1 Table 6-25
  4. Calibrate differential mode swing voltage of the AWG at PTP2\_cal with no cable model applied to Maximum Differential Swing 1200 mV using RXSB33PAT pattern.
  5. Connect the AWGs to the Sink DUT using TPA-P as shown in *Figure 18: Measurement configuration for Sink* on page 55.
  6. Complete the Link Training between Sink DUT and FRL Signal Generator for the selected FRL Rate. If Link Training is not successful, then FAIL
  7. Configure the AWGs to transmit RXSB33PAT pattern.
  8. Read the Error Counter from Sink DUT using I2C controller.
  9. Conduct error counter test as described in section *BER estimation procedure* on page 76. If error counter check fails, then FAIL.
  10. Configure the AWG to highest FRL rate supported by the DUT and connect the AWGs to the oscilloscope using AWG-HD box, Sync hub, TPA-P and TPA-R.
  11. Repeat Steps 4 to step 9 for successful link training.

## HRF2-2:Intra-Pair Skew

This test confirm that the maximum allowed timing skew within each FRL pair is supported by the Sink DUT

**Required test equipment**    *Equipment connection setup for Sink* on page 53  
*Recommended accessories* on page 5

- Measurement procedure**
1. Connect the AWGs (AWG70001A/AWG70001B) to the oscilloscope through AWG-HD box, Sync hub and TPA-PR fixture, as shown in the *Figure 18: Measurement configuration for Sink* on page 55.
  2. Configure the AWGs to lowest FRL rate supported by the DUT.
  3. Adjust the common mode voltage (VICM) to a level defined in HDMI version 2.1 Table 6-25.
  4. For all FRL Signals, set the single ended swing to 500 mV.
  5. Calibrate for a skew of  $0.15 \cdot T_{\text{bit}}$  on a line of the FRL target lane against its complement, at TP2 using WCM3 cable model.
  6. Connect the AWGs to the Sink DUT using TPA-P as shown in *Figure 18: Measurement configuration for Sink* on page 55.
  7. Complete the Link Training between Sink DUT and FRL Signal Generator for the selected FRL Rate. If Link Training is not successful, then FAIL.
  8. Configure the AWGs to transmit RXSB33PAT pattern.
  9. Read the Error Counter from Sink DUT using I2C controller.
  10. Conduct error counter test as described in section *BER estimation procedure* on page 76. If error counter check fails, then FAIL.
  11. Switch the setting of the signal delay on the complement line for the target FRL Lane pair. Repeat step 7 to Step 10.
  12. Configure the AWG to highest FRL rate supported by the DUT and connect the AWGs to the oscilloscope using AWG-HD box, Sync hub, TPA-P and TPA-R.
  13. Repeat Steps 5 to step 11 for all the FRL lines.

## HRF2-3:Inter-Pair Skew

This test confirm that the maximum allowed skew between FRL Lanes is supported by the Sink DUT.

**Required test equipment**    *Equipment connection setup for Sink* on page 53  
*Recommended accessories* on page 5

- Measurement procedure**
1. Connect the AWGs (AWG70001A/AWG70001B) to the oscilloscope through AWG-HD box, Sync hub and TPA-PR fixture, as shown in the *Figure 18: Measurement configuration for Sink* on page 55.
  2. Configure the AWGs to lowest FRL rate supported by the DUT.
  3. Adjust the common mode voltage (VICM) to a level defined in HDMI version 2.1 Table 6-25
  4. For all FRL Signals, set the single ended swing to 500 mV.
  5. Calibrate for the inter pair skew of  $[4T_{\text{bit}} + 500 \text{ ps}]$  on FRL Lane0 against all other lanes, in positive direction. Perform the calibration at TP2 using WCM3 cable model.
  6. Connect the AWGs to the Sink DUT using TPA-P as shown in *Figure 18: Measurement configuration for Sink* on page 55.
  7. Complete the Link Training between Sink DUT and FRL Signal Generator for the selected FRL Rate. If Link Training is not successful, then FAIL.
  8. Configure the AWGs to transmit RXSB33PAT pattern.
  9. Read the Error Counter from Sink DUT using I2C controller.
  10. Conduct error counter test as described in section “*BER estimation procedure* on page 76”. If error counter check fails, then FAIL.
  11. Calibrate for the inter pair skew of  $[4T_{\text{bit}} + 500 \text{ ps}]$  on FRL Lane0 against all other lanes, in negative direction. Perform the calibration at TP2 using WCM3 cable model. Repeat step 6 to Step 10.
  12. Repeat the test for the remaining untested FRL lane.
  13. Configure the AWG to highest FRL rate supported by the DUT and connect the AWGs to the oscilloscope using AWG-HD box, Sync hub, TPA-P and TPA-R.
  14. Repeat Steps 5 to Step 12 for all FRL lanes.

## HRF2-4:Minimum Link Rate Tolerance

This test confirm that the Sink DUT meets FRL Link Rate Tolerance requirements.

**Required test equipment**    *Equipment connection setup for Sink* on page 53  
*Recommended accessories* on page 5

- Measurement procedure**
1. Connect the AWGs (AWG70001A/AWG70001B) to the oscilloscope through AWG-HD box, Sync hub and TPA-PR fixture, as shown in the *Figure 18: Measurement configuration for Sink* on page 55.
  2. Configure the AWGs to lowest FRL rate supported by the DUT.
  3. Adjust the common mode voltage (VICM) to a level defined in HDMI version 2.1 Table 6-25.
  4. For all FRL Signals, set the single ended swing to 500 mV.
  5. Calibrate the data rate for +300 ppm for all FRL lanes, at TP2 using WCM3 cable model.
  6. Connect the AWGs to the Sink DUT using TPA-P as shown in *Figure 18: Measurement configuration for Sink* on page 55.
  7. Complete the Link Training between Sink DUT and FRL Signal Generator for the selected FRL Rate. If Link Training is not successful, then FAIL.
  8. Configure the AWGs to transmit RXSB33PAT pattern.
  9. Read the Error Counter from Sink DUT using I2C controller.
  10. Conduct error counter test as described in section *BER estimation procedure* on page 76. If error counter check fails, then FAIL.
  11. Calibrate the data rate for -300 ppm for all FRL lanes, at TP2 using WCM3 cable model. Repeat step 6 to step 10.
  12. Configure the AWG to highest FRL rate supported by the DUT and connect the AWGs to the oscilloscope using AWG-HD box, Sync hub, TPA-P and TPA-R.
  13. Repeat Steps 5 to Step 11 for all FRL Lanes.

## HFR2-5:Jitter Tolerance

This test confirm that the maximum allowed jitter is supported by the Sink DUT.

**Required test equipment**    *Equipment connection setup for Sink* on page 53  
*Recommended accessories* on page 5

- Measurement procedure**
1. Connect the AWGs (AWG70001A/AWG70001B) to the oscilloscope through AWG-HD box, Sync hub and TPA-PR fixture, as shown in the *Figure 18: Measurement configuration for Sink* on page 55.
  2. Configure the AWGs to lowest FRL rate supported by the DUT.
  3. Adjust the common mode voltage (VICM) to a level defined in HDMI version 2.1 Table 6-25.
  4. For all FRL Signals, set the single ended swing to 500 mV.
  5. Calibrate Random Jitter (RJ) =  $0.2 T_{\text{bit}} @ \text{BER } 10^{-10}$  using LTP3 pattern.
  6. Add accurate amount of SJ =  $0.10 UI @ 10 \text{ *fc}$ .
  7. Configure the AWGs to output RXSB33PAT with WCM3\_CTS applied, by keeping RJ and SJ as per step 5 and step 6.
  8. Calibrate the resulting signal, marginal to the TP2\_EQ eye diagram mask for the following conditions:
    - a. Condition 1:  $V_{\text{min}} \text{ (mV)} = 150 \text{ mV}$  and  $H(T_{\text{bit}}) @ \text{BER } 10^{-10} = 0.5$  if FRL rate is 3 Gbps.
    - b. Condition 2:  $V_{\text{min}} \text{ (mV)} = 150 \text{ mV}$  and  $H(T_{\text{bit}}) @ \text{BER } 10^{-10} = 0.4$  if FRL rate is 6 Gbps.
    - c. Condition 3:  $V_{\text{min}} \text{ (mV)} = 135 \text{ mV}$  and  $H(T_{\text{bit}}) @ \text{BER } 10^{-10} = 0.385$  if FRL rate is 8 Gbps.
    - d. Condition 4:  $V_{\text{min}} \text{ (mV)} = 120 \text{ mV}$  and  $H(T_{\text{bit}}) @ \text{BER } 10^{-10} = 0.37$  if FRL rate is 10 Gbps.
    - e. Condition 1:  $V_{\text{min}} \text{ (mV)} = 100 \text{ mV}$  and  $H(T_{\text{bit}}) @ \text{BER } 10^{-10} = 0.35$  if FRL rate is 12 Gbps.
      - a. Adjust DJ (ISI) until the measured total jitter becomes  $1 - H(T_{\text{bit}}) @ \text{BER } 10^{-10}$  from step 8 when measured with CRU as defined in Equation 6-4 of HDMI version 2.1 specification.
      - b. Adjust the Differential swing until the vertical opening is  $V_{\text{min}} \text{ (mV)} @ \text{BER } 10^{-10}$  in step 8 measured with CRU as defined in Equation 6 - 4 of HDMI version 2.1 specification.
  9. Connect the AWGs to the Sink DUT using TPA-P as shown in *Figure 18: Measurement configuration for Sink* on page 55.
  10. Complete the Link Training between Sink DUT and FRL Signal Generator for the selected FRL Rate. If Link Training is not successful, then FAIL.
  11. Configure the AWGs to transmit RXSB33PAT pattern.
  12. Read the Error Counter from Sink DUT using I2C controller.

13. Conduct error counter test as described in section *BER estimation procedure* on page 76. If error counter check fails, then FAIL.
14. Repeat Steps 6 to step 13 with following SJ:
  - a. SJ = 1.0 UI @ 0.1\*fc
  - b. SJ = 0.51 UI @ 0.2\*fc
  - c. SJ = 0.22 UI @ 0.5\*fc
  - d. SJ = 0.14 UI @ 1\*fc
  - e. SJ = 0.11 UI @ 2\*fc
  - f. SJ = 0.10 UI @ 5\*fc
15. Configure the AWG to highest FRL rate supported by the DUT and connect the AWGs to the oscilloscope using AWG-HD box, Sync hub, TPA-P and TPA-R
16. Repeat Steps 5 to Step 14 for error control link.

## BER estimation procedure

BER estimation check on all active lanes should be the PASS/FAIL criteria for FRL Sink Electrical Tests.

1. Read the CED counter to clear it, make sure the Valid flag is set.
2. Count the errors until at least  $10^{11}$  bits were received.
3. Read error counter, calculate BER based on accumulated errors and total elapsed time.
  - a. calculate the BER as (total number of errors reported by DUT since the test started) / (bitrate \* total time elapsed since the test started).
  - b. If BER is greater than  $10^{-10}$ , then FAIL.
  - c. If BER is greater than  $5 \cdot 10^{-11}$  (i.e. half of the allowed maximum), repeat test period to acquire more data.
  - d. If this is already the 10th repetition, and BER is greater than  $10^{-10}$ , then FAIL, otherwise, continue to next step.
  - e. Check if tested lanes are all locked; if any lane is not locked, then FAIL.

# SCPI commands

## About SCPI command

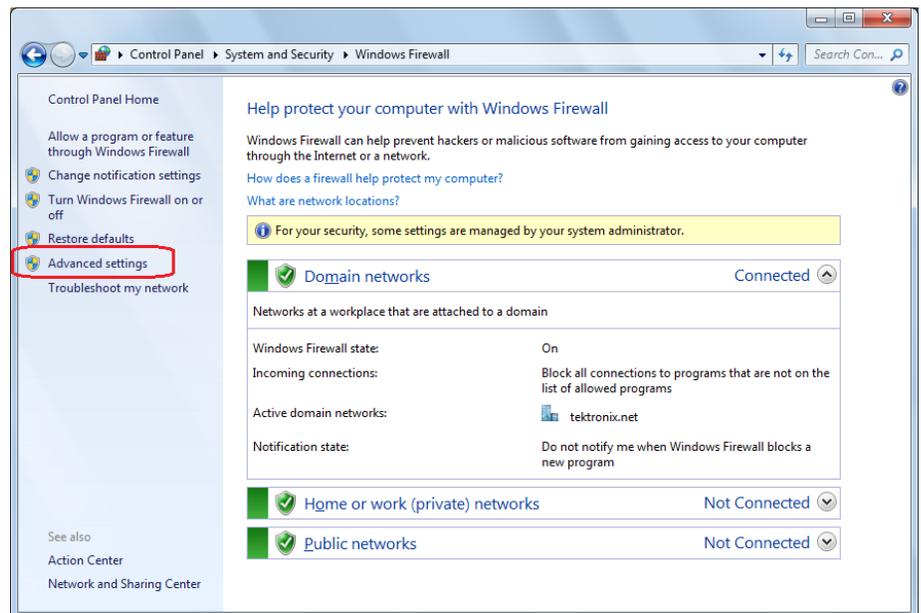
You can use Standard Commands for Programmable Instruments (SCPI) to communicate with the TekExpress application.

## Socket configuration for SCPI commands

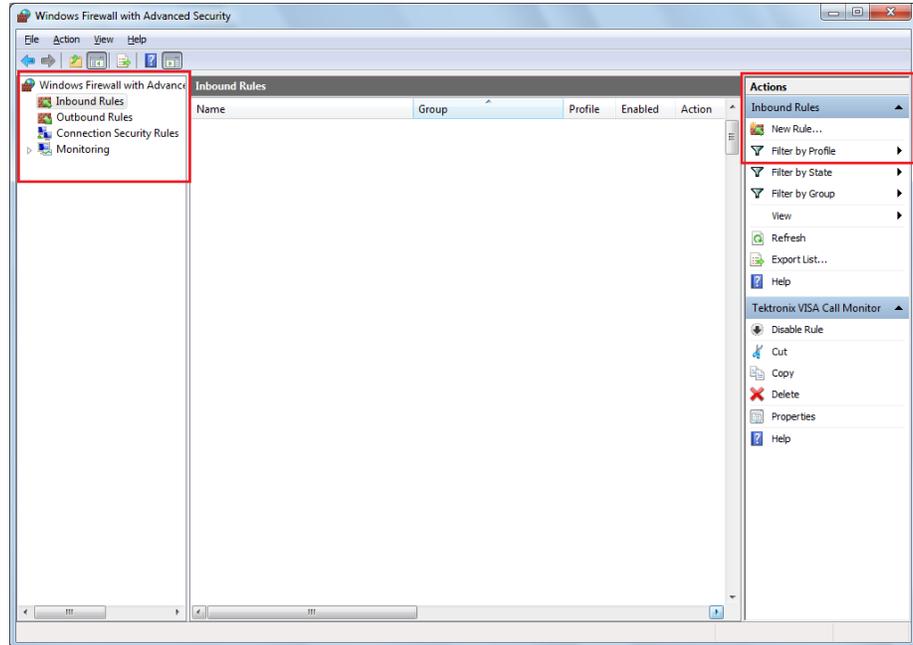
This section describes the steps for TCP/IP socket configuration and TekVISA configuration to execute the SCPI commands.

### TCP/IP socket configuration

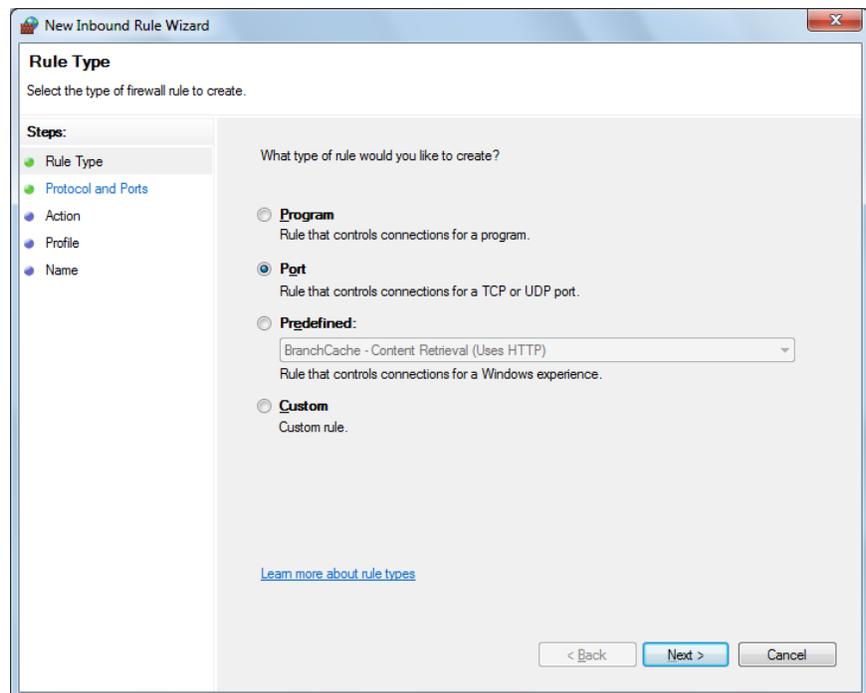
1. Click **Start > Control Panel > System and Security > Windows Firewall > Advanced settings**.



2. In Windows Firewall with Advanced Security menu, select **Windows Firewall with Advanced Security on Local Computer > Inbound Rules** and click **New Rule...**



3. In New Inbound Rule Wizard menu
  - a. Select **Port** and click **Next**.



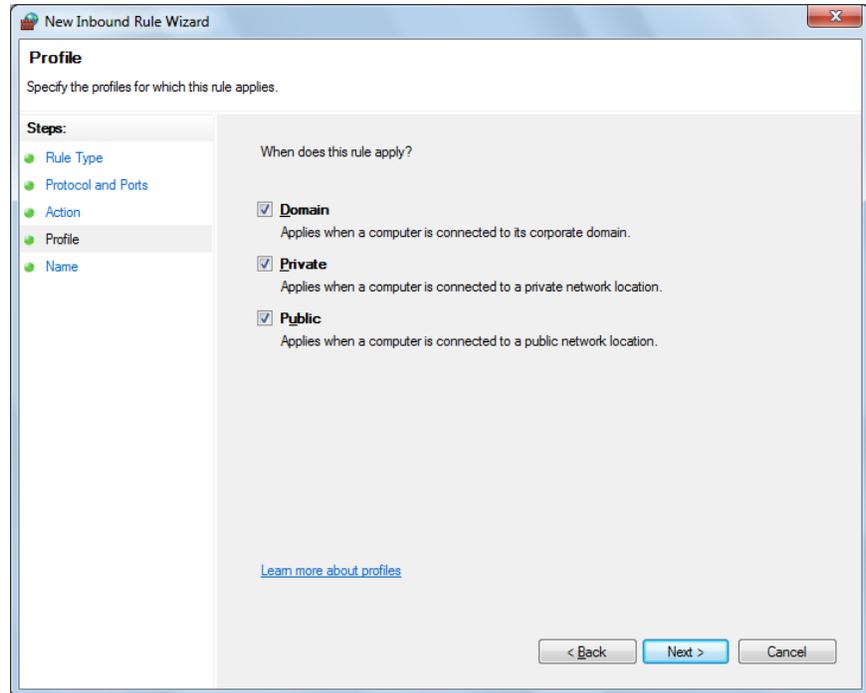
- b. Select **TCP** as rule apply and enter 5000 for **Specific local ports** and click **Next**.

The screenshot shows the 'New Inbound Rule Wizard' dialog box, specifically the 'Protocol and Ports' step. The title bar reads 'New Inbound Rule Wizard'. The main heading is 'Protocol and Ports' with the instruction 'Specify the protocols and ports to which this rule applies.' On the left, a 'Steps:' list shows 'Rule Type', 'Protocol and Ports', 'Action', 'Profile', and 'Name', with 'Protocol and Ports' selected. The main area contains two questions: 'Does this rule apply to TCP or UDP?' with radio buttons for 'TCP' (selected) and 'UDP'; and 'Does this rule apply to all local ports or specific local ports?' with radio buttons for 'All local ports' and 'Specific local ports:' (selected). The 'Specific local ports:' field contains '5000' and has an example 'Example: 80, 443, 5000-5010' below it. A link 'Learn more about protocol and ports' is at the bottom left. At the bottom right are buttons for '< Back', 'Next >', and 'Cancel'.

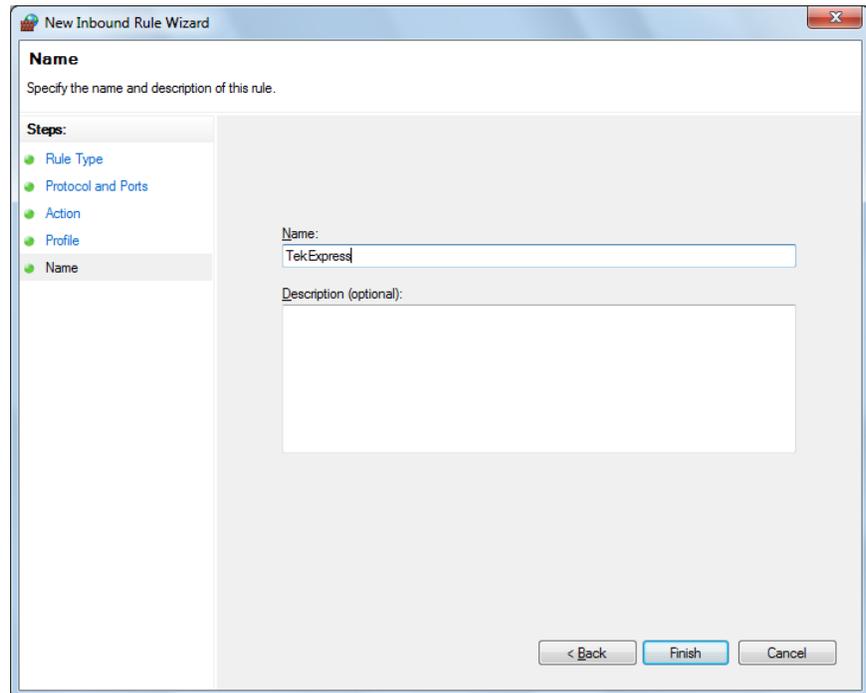
- c. Select **Allow the connection** and click **Next**.

The screenshot shows the 'New Inbound Rule Wizard' dialog box, specifically the 'Action' step. The title bar reads 'New Inbound Rule Wizard'. The main heading is 'Action' with the instruction 'Specify the action to be taken when a connection matches the conditions specified in the rule.' On the left, a 'Steps:' list shows 'Rule Type', 'Protocol and Ports', 'Action', 'Profile', and 'Name', with 'Action' selected. The main area contains the question 'What action should be taken when a connection matches the specified conditions?' with three radio button options: 'Allow the connection' (selected), 'Allow the connection if it is secure', and 'Block the connection'. The 'Allow the connection' option has a description: 'This includes connections that are protected with IPsec as well as those are not.' The 'Allow the connection if it is secure' option has a description: 'This includes only connections that have been authenticated by using IPsec. Connections will be secured using the settings in IPsec properties and rules in the Connection Security Rule node.' and a 'Customize...' button. The 'Block the connection' option has a description: 'This includes only connections that have been authenticated by using IPsec. Connections will be secured using the settings in IPsec properties and rules in the Connection Security Rule node.' A link 'Learn more about actions' is at the bottom left. At the bottom right are buttons for '< Back', 'Next >', and 'Cancel'.

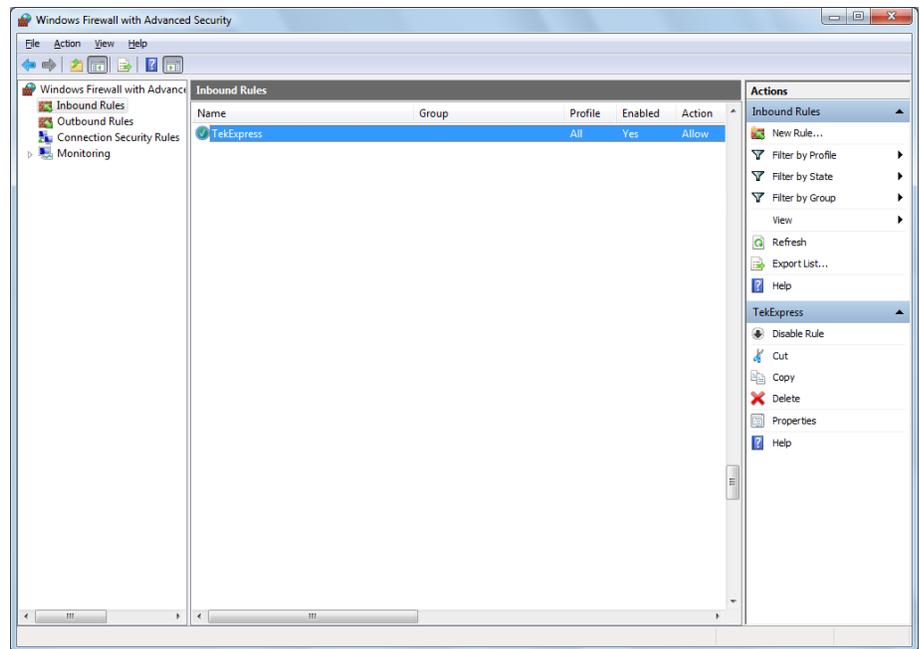
- d. Select **Domain**, **Private**, **Public** and click **Next**.



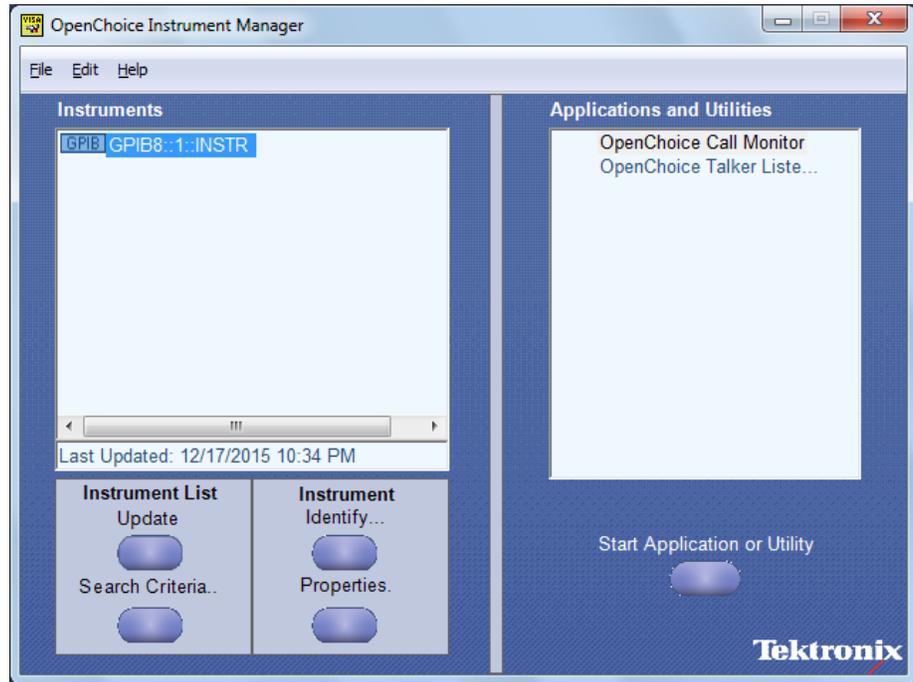
- e. Enter **Name**, Description (optional), and click **Finish**.



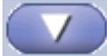
4. Check whether the Rule name is displayed in **Windows Firewall with Advanced Security** menu > **Inbound Rules**.



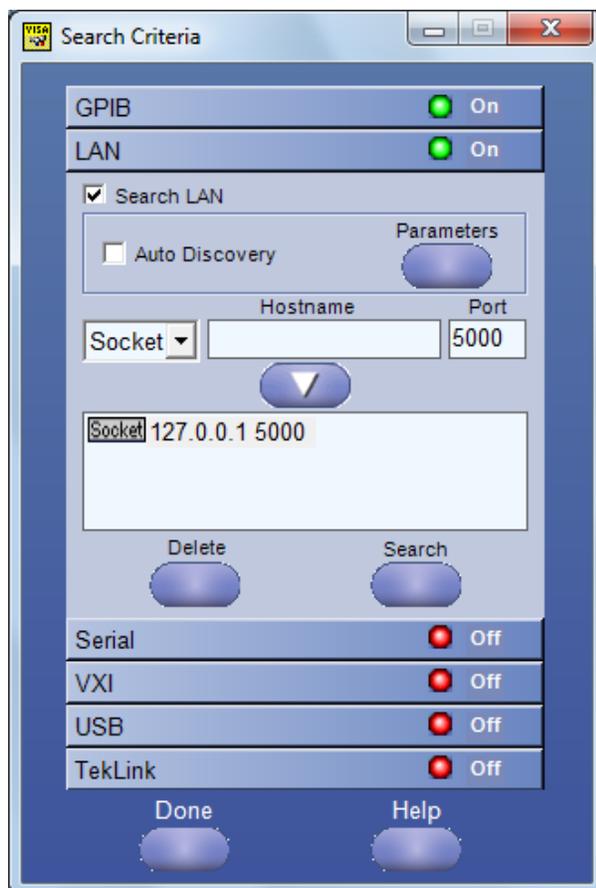
- TekVISA configuration**
1. Click **Start > All Programs > TekVISA > OpenChoice Instrument Manager**.



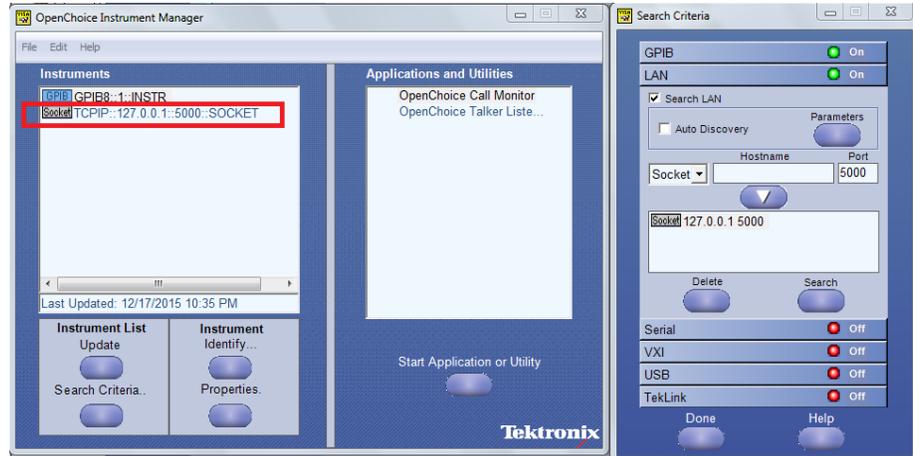
2. Click **Search Criteria**. In Search Criteria menu, click **LAN** to Turn-on. Select **Socket** from the drop-down list, enter the IP address of the

TekExpress device in **Hostname** and type **Port** as 5000. Click  to configure the IP address with Port.

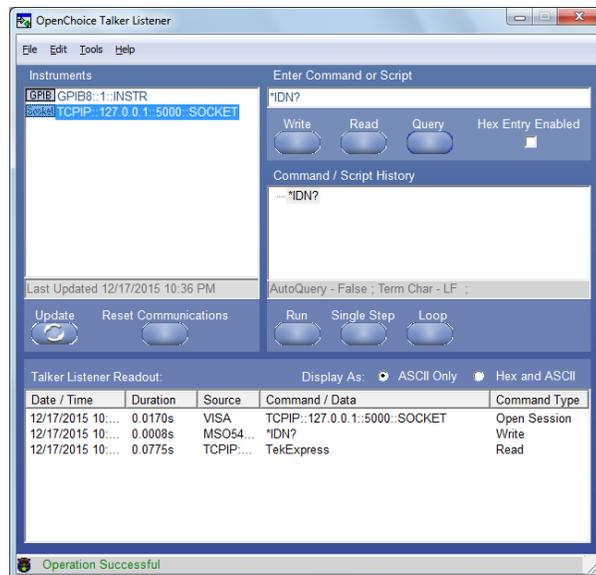
Enter the Hostname as 127.0.0.1 if the TekVISA and TekExpress application are in the same system, else enter the IP address of the TekExpress application system.



- Click **Search** to setup the TCPIP connection with the host. Check whether the TCPIP host name is displayed in **OpenChoice Instrument Manager > Instruments**.



- Double-click **OpenChoice Talker Listener** and enter the Command **\*IDN?** in command entry field and click **Query**. Check that the Operation is successful and Talker Listener Readout displays the Command / Data.



## TEKEXP:\*IDN?

This command queries the active TekExpress application name running on the oscilloscope.

**Syntax**    TEKEXP:\*IDN?\n

**Inputs**    NA

**Outputs**   Returns active TekExpress application name running on the oscilloscope.

## TEKEXP:\*OPC?

This command queries the execution status of the last executed command.

**Syntax**    TEKEXP:\*OPC?\n

**Inputs**    NA

**Outputs**   0 - last command execution is not complete  
              1 - last command execution is complete

## TEKEXP:ACQUIRE\_MODE

This command sets the acquire mode as live or pre-recorded.

**Syntax**    `TEKEXP:ACQUIRE_MODE {LIVE | PRE-RECORDED}\n`

**Inputs**    `{LIVE | PRE-RECORDED}`

**Outputs**   `NA`

## TEKEXP:ACQUIRE\_MODE?

This command queries the acquire mode type.

**Syntax**    `TEKEXP:ACQUIRE_MODE?\n`

**Inputs**    `NA`

**Outputs**   `{LIVE | PRE-RECORDED}`

## TEKEXP:EXPORT

This command returns all the bytes of data to the specified file.

| Syntax                             | Outputs                                      |
|------------------------------------|--|
| TEKEXP:EXPORT REPORT\n             | Returns the report file in bytes             |
| TEKEXP:EXPORT WFM,"<FileName>"\n   | Returns the specified waveform file in bytes |
| TEKEXP:EXPORT IMAGE,"<FileName>"\n | Returns the specified image file in bytes    |

**Inputs**    FileName - Specifies the file name

## TEKEXP:INFO?

This command queries the information about the file(s).

| Syntax                   | Outputs   |
|--------------------------|---|
| TEKEXP:INFO?<br>REPORT\n | <ReportFileSize>,"<ReportFileName.mht>"                                     |
| TEKEXP:INFO? WFM<br>\n   | <WfmFile1Size>,"<WfmFileName1.wfm>";<WfmFile2Size>,"<WfmFileName2.wfm>";... |
| TEKEXP:INFO?<br>IMAGE\n  | <Image1FileSize>,"<Image1FileName>";<Image2FileSize>,"<Image2FileName>";... |

## TEKEXP:INSTRUMENT

This command sets the value for the selected instrument type.

**Syntax**    `TEKEXP:INSTRUMENT "<InstrumentType>",<Value>"\n`

**Inputs**    InstrumentType  
               Value




---

**TIP.** Check Command parameters list section for InstrumentType and Value parameters.

---

**Outputs**    NA

## TEKEXP:INSTRUMENT?

This command queries the instrument selected for the specified instrument type.

**Syntax**    `TEKEXP:INSTRUMENT? "<InstrumentType>"\n`

**Inputs**    InstrumentType




---

**TIP.** Check Command parameters list section for InstrumentType parameters.

---

**Outputs**    Returns the instrument selected for the specified instrument type

## TEKEXP:LASTERROR?

This command queries the last error string occurred for the current TCP session. If there are no errors since startup, or since the last call to TEKEXP:LASTERROR?\n, this command returns an empty string.

**Syntax**    TEKEXP:LASTERROR?\n

**Inputs**    NA

**Outputs**   <string>

## TEKEXP:LIST?

This command queries the list of available device, suite, test, version or instrument.

| Syntax   | Outputs   |
|--|---|
| TEKEXP:LIST? DEVICE\n                          | Returns the list of available device(s) as comma separated values.                                  |
| TEKEXP:LIST? SUITE\n                           | Returns the list of available suite(s) as comma separated values.                                   |
| TEKEXP:LIST? TEST\n                            | Returns the list of available test(s) as comma separated values.                                    |
| TEKEXP:LIST? VERSION\n                         | Returns the list of available version(s) as comma separated values.                                 |
| TEKEXP:LIST?<br>INSTRUMENT,"<InstrumentType>\n | Returns the list of available instruments' for the given Instrument type as comma separated values. |

---

**NOTE.** This command returns the list of items within double quotes ("""). Iterate the receive procedure until the list ends with double quotes otherwise the next query commands won't work as expected.

---

**Inputs**    InstrumentType



---

**TIP.** Check Command parameters list section for InstrumentType parameters.

---

## TEKEXP:MODE

This command sets the execution mode as compliance or user defined.

**Syntax**    TEKEXP:MODE {COMPLIANCE | USER-DEFINED}\n

**Inputs**    {COMPLIANCE | USER-DEFINED}

**Outputs**    NA

## TEKEXP:MODE?

This command queries the execution mode type.

**Syntax**    TEKEXP:MODE?\n

**Inputs**    NA

**Outputs**    {COMPLIANCE | USER-DEFINED}

## TEKEXP:POPUP

This command sets the response to the active popup shown in the application.

**Syntax**    TEKEXP:POPUP “<PopupResponse>”\n

**Inputs**    PopupResponse

**Outputs**   NA

## TEKEXP:POPUP?

This command queries the active popup information shown in the application.

**Syntax**    TEKEXP:POPUP?\n

**Inputs**    NA

**Outputs**   Returns the active popup information in the application.

## TEKEXP:REPORT

This command generates the report for the current session.

**Syntax**    TEKEXP:REPORT GENERATE\n

**Inputs**    GENERATE

**Outputs**    NA

## TEKEXP:REPORT?

This command queries the queried header field value in the report.

**Syntax**    TEKEXP:REPORT? "<HeaderField>"\n

**Inputs**    HeaderField - Specifies to return the measured value for the indicated test.



---

**TIP.** Check **Report** for HeaderField parameters.

---

**Outputs**    Returns the queried header field value in the report

## TEKEXP:RESULT?

This command queries the result available in report summary/details table.

| Syntax  | Outputs  |
|---|--|
| TEKEXP:RESULT? "<TestName>"\n                           | Return Pass/Fail status of the test.                               |
| TEKEXP:RESULT? "<TestName>",<ColumnName>"\n             | Returns all the row values of the specified column for the test.   |
| TEKEXP:RESULT? "<TestName>",<ColumnName>",<RowNumber>\n | Returns the column value for the specified row number <sup>1</sup> |

- Inputs**
- TestName - Specifies the name of the test for which to obtain the test result value.
  - ColumnName - Specifies the column name for the measurement
  - RowNumber - Specifies the row number of the measurement



**TIP.** Check **Results** panel for TestName, ColumnName, and RowNumber parameters.

<sup>1</sup> Row number starts from zero.

## TEKEXP:SELECT

This command selects the device, suite, version, or test.

**Syntax**    `TEKEXP:SELECT <string1>,<string2>,<string4>\n`  
`TEKEXP:SELECT TEST,<string3>,<string4>\n`

**Inputs**    `<string1> = {DEVICE | SUITE | VERSION}`  
`<string2> = {DeviceName | SuiteName | VersionName}`  
`<string3> = {"<TestName>" | ALL | REQUIRED }`  
`<string4> = {TRUE | FALSE}`



**TIP.** Check Command parameters list section for DeviceName, SuiteName, VersionName, and TestName parameters.

---

**Outputs**    NA

## TEKEXP:SELECT?

This command queries the name of the selected device, suite, version, or test.

**Syntax**    `TEKEXP:SELECT? {DEVICE | SUITE | TEST | VERSION}\n`

**Inputs**    `{DEVICE | SUITE | TEST | VERSION}`

**Outputs** Returns the name of the selected device, suite, version, or test.

## TEKEXP:SETUP

This command sets the value of the current setup.

| Syntax                              | Outputs                                     |
|-------------------------------------|---|
| TEKEXP:SETUP DEFAULT\n              | Restore to default Setup                    |
| TEKEXP:SETUP OPEN,"<SessionName>"\n | Open the session                            |
| TEKEXP:SETUP SAVE\n                 | Saves the already existing modified session |
| TEKEXP:SETUP SAVE,"<SessionName>"\n | Save the session                            |

**Inputs** SessionName - The name of the session

## TEKEXP:STATE

This command sets the execution state of the application.

**Syntax** TEKEXP:STATE {RUN | STOP | PAUSE | RESUME}\n

**Inputs** {RUN | STOP | PAUSE | RESUME}

**Outputs** NA

## TEKEXP:STATE?

This command queries the current setup state.

| Syntax              | Outputs                                 |
|---------------------|---|
| TEKEXP:STATE?       | RUNNING   PAUSED   WAIT   ERROR   READY |
| TEKEXP:STATE? SETUP | SAVED   NOT_SAVED                       |

## TEKEXP:VALUE

This command sets the value of parameters of type General, Acquire, Analyze, or DUTID.

**Syntax**    `TEKEXP:VALUE GENERAL,"<ParameterName>","<Value>"\n`  
               `TEKEXP:VALUE ACQUIRE,"<TestName>","<AcquireType>","<ParameterName>","<Value>"\n`  
               `TEKEXP:VALUE ANALYZE,"<TestName>","<ParameterName>".<Value>"\n`  
               `TEKEXP:VALUE DUTID,"<Value>"\n`  
               `TEKEXP:VALUE VERBOSE,{TRUE | FALSE}\n`  
               `TEKEXP:VALUE`  
               `WFMFILE,<Test_Name>,<Acquire_Type>,<FileName1$FileName2>\n`

**Inputs**    `ParameterName` - Specifies the parameter name  
               `TestName` - Specifies the test name  
               `AcquireType` - Specifies the acquire type  
               `Value` - Specifies the value to set  
               `FileName1$FileName2` - Specifies the waveform file name  
               `TRUE` - Pop-ups are enabled  
               `FALSE` - Pop-ups are disabled




---

**TIP.** Check Command parameters list section for *ParameterName*, *AcquireType*, and *Value* parameters.

---

**Outputs** NA

## TEKEXP:VALUE?

This command queries the value of the parameter for type General, Acquire, Analyze, or DUTID.

| Syntax   | Outputs  |
|--|--|
| TEKEXP:VALUE?<br>GENERAL,"<ParameterName>"\n                               | Returns the value of Parameter for type<br>GENERAL |
| TEKEXP:VALUE? ACQUIRE,"<TestName>",<br>"<AcquireType>","<ParameterName>"\n | Returns the value of Parameter for type<br>ACQUIRE |
| TEKEXP:VALUE? ANALYZE,<br>"<TestName>","<ParameterName>"\n                 | Returns the value of Parameter for type<br>ANALYZE |
| TEKEXP:VALUE? DUTID\n  | Returns the DUTID value                            |
| TEKEXP:VALUE?<br>WFMMFILE,<Test_Name>,<Acquire_Type>\n                     | Returns the waveform file name                     |
| TEKEXP:VALUE? VERBOSE  | Returns the verbose mode type                      |

**Inputs** ParameterName - Specifies the parameter name

TestName - Specifies the test name

AcquireType - Specifies the acquire type

TRUE - Pop-ups are enabled

FALSE - Pop-ups are disabled



**TIP.** Check Command parameters list section for ParameterName and AcquireType parameters.

**Outputs** Returns the value of Parameter for type GENERAL | ACQUIRE | ANALYZE | DUTID.

## Command parameters

This section provides the parameters list for the SCPI commands.

Specifies the Parameter Name and Value for DUT, Test selection, Acquisition, Configuration and Preferences tabs.

| Parameters                      | Description   |
|---------------------------------|---|
| DUT ID                          | Specifies the value parameters For DUTID, valid value is: Comment   |
| Acquiremode                     | Specifies the acquire mode parameters <ul style="list-style-type: none"> <li>■ Acquire live waveforms</li> <li>■ Use pre-recorded waveform files</li> </ul>   |
| Mode                            | <ul style="list-style-type: none"> <li>■ Compliance</li> <li>■ User Defined</li> </ul>  |
| Version                         | CTS 2.1   |
| Suite                           | <ul style="list-style-type: none"> <li>■ Source</li> <li>■ Sink</li> </ul>  |
| <b>Device Profile</b>           |   |
| Data Rate                       | For 3,6,8,10,12 <ul style="list-style-type: none"> <li>■ TRUE</li> <li>■ FALSE</li> </ul>   |
| Data Rate to run Minimum (Gbps) | 3   |
| Data Rate to run Maximum (Gbps) | 12  |
| Vterm(V)                        | 0 to 3.4  |
| EDID/SCDC Controller            | <ul style="list-style-type: none"> <li>■ None</li> </ul>  |
| Signal Validation               | <ul style="list-style-type: none"> <li>■ Prompt me if Signal Check Fails</li> <li>■ Skip Test if Signal Check Fails</li> <li>■ Turn Off Signal Check</li> </ul>   |
| Multi-Lane (Setup)              | <ul style="list-style-type: none"> <li>■ P76XX/P77XX</li> <li>■ Dual Stack               <ul style="list-style-type: none"> <li>■ Lane 0</li> <li>■ Lane 1</li> <li>■ Lane 2</li> <li>■ Lane 3</li> </ul> </li> </ul> |

**Table 16: Parameter Name and Value for Test Selection tab**

| Parameters | Description  |
|------------|--|
| Source     | Specifies the test measurement name <ul style="list-style-type: none"> <li>■ HFR1-1: DC Common Mode Voltage</li> <li>■ HFR1-2: Vse_max ,Vse_min</li> <li>■ HFR1-3: Rise/Fall Slew Rate</li> <li>■ HFR1-4: Inter-Pair Skew</li> <li>■ HFR1-5: FRL Rates</li> <li>■ HFR1-6: Data Jitter(RJ)</li> <li>■ HFR1-7: Data Eye Diagram</li> <li>■ HFR1-8: AC Common Mode Voltage</li> <li>■ HFR1-9: FFE Monotonicity-Method 1</li> <li>■ HFR1-9: FFE Monotonicity-Method 2</li> </ul> |
| Sink       | Specifies the test measurement name <ul style="list-style-type: none"> <li>■ HFR2-1: Max Differential Swing Tolerance</li> <li>■ HFR2-2: Intra-Pair Skew</li> <li>■ HFR2-3: Inter-Pair Skew</li> <li>■ HFR2-4: Minimum Link Rate Tolerance</li> <li>■ HFR2-5: Jitter Tolerance</li> </ul>  |

**Table 17: Parameter Name and Value for Acquisitions tab**

| Parameters              | Description   |
|-------------------------|---|
| Acquisition Options     | <ul style="list-style-type: none"> <li>■ Acquire all and analyze</li> <li>■ Acquire only</li> </ul> |
| Waveform Options        | <ul style="list-style-type: none"> <li>■ Retain</li> <li>■ Delete</li> </ul>                        |
| Show Acquire Parameters | <ul style="list-style-type: none"> <li>■ TRUE</li> <li>■ FALSE</li> </ul>                           |

**Table 18: Parameter Name and Value for Preferences tab**

| Parameters   | Description  |
|--|--|
| Number of Runs   |  |
| Acquire/Analyze each test                                    | <ul style="list-style-type: none"> <li>■ TRUE</li> <li>■ FALSE</li> </ul> 1 to 1000 times              |
| Popup Settings   |  |
| Auto close Warnings and informations during Sequencing       | <ul style="list-style-type: none"> <li>■ TRUE</li> <li>■ FALSE</li> </ul> Value to be given in seconds |
| Auto close Error Messages during Sequencing. Show in Reports | <ul style="list-style-type: none"> <li>■ TRUE</li> <li>■ FALSE</li> </ul> Value to be given in seconds |
| Show messages with a beep sound                              | <ul style="list-style-type: none"> <li>■ TRUE</li> <li>■ FALSE</li> </ul>                              |

**Table 19: Parameter Name and Value for General**

| Parameters                         | Description  |
|------------------------------------|--|
| Generate new report                | <ul style="list-style-type: none"> <li>■ TRUE</li> <li>■ FALSE</li> </ul>  |
| Append with previous run session   | <ul style="list-style-type: none"> <li>■ TRUE</li> <li>■ FALSE</li> </ul>  |
| Replace current test results       | <ul style="list-style-type: none"> <li>■ TRUE</li> <li>■ FALSE                             <ul style="list-style-type: none"> <li>■ in previous run, current session</li> <li>■ in any run, any session</li> </ul> </li> </ul> |
| Include Header in appended reports | <ul style="list-style-type: none"> <li>■ TRUE</li> <li>■ FALSE</li> </ul>  |
| Save As Type                       | <ul style="list-style-type: none"> <li>■ Web Archive (*.mht;*.mhtml)</li> <li>■ PDF (*.pdf)</li> <li>■ CSV (*.csv)</li> </ul>  |

| Parameters  | Description  |
|---|--|
| Auto increment report name if duplicate           | <ul style="list-style-type: none"> <li>■ TRUE</li> <li>■ FALSE</li> </ul>  |
| Create report automatically at the end of the run | <ul style="list-style-type: none"> <li>■ TRUE</li> <li>■ FALSE</li> </ul>  |
| Include pass/fail results Summary                 | <ul style="list-style-type: none"> <li>■ TRUE</li> <li>■ FALSE</li> </ul>  |
| Include detailed results                          | <ul style="list-style-type: none"> <li>■ TRUE</li> <li>■ FALSE</li> </ul>  |
| Include plot images                               | <ul style="list-style-type: none"> <li>■ TRUE</li> <li>■ FALSE</li> </ul>  |
| Include setup configuration                       | <ul style="list-style-type: none"> <li>■ TRUE</li> <li>■ FALSE</li> </ul>  |
| Include user comments                             | <ul style="list-style-type: none"> <li>■ TRUE</li> <li>■ FALSE</li> </ul>  |
| Margin value in percentage                        | <ul style="list-style-type: none"> <li>■ TRUE</li> <li>■ FALSE</li> </ul>  |
| View report after generating                      | <ul style="list-style-type: none"> <li>■ TRUE</li> <li>■ FALSE</li> </ul>  |
| Vertical Autoset                                  | <ul style="list-style-type: none"> <li>■ Auto</li> <li>■ Manual</li> </ul> |
| Vertical Offset(V)                                | 0 to 4   |
| Vertical Position(div)                            | -1 to 1  |
| Vertical Scale(mV)                                | 30 to 100  |
| Vertical Bandwidth                                | 0.5 to 21  |
| Horizontal Sampling Rate(GS/s)                    | 50 to 200  |
| Record Length                                     | 8000000 to 16000000  |
| Apply DE-Embed                                    | <ul style="list-style-type: none"> <li>■ TRUE</li> <li>■ FALSE</li> </ul>  |

**Table 20: Parameter Name and Value for Acquire**

| Test Name  | Acquire Type | Parameter Name     | Value |
|--|--------------|--------------------|-------|
| <ul style="list-style-type: none"> <li>■ HFR1-8: AC Common Mode Noise</li> </ul> |              | Bandwidth (3Gbps)  | 2 GHz |
|  |              | Bandwidth (6Gbps)  | 3 GHz |
|  |              | Bandwidth (8Gbps)  | 4 GHz |
|  |              | Bandwidth (10Gbps) | 5 GHz |
|  |              | Bandwidth (12Gbps) | 6 GHz |

**Table 21: Parameter Name and Value for Clock Recovery**

| Test Name   | Acquire Type | Parameter Name        | Value   |
|---|--------------|-----------------------|---|
| <ul style="list-style-type: none"> <li>■ HFR1-6: Data Jitter(RJ)</li> <li>■ HFR1-7: Data Eye Diagram</li> </ul> |              | PLL Model             | <ul style="list-style-type: none"> <li>■ Type I</li> <li>■ Type II</li> </ul> |
|   |              | 3Gbps : Loop BW(MHz)  | 0.000001 to 2500  |
|   |              | 6Gbps : Loop BW(MHz)  | 0.000001 to 2500  |
|   |              | 8Gbps : Loop BW(MHz)  | 0.000001 to 2500  |
|   |              | 10Gbps : Loop BW(MHz) | 0.000001 to 2500  |
|   |              | 12Gbps : Loop BW(MHz) | 0.000001 to 2500  |

**Table 22: Parameter Name and Value for Cable Settings**

| Test Name   | Acquire Type | Parameter Name         | Value  |
|---|--------------|------------------------|--|
| <ul style="list-style-type: none"> <li>■ HFR1-6: Data Jitter(RJ)</li> <li>■ HFR1-7: Data Eye Diagram</li> </ul> |              | Cable Model            | <ul style="list-style-type: none"> <li>■ SCM</li> <li>■ WCM</li> <li>■ Both</li> </ul>   |
|   |              | Crosstalk              | <ul style="list-style-type: none"> <li>■ With</li> <li>■ Without</li> <li>■ Both</li> </ul>  |
|   |              | Equalizer Options      | <ul style="list-style-type: none"> <li>■ CTLE+DFE</li> <li>■ CTLE</li> </ul>   |
|   |              | CTLE                   | <ul style="list-style-type: none"> <li>■ SCM (dB) <ul style="list-style-type: none"> <li>■ 1 to 8 , All</li> </ul> </li> <li>■ WCM (dB) <ul style="list-style-type: none"> <li>■ 1 to 8 , All</li> </ul> </li> </ul> |
|   |              | Apply Custom Mask File | <ul style="list-style-type: none"> <li>■ TRUE</li> <li>■ FALSE</li> </ul>  |

## Examples

| Example   | Description   |
|---|---|
| TEKEXP:*IDN?  | It returns the active TekExpress application name running on the scope.   |
| TEKEXP:*OPC?  | It returns the last command execution status.   |
| TEKEXP:ACQUIRE_MODE PRE-RECORDED                                  | It sets the acquire mode as pre-recorded.   |
| TEKEXP:ACQUIRE_MODE?  | It returns LIVE when acquire mode is set to live.   |
| TEKEXP:EXPORT REPORT  | It returns the report file in bytes. This can be written into another file for further analysis.  |
| TEKEXP:INFO? REPORT   | It returns "100,"ReportFileName.mht", when 100 is the filesize in bytes for the filename ReportFileName.  |
| TEKEXP:INFO? WFM  | It returns "100,"WfmFileName1.wfm";"200,"WfmFileName2.wfm" when 100 is the filesize in bytes for the filename WfmFileName1.wfm and 200 is the filesize in bytes for the filename WfmFileName2.wfm.            |
| TEKEXP:INSTRUMENT "Real Time Scope",DPO72504D ( GPIB8::1::INSTR ) | It sets the instrument value as DPO73304SX ( GPIB8::1::INSTR ) for the selected instrument type Real Time Scope.  |
| TEKEXP:INSTRUMENT? "Real Time Scope"                              | It returns "DPO73304SX ( GPIB8::1::INSTR )", when DPO73304SX ( GPIB8::1::INSTR ) is the selected instrument for the instrument type Real Time Scope.  |
| TEKEXP:LASTERROR?   | It returns ERROR: INSTRUMENT_NOT_FOUND, when no instrument is found.  |
| TEKEXP:LIST? DEVICE   | It returns "Source" when Source is the available suite.   |
| TEKEXP:LIST? INSTRUMENT,"Real Time Scope"                         | It returns "DPO73304SX ( GPIB8::1::INSTR ),DPO73304SX ( TCPIP::134.64.248.91::INSTR )" when DPO73304SX ( GPIB8::1::INSTR ), DPO73304SX ( TCPIP::134.64.248.91::INSTR ) are the list of available instruments. |
| TEKEXP:MODE COMPLIANCE  | It sets the execution mode as compliance.   |
| TEKEXP:MODE?  | It returns COMPLIANCE when the execution mode is compliance.  |
| TEKEXP:POPOPUP "OK"   | It sets OK as the response to active popup in the application.  |
| TEKEXP:POPOPUP?   | It returns "OK", when OK is the active popup information shown in the application.  |
| TEKEXP:REPORT GENERATE  | It generates report for the current session.  |
| TEKEXP:REPORT? "Scope Model"                                      | It returns "DPO73304SX" when DPO73304SX is the scope model.   |
| TEKEXP:REPORT? "DUT ID"   | It returns "DUT001" when DNI_DUT001 is the DUT ID.  |
| TEKEXP:RESULT? "HFR1-1: DC Common Mode"                           | It returns Pass, then the test result is Pass.  |
| TEKEXP:RESULT? "HFR1-1: DC Common Mode", "Margin"                 | It returns list of values then that is 'Margin' column data.  |
| TEKEXP:RESULT? TEKEXP:RESULT? "HFR1-1: DC Common Mode", "Units",0 | It returns the unit of the first row of result.   |
| TEKEXP:SELECT DEVICE,"FRL"  | It selects device as "Source".  |
| TEKEXP:SELECT TEST,"HFR1-1: DC Common Mode", TRUE                 | It selects "HFR1-1: DC Common Mode" measurement.  |
| TEKEXP:SETUP DEFAULT  | It restores the application to default setup.   |
| TEKEXP:STATE STOP   | It stops the test execution.  |

---

| Example   | Description  |
|---|--|
| TEKEXP:STATE?   | It returns as READY when the application is ready to run next measurement.               |
| TEKEXP:STATE? SETUP   | It returns as NOT_SAVED when the current setup is not saved.                             |
| TEKEXP:VALUE GENERAL, "3 Gbps", " False "                             | It selects 3 Gbps data rate in the DUT panel by deselecting checkbox.                    |
| TEKEXP:SELECT TEST , "HFR2-1: Max Differential Swing Tolerance", True | The test "HFR2-1: Max Differential Swing Tolerance" is selected in test selection panel. |
| TEKEXP:VALUE GENERAL, "Execute", "Verify Calibration"                 | It selects verify calibration in the drop-down from DUT panel.                           |



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