User's Guide │ LUNA 6415

Class 1 Laser Product
Appareil Laser Classe 1
Laser Produkt Klass 1
IEC60825-1, 2014
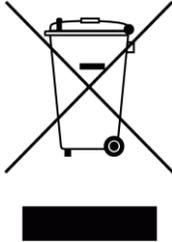
Many regions prohibit the disposal of WEEE (Waste Electrical and Electronic Equipment) in the normal waste stream, to comply with the Restriction of Hazardous Substances (RoHS) released into the environment. Please contact your local waste authority for instructions on proper recycling of the electronic product(s) described in this *User Guide*.

User's Guide *LUNA 6415*
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Luna Innovations Inc.
3155 State Street
Blacksburg, VA 24060
Phone: (866) 586-2682
Fax: (540) 961-5191
E-mail: solutions@lunainc.com
Web: www.lunainc.com

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1 Safety

The advisory words **Danger**, **Warning** and **Caution** used in this manual identify the level of hazard that may be encountered by the user.

- **DANGER** means if the danger is not avoided, it will cause death or serious injury.

- **WARNING** means if the warning is not heeded, it can cause death or serious injury.

- **CAUTION** means if the precaution is not taken, it may cause minor or moderate injury.

⚠ Warning

The protection provided by the equipment may be impaired if the equipment is used in a manner not specified by the manufacturer, resulting in serious injury or death.

The power cord is the main electrical disconnect for this equipment. If it is necessary to ensure no power to the unit, remove the power cord.

The use of controls, adjustments, performance, or procedures other than those specified herein may result in hazardous laser radiation exposure and one or more safety protections may be impaired or rendered ineffective.

⚠ Attention

La protection fournie par l'équipement peut être compromise si l'équipement est utilisé d'une manière non spécifiée par le fabricant, entraînant des blessures graves ou la mort.

Le cordon d'alimentation est le principal disjoncteur électrique de cet équipement. S'il est nécessaire de ne pas mettre l'appareil hors tension, retirez le cordon d'alimentation.

L'utilisation de commandes, d'ajustements, de performances ou de procédures autres que celles spécifiées ici peut entraîner une exposition dangereuse au rayonnement laser et une ou plusieurs protections de sécurité peuvent être altérées ou rendues inefficaces.

2 Technical Support

If you have concerns with or questions about the information contained in this document, contact our technical support staff using one of the following methods:

2.1 Mail

Luna Innovations Inc.
3155 State Street
Blacksburg, VA 24060

2.2 Phone

Main Phone: (540) 961-5190
Toll-Free Support: 1.866.LUNA OVA (866.586.2682)

2.3 E-mail

support@lunainc.com

www.lunainc.com

3 Overview and Setup

The Luna 6415 is a fast and simple-to-use analyzer for passive optical components and modules. The Luna 6415 extends the industry-leading optical frequency domain reflectometry (OFDR) platform from Luna Innovations to manufacturing test and quality control applications.

Unlike traditional passive component testers, the Luna 6415 measures and analyzes the Insertion Loss (IL) and Return Loss (RL) distribution, as well as length, working in either reflection or transmission. The Luna 6415 features extremely high sensitivity, 20 µm spatial sampling resolution, and very fast scanning for high test throughput.

This user's guide covers how to set up and use the application software. Please refer to the Luna 6415 Setup Guide for information regarding the proper methods of setting up and maintaining the hardware.

4 User Interface

Let us take a tour of the application's User Interface (UI). The tour will start with an introduction to the UI layout, then further explains each UI components which includes Delay Plot, Spectral Plot, Event Table, Measurement Control and Information displays.

4.1 UI Layout Overview

After you power on the system and start the Luna 6415 software on the controller PC, the application UI screen will appear on the PC screen. The system will initialize, then launch the hardware in reflection mode and display one measurement result on the screen. The image below (Figure 1) is an illustration of a typical UI screen layout with all optional displays turned on for a reflection measurement (for a transmission measurement, UI layout is pretty much same except for the omitting of all elements related to return loss).

The upper section of UI screen is for the display of Measurement Controls and Information.

The lower section of UI screen is the Delay Plot (UPPER LEFT side) along with an optional Spectral Plot (LOWER LEFT side) and an optional Event Table (RIGHT side). The Delay Plot would be scaled to take up the whole lower section area if the optional displays are turned off (which is the default when the system is just powered up).

Each of the above UI components is further explained in the following titled sections, respectively.
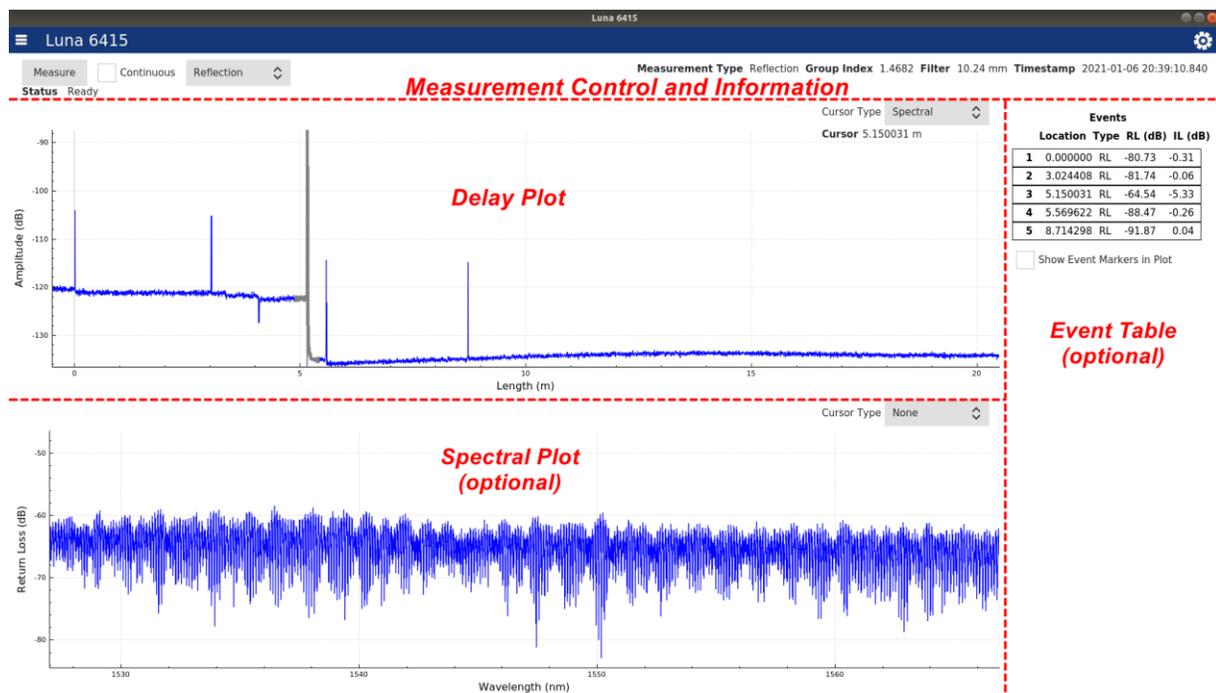
Figure 1 UI Screen Layout

4.2 Delay Plot

When you first open the application, the UI screen appears with the Delay Plot. The Delay Plot screen displays acquired measurements in the Time Delay Domain (reflection amplitude vs time of flight, or reflection amplitude vs length).

The plot x-axis unit can be displayed in one of the following four options: m, mm, inch and ns.
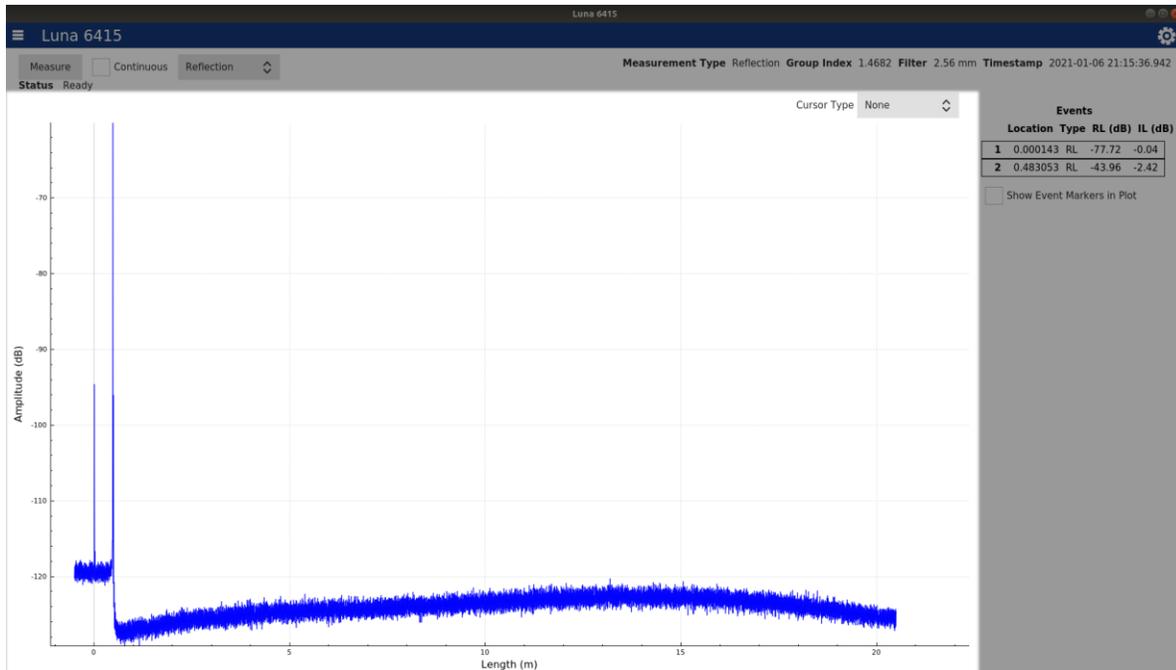
Figure 2 Delay Plot

The Delay Plot Screen allows the user to change the Cursor Type to one of four possible values by choosing a Cursor Type selection in the upper right area of the plot:

- None – Only the graph of the acquired data is displayed

- Single – A single vertical cursor is shown that allows for RL and IL measurements to be made

- Vertical – Two vertical cursors are shown that can be used to make length measurements

- Horizontal – Two horizontal cursors are shown that can be used to make IL measurements and compare the reflectivity of various features in the measurement

- Spectral – A single vertical cursor allows users to select a windowed range in the Delay Plot and then viewing a calculated metric (e.g., return loss) in Spectral Plot; it is only available for selection when "Spectral Plot" option is enabled in measurement settings.

Cursors can be moved by dragging them across the screen by using touchpad or mouse. When the cursors are selected and are being moved, they will change color to black (The cursor turns black

when you press it, indicating that it can be moved). Clicking once on the cursor will cause it to snap to the highest point within its highlighted zone.

4.2.1 Plot Navigation

The plots shown in the LUNA 6415 user interface can all be manipulated through mouse or touchpad actions on the laptop PC.

Panning – The plot can be panned over the X and Y axes by pressing and dragging at any point within the plot.

Zooming – The plot can be zoomed using a two-finger pinch or expanding motion at any point within the plot on touchpad or scrolling wheel on a mouse.

Constrained Panning or Zoom – It is possible to constrain the panning and zooming to one of the two axes by first left clicking on the desired axis. It will turn blue while panning and zooming are constrained.

Plot Rescaling – Double click on an axis to scale it to fit all data in the range.

4.2.2 Single Cursor

The single cursor view provides a single vertical cursor with integration regions for measurement of both the RL and IL across an event. The region with red highlighting is integrated to provide a RL measurement. The two regions with grey highlighting are used to compute the IL. The corresponding RL Width and IL Width can be change in Measurement Tab (Refer to "4.5.2.1 Measurement Tab").
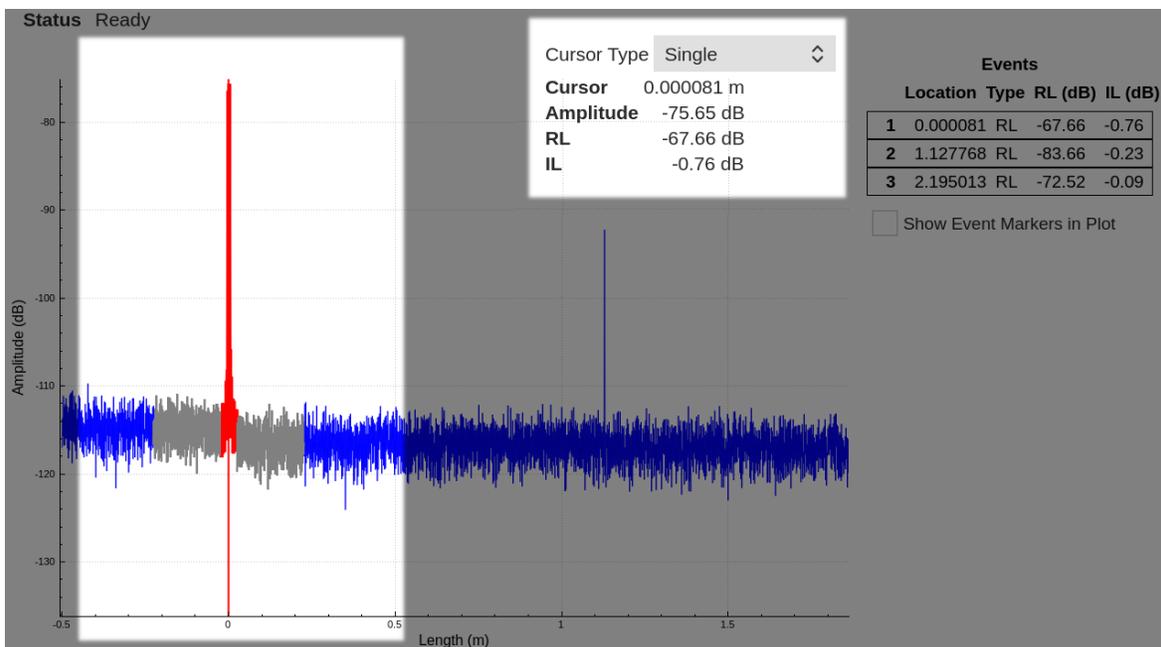
Figure 3 Single Cursor view

4.2.3 Vertical Cursor

The vertical cursor view provides two cursors that can be used to measure the length between two events or measure the IL over any distance. The RL, position, and IL information is shown in the upper right area of the plot, under the Cursor Type selection.
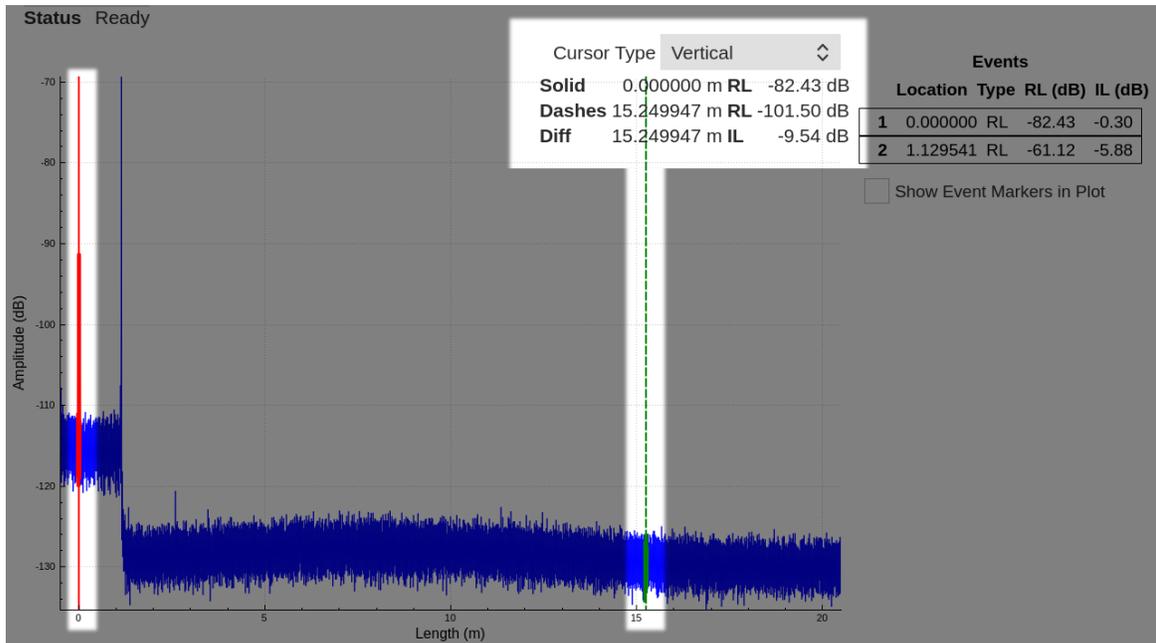
Figure 4 Vertical Cursor view

4.2.4 Horizontal Cursors

The horizontal cursors are used to compare the amplitude of two events in the data.
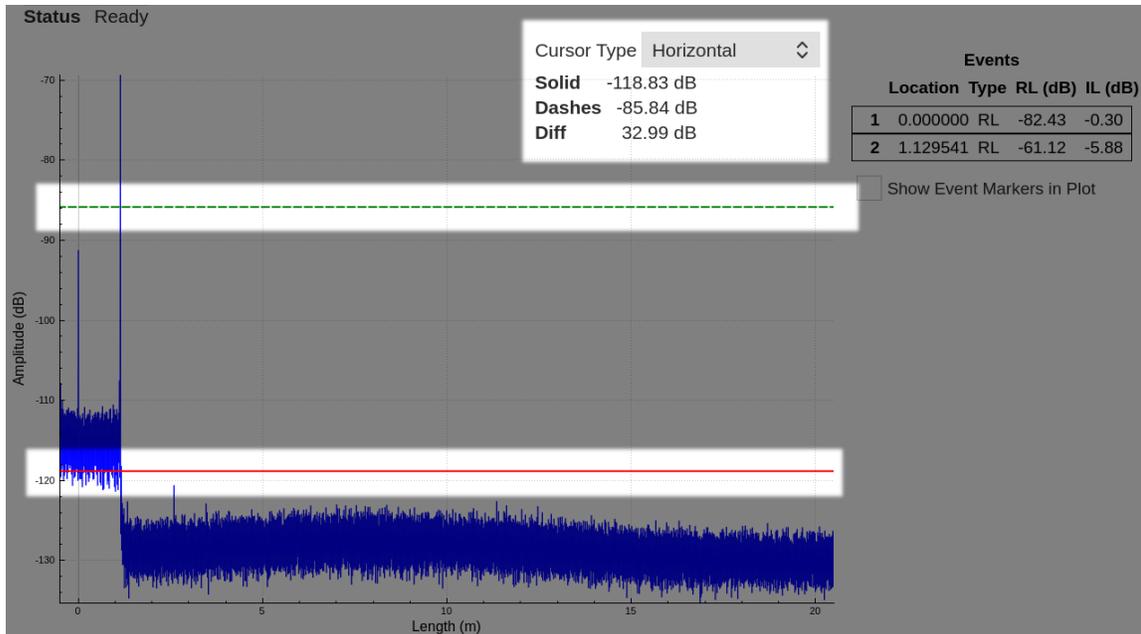
Figure 5 Horizontal Cursor view

It is important to remember that the amplitude data can be shown with varying levels of filtering which may make reflection peaks look smaller than they truly are.

4.2.5 Spectral Cursor

The cursor is only available for selection when "Spectral Plot" option is enabled in measurement settings. The single vertical cursor is used to select a windowed range in the Delay Plot and then viewing a calculated metric (e.g., return loss) in Spectral Plot. More on its usage and Spectral Plot is introduced in next section.

4.3 Spectral Plot

4.3.1 Spectral Plot Overview

When "Spectral Plot" option is enabled in Settings and Tools (refer to Section "4.5.2.1 Measurement Tab"), a single vertical Spectral Cursor is displayed in the upper Delay Plot, meanwhile the calculated Spectral Loss of the given set of data (defined by the Spectral Cursor) is displayed as a function of optical wavelength in the lower Spectral Plot.
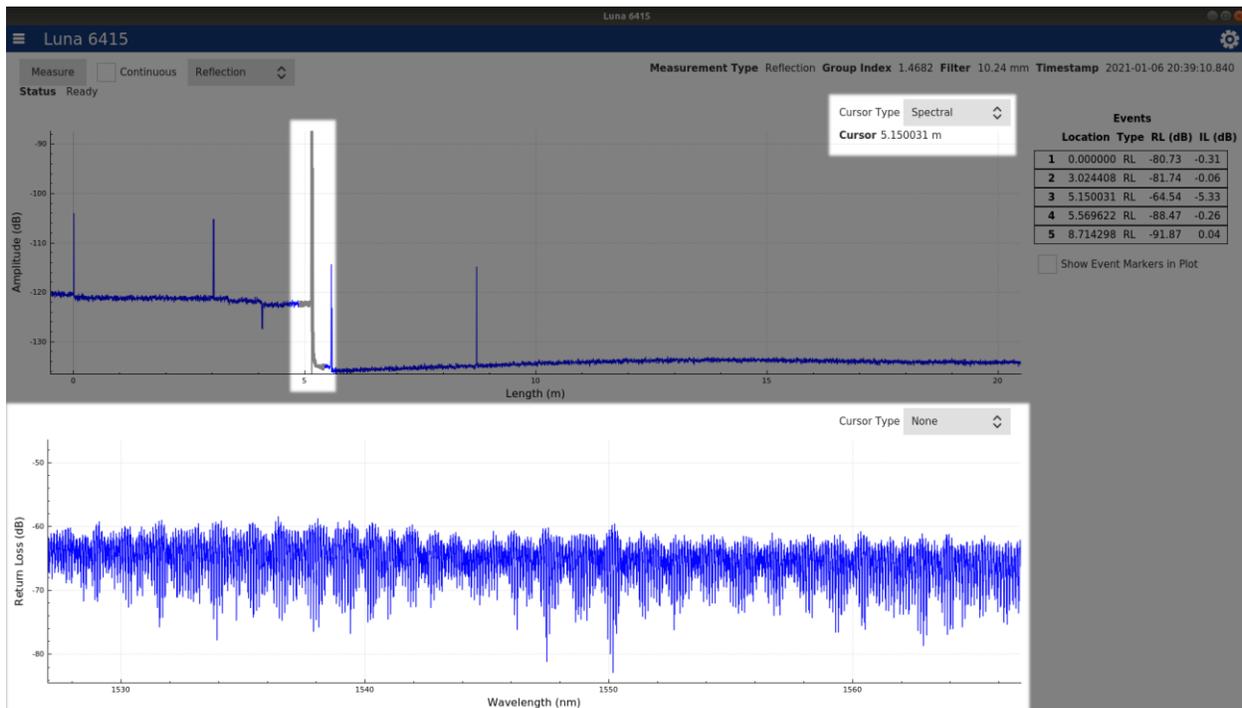
Figure 6 Spectral Plot

4.3.2 Turn Spectral Plot Display On/Off

Spectral Plot is not displayed by default after you first open the application. The Spectral Plot (as well as Spectral Cursor in the Delay Plot) is only available when "Spectral Plot" option is enabled in measurement settings, which can be achieved by check the "*Spectral Plot*" view control in Settings and Tools (please refer to "4.5.2.1 Measurement Tab"). You can turn the Spectral Plot display back off, by unchecking the "*Events*" view control in Settings and Tools (giving its display estate to the Delay Plot so that the Delay Plot can be shown on a larger area).

4.3.3 Operations on Spectral Plot

By manipulating the Spectral Cursor, the users can define a range of Time Delay Domain data that is used to perform the analysis of the spectral loss in the program. The location of the Spectral Cursor

data selection range in the Delay Plot can be changed by moving the cursor to different locations in the plot; also the width of the data selection range can be change by changing the Spectral Cursor width setting in the Measurement Tab (in the Settings and Tools, please refer to "4.5.2.1 Measurement Tab").

In viewing the Spectral Plot (like it in the Delay Plot), the user has options of utilizing several types of cursors to analyze the plot data. The application allows the user to change the Cursor Type of the Spectral Loss graph to one of three possible values:

- None – Only the graph of the acquired data is displayed, no characteristics of the data are shown.
- Vertical – using two vertical cursors, displays the location at each cursor and the difference between them.
- Horizontal – using two horizontal cursors, displays the amplitude at each cursor location along with the difference between them.

4.4 Event Table

The Event Table of the Luna 6415 software displays the applicable return loss (RL) and insertion loss (IL) events detected in the Time Delay Domain and gives location, return loss, and insertion loss data for those events.
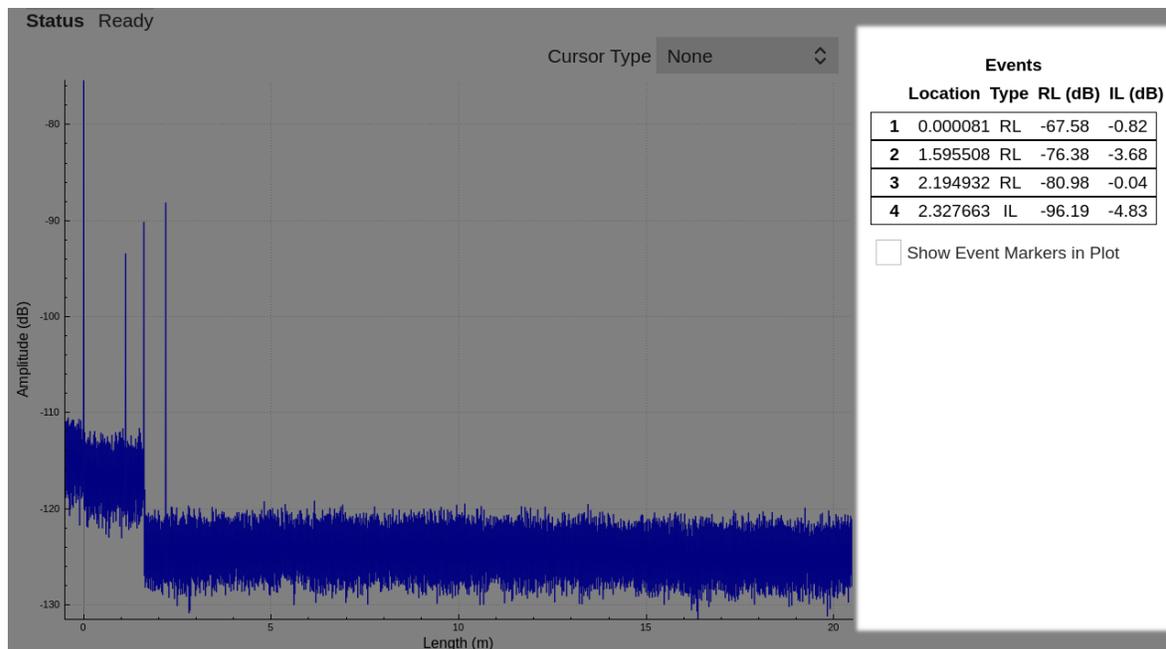
Figure 7 Event Table

4.4.1 Events

The Lightwave Analyzer can display an Event Table showing the most significant return loss and insertion loss events found in the current measurement.

A number of parameters affect the event calculations:

- Min Location

- Max Location

- RL Threshold

- IL Threshold

The RL Width and IL Width controls (which affect the single cursor) affect the RL and IL calculations, which in turn affects the events reported in the Event Table.

A return loss event occurs when the return loss at a particular location is greater than the surrounding return loss by the RL Threshold. The return loss at each location is compared to the return loss before and after it by a distance of RL Width.

An insertion loss event occurs when the insertion loss at a location is greater than (i.e. more negative than) the IL Threshold.

Return loss events take precedence over insertion loss events. Return loss events often have significant insertion loss. The event table displays a single return loss event instead of reporting a return loss and insertion loss event at the same location.

The min and max locations can be used restrict the event reporting to a certain area of the measurement.

4.4.2 Turn Event Table Display On/Off

Event Table is displayed by default after you first open the application. Yet you have the option of not showing the Event Table (giving its display estate to the Delay Plot so that the plot can be shown on a larger area), which can be achieved by uncheck the "*Events*" view control in Settings and Tools (please refer to "4.5.2.1 Measurement Tab"). You can turn the Event Table display back on, by checking the "*Events*" view control in Settings and Tools.

4.4.3 Event Marks in the Delay Plot

You can check/enable the "*Show Event Markers in Plot*" checkbox to show vertical markers on all event locations.
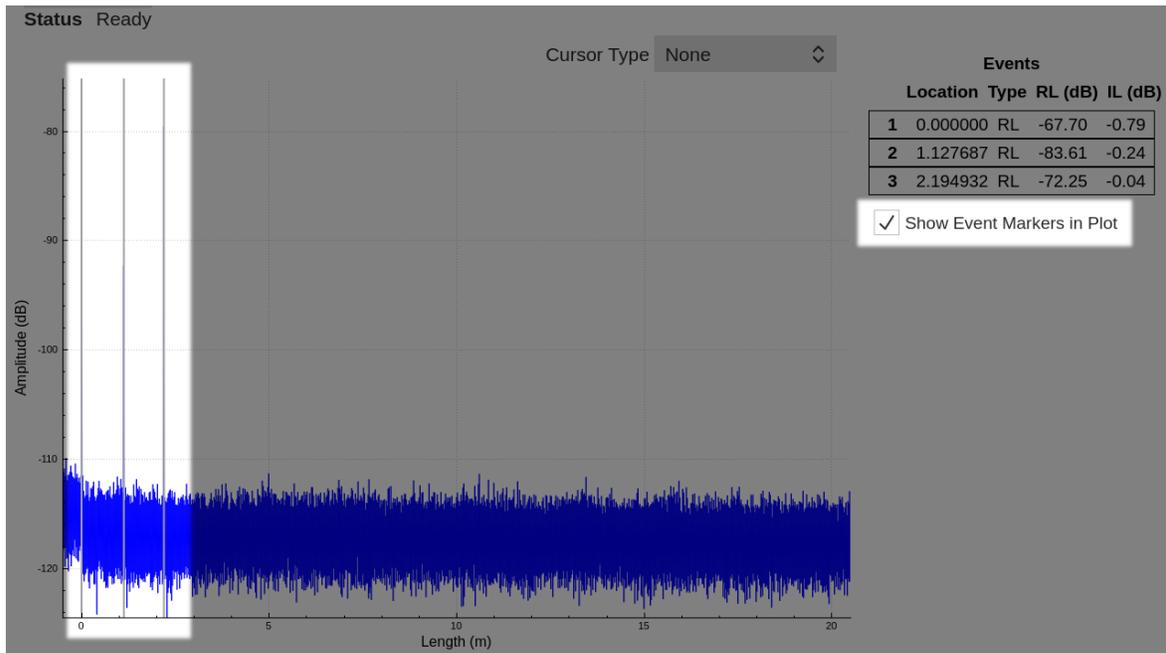
Figure 8 "Show Event Markers in Plot" enabled, showing vertical markers on all event locations.

Clicking an individual event draws a marker at that event location. Clicking the event again removes the marker. If you are using Single, or Vertical cursors, clicking an Event table entry snaps the closest cursor to that event location.
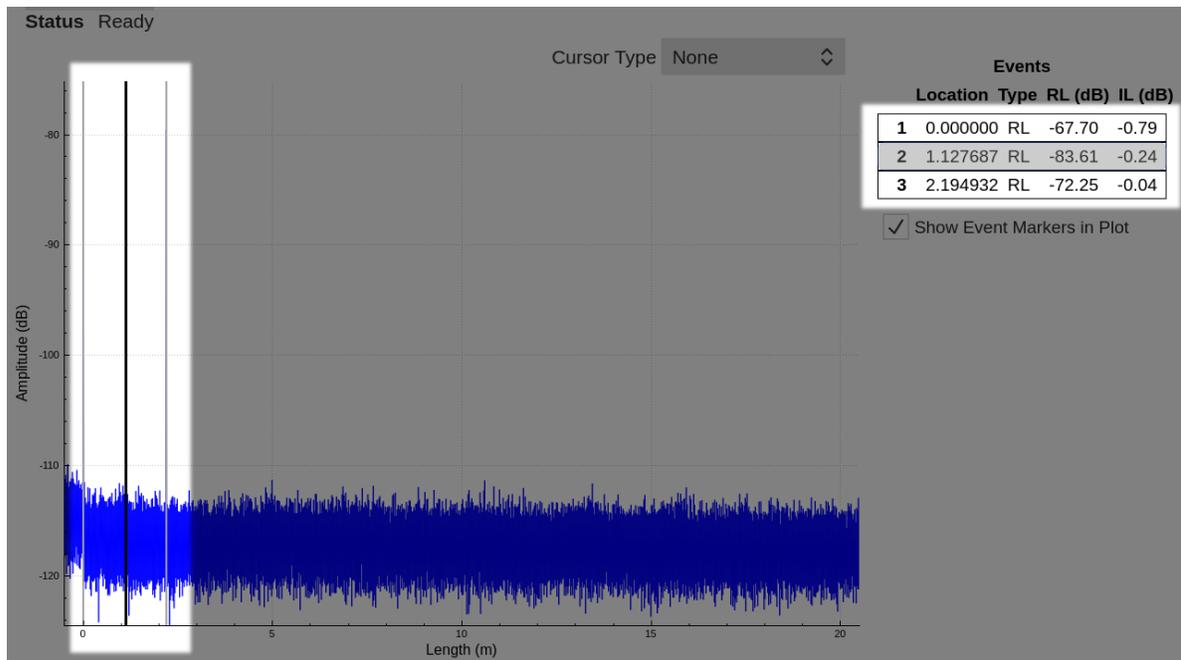
Figure 9 Clicking an individual event draws a mark at that event location (event 2 in example)

Double clicking an entry in the event table zooms the plot to that event's location.
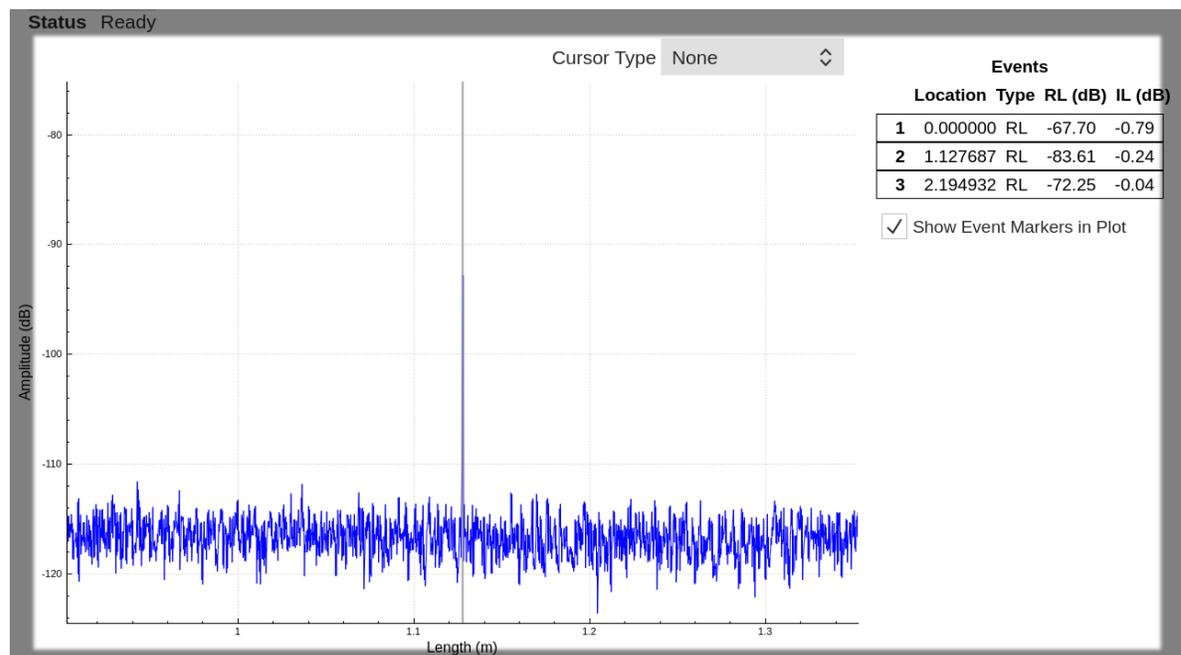
Figure 10 Zooms plot to an individual event's location by double clicking its entry in event table (event 2 in example)

4.5 Measurement Control and Information

4.5.1 Overview

Most of items in the Measurement Control and Information section on the top of the UI screen are explicit and straightforward. For example, a "*Measure*" button to initiate a measurement, the options to make only one single measurement or continuous measurement by uncheck/check the "*Continuous*" checkbox, the option to switch the measurement type between "*Reflection/Transmission"* types, a timestamp to display the date and the time of the measurement taken, a battery indicator, etc.

In this section, focus of introduction is mainly on 1) the "Settings and Tools" that can be opened by clicking the Gear Tool Icon on the upper right corner of the screen; and 2) the "File Operations" menu can be opened by clicking the Menu Button Icon on the upper left corner of the screen.
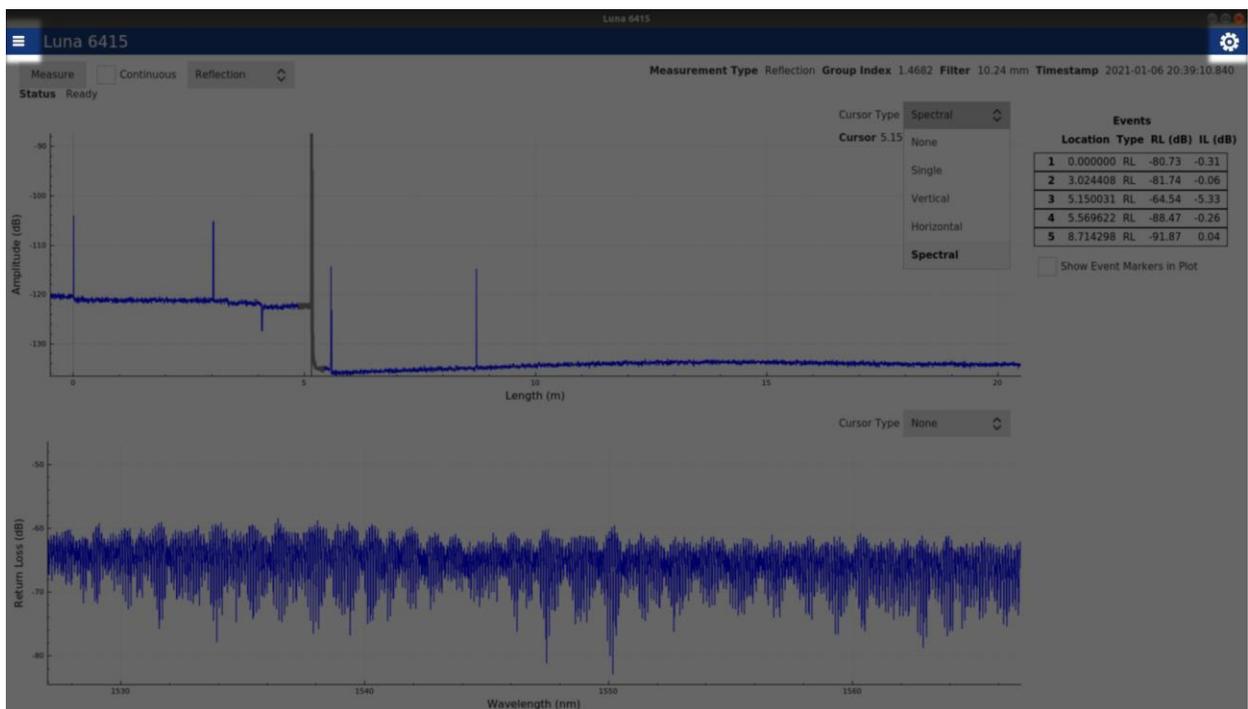
Figure 11 "Settings and Tools" can be opened by clicking on the gear tool icon in upper-right corner of the screen; and "File Operation" menu can be opened by clicking on Menu button icon in the upper-left corner of the screen.

4.5.2 Settings and Tools

Once the Gear Tool Icon is opened, "Settings and Tools" contains are shown/grouped in three display tabs titled *Measurement*, *System* and *About* respectively. The three tabs can be switched by clicking the tab titles on the top.

4.5.2.1 Measurement Tab

As shown in Figure 12, there are three groups of control options in the Measurement Tab, which are titled as Measurement Options, Event Options and View.

Measurement Options

- *Group Index* – allows the user to specify the group index of refraction (range: 1 – 4).

- *RL Width* and *IL Width* – allow the user to change the width of the integration regions that are used for return loss and insertion loss measurements. In the Delay Plot, the single cursor view provides a single vertical cursor with integration regions for measurement of both the RL and IL across an event. The region with red highlighting is integrated to provide a RL measurement. The two regions with grey highlighting are used to compute the IL.

- *Length* – allow the user to change the measurement range among 20 meter, 50 meter and 100 meter options.

Event Options (would be grayed out/disabled if *Events* is unchecked)

- *Min Location* and *Max Location* – allows the user to specify the length/location range of events reported in the Event Table.

- *RL Threshold* and *IL Threshold* – allows the user to specify threshold value for RL or IL for its qualified as RL or IL events and to be reported in the Event Table.

View

- *Gaussian Filter* – if checked (by default), applies a Gaussian filter to the data to smooth out the graph. This is turned on by default.

- *Filter Size* – sets the Gaussian Filter width in mm, options are 0.16mm, 0.32mm, 0.64mm, 1.28mm, 2.56mm, 5.12mm and 10.24mm (default).

- *Length unit* - The plot x-axis unit can be displayed in one of the following four options: m (default), mm, inch and ns.

- *Events* – If checked (unchecked by default), Event Table is displayed in UI. If unchecked, Event Table is not displayed in UI, and Event Options settings would be disabled (grayed out).

Figure 12 Measurement tab

4.5.2.2 About Tab

The About tab screen displays the system model (Luna 6415), installed Software version and Firmware (FPGA and FX3) version information. It also provides a control for Software Update. If the controller PC is connected to a network, the network port # is also displayed in the About (When unitizing SCPI for supported remote applications, the port # can be referred to for establish of the connection between the controller PC and remote PC).

Figure 13 About Tab

4.5.3 File Operations

The "File Operations" menu can be opened by clicking the Menu Button Icon on the upper left corner of the screen.

Once the menu is opened, "File Operations" contains five menu items: 1) Save File, 2) Load File, 3) Delete File(s), 4) Manage Configurations and 5) Exit. The user can open any one of the menu items by click on its menu title to continue with its relevant operations.
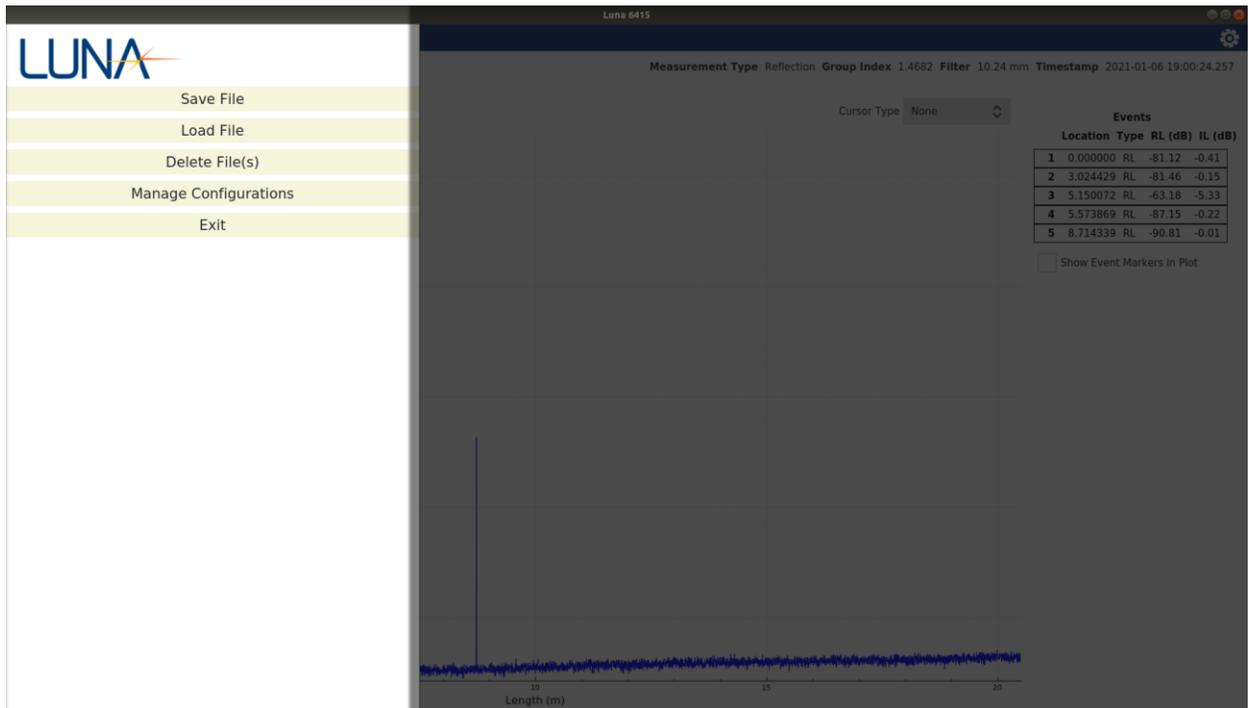
Figure 14 File Operation Menu

4.5.3.1 Save File

Clicking "Save File" menu item, the users open the "Save Measurement File" dialogue screen, which allows user to save the latest measurement data to system's internal storage. In the dialogue screen, the users will need to type in a unique filename of user's choice; the users also have the options to save result as the raw date file (as Measurement File option) and/or delimited spreadsheet file (TSV Data File option).   For the TSV Data File, the users have option to save a combination of the following measurement results: Delay Domain Plot result, Spectral Domain Plot result and Events result; Instead of the full measurement length, users also have the option to save a subsection of the Delay Domain Plot data in TSV file.

Save Measurement File

Filename	measurement filename	
✓ Measurement File		
✓ TSV Data File		
	✓ Delay Domain Plot	
	☐ Save segment Start (m) 4 End (m) 5	
	✓ Spectral Domain Plot	
	✓ Events	

Cancel	Save

Figure 15 Save Measurement File dialogue

Files are saved to the directory /cust/data.

Starting in software version 2.6.0, measurements files are saved as a single file with a .ofdr extension. Earlier software version created two files when saving a measurement file: a .ofdr file and a larger .bin file. Both the .bin and .ofdr file must be present in the /cust/data directory in order to load the measurement.

4.5.3.2 Load File

Clicking "Load File" menu item, the users open the "Select File to Load" dialogue screen, which allows the users to select one saved Measurement File and to load its measurement result to display back on the screen, with the loaded filename displayed on the top of the screen.

Select File to Load: test A --   2021-01-06 20:46:41.403

Test B
test A
test C

Cancel	Open
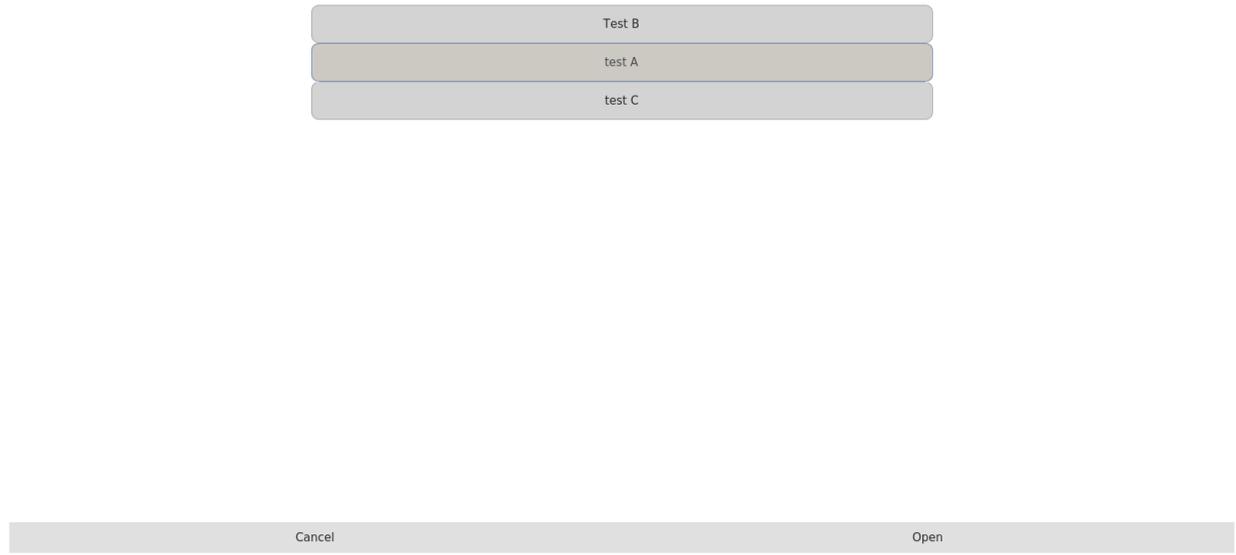
Figure 16 Load File dialogue
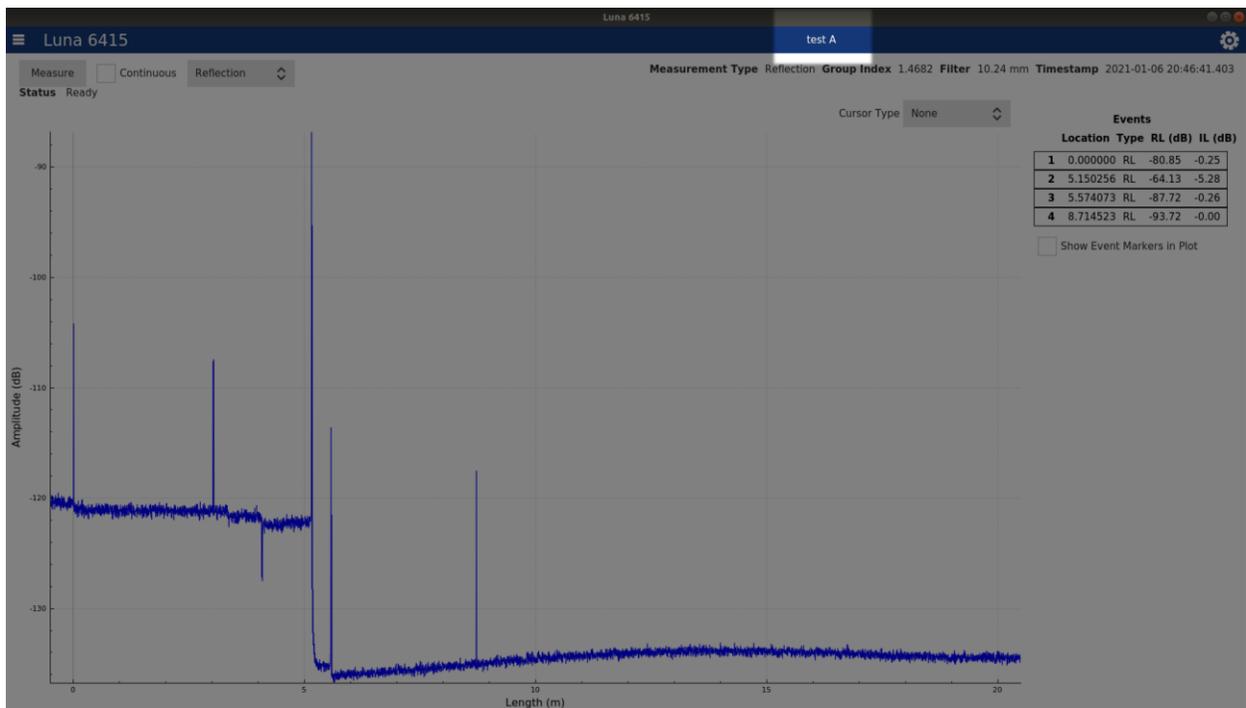
Figure 17 Test name is displayed on the top of screen after a test file is loaded

4.5.3.3 Delete File

Clicking "Delete File" menu item, the users open the "Select File to Delete" dialogue screen. Once in the dialogue screen, the users can select one or more Measurement File(s) by using the check the box(s). After complete selecting the check box(s), the users can press OK button to proceed; and the program will provide warning and ask the users to confirm the file delete selection for one more time before the selected file(s) is deleted permanently.

Select Files to Delete	
✓	001
✓	002
☐	4a001-50m
☐	4a002-20m
☐	4b001-50m
☐	4b002-20m
☐	A1
☐	B1
☐	GC on A
☐	GC on A 50m
OK	Cancel

Figure 18 Delete File dialogue

4.5.3.4 File Location

Should a user want to copy the saved TSV files to a different computer, the saved files can be found in the following location in the Controller PC:

"Computer/cust/data"

For reference, "Computer" can be readily accessed by clicking "Other Locations" in Nautilus (Default Ubuntu File Manager).
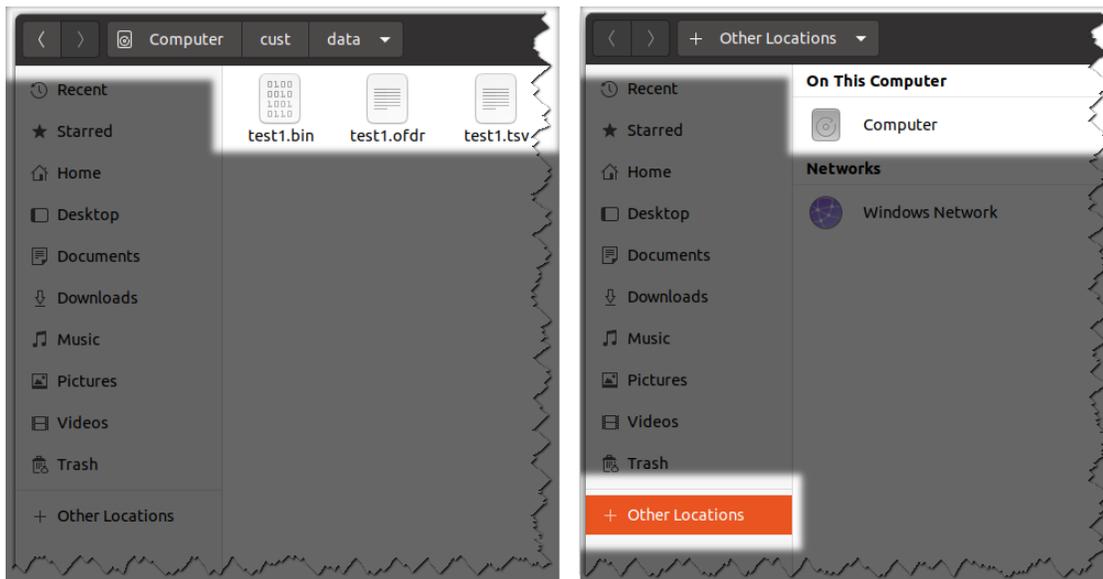
Figure 19 Saved data file location (displayed in Nautilus)

4.5.3.5 Manage Configurations

Once the Manage Configurations menu is opened, its dialogue page contains are shown/grouped in three display tabs titled Save Configuration, Load Configuration, Startup Configuration and Delete Configuration(s) respectively. The four tabs can be switched by clicking the tab titles on the top.

4.5.3.5.1 Save Configuration Tab

The "Save Configuration" tab allows the users to save the Measurement Options currently in use in the program, with a unique Configuration name of user's choice. The user can then reuse the same Measurement Options by loading the saved configuration into the program at a later time.

Figure 20 Save Configuration Tab

4.5.3.5.2 Load Configuration Tab

The "Load Configuration" tab allows the users to load a previously saved configuration into the program so the users can reuse previous Measurement Options.
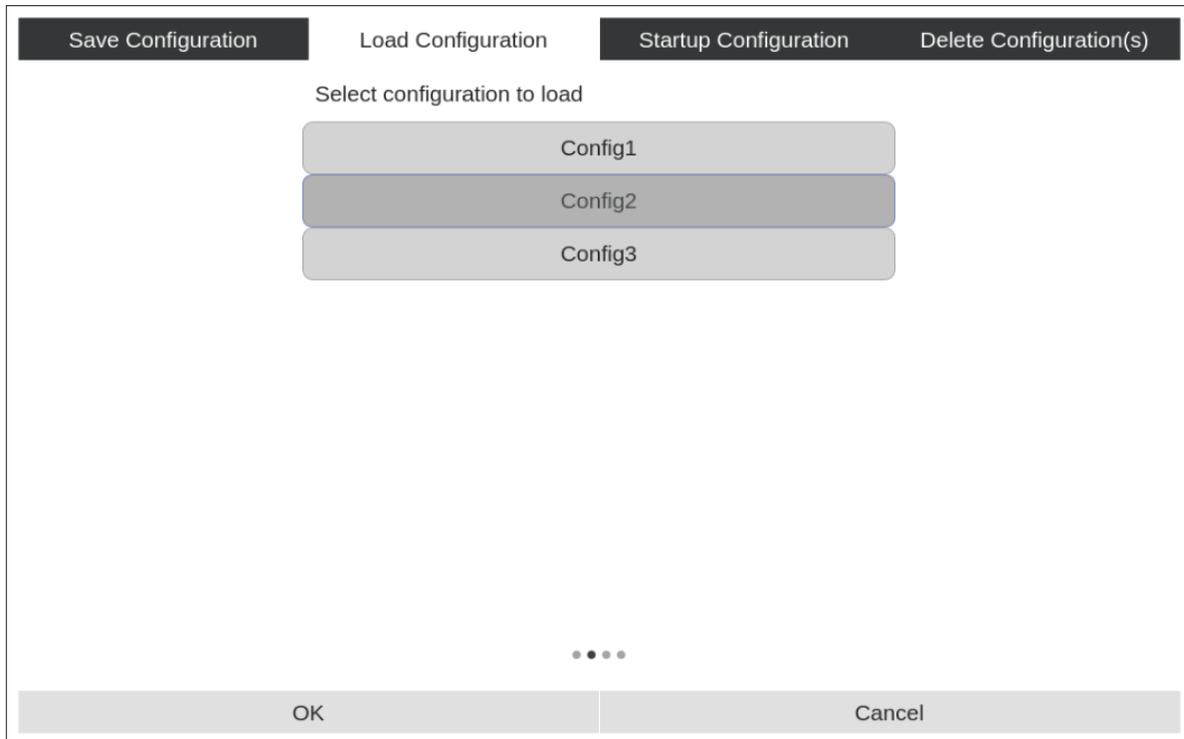
Figure 21 Load Configuration Tab

4.5.3.5.3 Startup Configuration Tab

The "Startup Configuration" tab allows the users to setup the program to load a specific previously saved configuration on the program startup. The users can enable it by choosing a previously saved configuration (clicking on the name to highlight it) and make sure the check box on the top of the configuration list is checked.   To disable this, the users can simply uncheck the check box on the top of the configuration list.
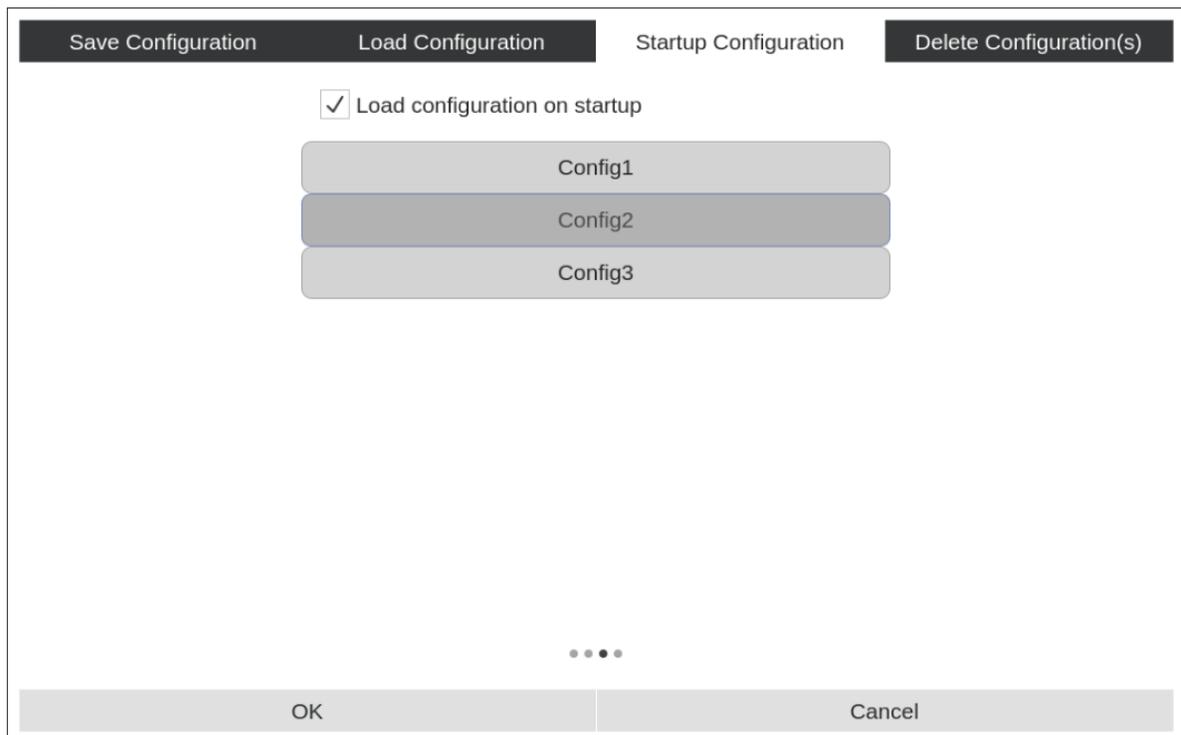
Figure 22 Startup Configuration Tab

4.5.3.5.4 Delete Configuration Tab

The "Delete Configuration" tab allows the users to delete previously saved configuration(s). In the tab, the users can select one or more Configuration(s) by using the check the box(s). After complete selecting the check box(s), the users can press OK button to proceed; and the program will provide warning and ask the users to confirm the delete selection for one more time before the selected configuration(s) is deleted permanently.

Figure 23 Delete Configuration Tab

5 SCPI Interface

5.1 Introduction to SCPI

SCPI commands may be sent to the controller over a network interface using the TCP/IP protocol. The IP address of the controller is displayed in the "About" settings page for your reference.

Port 5025 is used to communicate with the controller over a raw TCP/IP socket connection. Use this port when sending SCPI commands from most all programs since it is more compliant with the SCPI standard than port 5024.

Port 5024 is used to communicate with the controller using a telnet client. Use this port when you are sending SCPI commands manually. This port has several advantages over port 5025 for manual use:

(1) Telnet parameters are negotiated when a connection is established. This configures local echo and line termination automatically so that your telnet client behaves as expected.

(2) A prompt (">") is displayed when the SCPI parser is ready to accept another command. This makes it clearer that the previous command has completed execution.

(3) The :SYSTem:ERRor[:NEXT]? query is automatically performed after each program message completes execution. This makes it harder for the user to overlook an error when it occurs.

(4) Several command-line keyboard shortcuts are enabled to improve the user experience. These shortcuts should function as expected regardless of which terminal emulation mode your telnet client is using. These are very similar to the shortcuts used by the Bash shell.

Shortcut	Action
CTRL-P or UP-ARROW	Recall the previous command in the recent command history
CTRL-N or DOWN-ARROW	Recall the next command in the recent command history
CTRL-B or LEFT-ARROW	Move the cursor left
CTRL-F or RIGHT-ARROW	Move the cursor right
ALT-B or CTRL-LEFT-ARROW	Move the cursor left one word
ALT-F or CTRL-RIGHT-ARROW	Move the cursor right one word
CTRL-A or HOME	Move the cursor to the beginning of the line
CTRL-E or END	Move the cursor to the end of the line
CTRL-H or BACKSPACE	Delete the character before the cursor
CTRL-D or DELETE	Delete the character under the cursor
ALT-CTRL-H or ALT-BACKSPACE	Delete the previous word up to a non-alphanumeric character
ALT-D or ALT-DELETE	Delete the next word up to a non-alphanumeric character
CTRL-W	Delete the previous word up to a whitespace character
ALT-MINUS CTRL-W	Delete the next word up to a whitespace character
CTRL-U	Delete all characters before the cursor to the beginning of the line
CTRL-K	Delete all characters from the cursor to the end of the line
CTRL-V	Interpret the next character literally
INSERT	Toggle between insert and overwrite mode
CTRL-L	Clear the screen and redraw the current line
CTRL-G	Redraw the current line
CTRL-D (on empty line)	Close the telnet connection

CTRL-C	Cancel the command
ALT-<n>	Repeat the next operation <n> times
ALT-MINUS-<n>	Repeat the inverse of the next operation <n> times

5.2 Luna 6415 SCPI Instrument Model
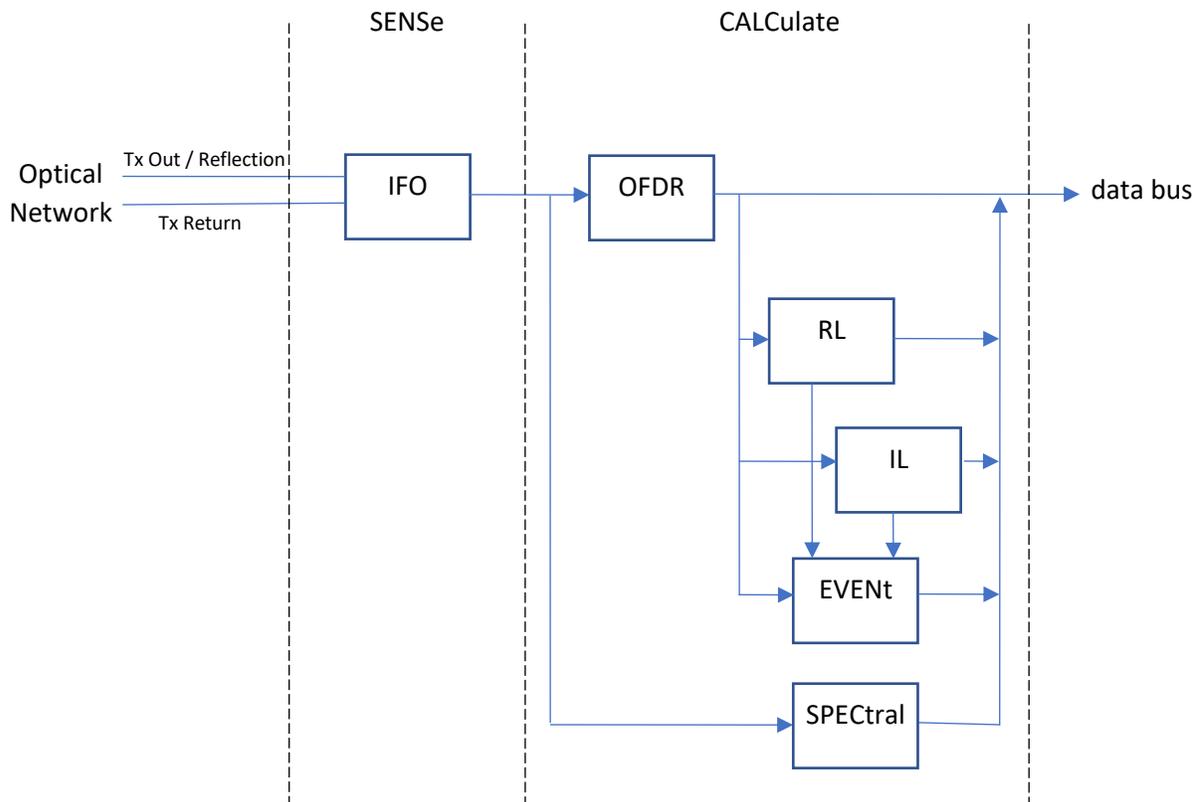
5.3 SCPI is Not a Data Streaming Protocol

SCPI should not be used while making continuous measurements. The SCPI protocol does not allow for the SCPI server to send unsolicited messages to the client. This means that the 6415 software cannot send continuous measurement data as measurements are taken.

Instead, the client must send individual FETCh queries (ex: FETC:OFDR?, FETC:DIST?) which the server can respond to. However, there is no SCPI mechanism for knowing when a new measurement is available or to prevent the 6415 from making a new measurement at the same time that the query is retrieving data.

To make and retrieve measurements as quickly as possible using SCPI, the client should send the INIT command to initiate a measurement, followed the desired FETCh queries to retrieve data. The queries will not execute until the measurement has finished. This sequence can be repeated in a loop to acquire and retrieve multiple measurements.

5.4 Example SCPI Command Sequences

This section provides a few example command sequences to help demonstrate the use of SCPI of the Luna 6415.

Keep in mind that it might be a good idea to follow each SCPI command or query with :SYST:ERR? to determine if an error was generated during the previous program message unit. For the sake of brevity, these examples don't demonstrate the use of the :SYST:ERR? query.

Refer to Section 5.3 for a complete list of supported SCPI commands.

5.4.1 Example 1: Take Sequential Measurements

DEL REFL	# Use REFLection mode, not TRANsmission mode
LENG 20	# Use 20 meter mode, not the 50 meter or 100 meter modes
GIND 1.4682	# Set the group index to 1.4682
MEAS:RL? 3,0.05	# Take a measurement and get the return loss at a distance of 3m with a width of 0.05m
MEAS:RL? 3ft	# Take a measurement and but get the return loss at 3ft (still with a width of 0.05m)
MEAS:OFDR?	# Take a measurement and return the amplitudes from the OFDR plot
MMEM:STOR ofdr,"test1"	# Store the measurement data to the file "test1.ofdr"
MMEM:STOR tsv_ose,"test1"	# Store all the measurement data to the file "test1.tsv"

5.4.2 Example 2: Get Multiple Results from a Single Measurement

DEL REFL	# Use REFLection mode, not TRANsmission mode
LENG 20	# Use 20 meter mode, not 50 meter or 100 meter modes
GIND 1.4682	# Set the group index to 1.4682
CONF:RL DEF,0.05	# Set the return loss width to 0.05 meters
CONF:IL DEF,0.2	# Set the insertion loss width to 0.2 meters
CONF:SPEC DEF,0.5	# Set the spectral cursor width to 0.5 meters
INIT	# Start a measurement
FETC:OFDR?	# Wait for the measurement to complete and get amplitudes in dB from the OFDR plot
FETC:DIST?	# Get distances in meters from the OFDR plot
FETC:SPEC? 1	# Get the return loss values in dB from the spectral plot with the spectral cursor at 1m
FETC:WAV?	# Get the wavelengths in nm from the spectral plot
FETC:EVEN?	# Get the event table
FETC:RL? 1.2	# Get the return loss at a distance of 1.2 meters from the unit
FETC:RL? 3ft	# Get the return loss at a distance of 3 feet from the unit

FETC:IL? 3.4m   # Get the insertion loss at a distance of 3.4 meters from the unit

5.4.3 Example 3: Get a Subset of the Measurement Data

DEL REFL   # Use REFLection mode, not TRANsmission mode
LENG 20   # Use 20 meter mode, not 50 meter or 100 meter modes
INIT   # Start a measurement
CONF:OFDR 0, 1.5, 2.5   # Configure FETC:OFDR? and DIST? queries to return data from 1.5m to 2.5m
FETC:OFDR?   # Wait for the measurement to complete and get amplitudes in dB from the OFDR plot
FETC:DIST?   # Get distances in meters from the OFDR plot

5.5 SCPI Command Reference

5.5.1 SENSe Subsystem

5.5.1.1 [:SENSe][:IFO]:DELay

```
> [:SENSe][:IFO]:DELay <CHARACTER PROGRAM DATA>
```

This command sets the measurement type. The parameter should be either TRANsmission or REFLection.

Note that IFO is an abbreviation for "interferometer".

If a startup configuration file is enabled, then the *RST command sets the delay to the value from the startup configuration file. Otherwise, the *RST command sets the delay to REFLection.

5.5.1.2 [:SENSe][:IFO]:DELay?

```
> [:SENSe][:IFO]:DELay?
< <CHARACTER RESPONSE DATA>
```

This query returns the current measurement type. The response shall be either TRAN or REFL.

Note that IFO is an abbreviation for "interferometer".

5.5.1.3 [:SENSe][:IFO]:LENGth

```
> [:SENSe][:IFO]:LENGth <numeric_value>[<SUFFIX>]
```

This command sets the measurement length. The parameter shall be 20m, 50m or 100m. The default units are meters ("m"). Although other units may be specified, the suffix (if provided) should be meters to guarantee that this setting is interpreted properly.

Note that IFO is an abbreviation for "interferometer".

If a startup configuration file is enabled, then the *RST command sets the measurement length to the value from the startup configuration file. Otherwise, the *RST command sets the measurement length to 20m.

The 50m and 100m lengths are only available on units with the corresponding feature keys installed.

5.5.1.4 [:SENSe][:IFO]:LENGth?

```
> [:SENSe][:IFO]:LENGth?
< <NR1>
```

This query returns the current measurement length. The response shall be 20, 50 or 100. The response is always in units of meters.

Note that IFO is an abbreviation for "interferometer".

5.5.1.5 [:SENSe][:IFO]:GINDex

```
> [:SENSe][:IFO]:GINDex <numeric_value>
```

This command sets the group index.

Note that IFO is an abbreviation for "interferometer".

If a startup configuration file is enabled, then the *RST command sets the group index to the value from the startup configuration file. Otherwise, the *RST command sets the group index to 1.4682.

5.5.1.6 [:SENSe][:IFO]:GINDex?

```
> [:SENSe][:IFO]:GINDex?
< <NR2>
```

This query returns the current group index.

Note that IFO is an abbreviation for "interferometer".

5.5.2 CALCulate Subsystem

5.5.2.1 :OFDR:FILTer:GAUSsian[:STATe]

```
> :OFDR:FILTer:GAUSsian[:STATe] <boolean>
```

This command turns the Gaussian filter on or off on the OFDR data plot. A <boolean> value of 1 or ON turns on the Gaussian filter while a value of 0 or OFF turns it off.

Note that OFDR is an alias for CALCulate[1]. These program mnemonics may be used interchangeably.

If a startup configuration file is enabled, then the *RST command sets the Gaussian filter state to the value from the startup configuration file. Otherwise, the *RST command turns the Gaussian filter on.

5.5.2.2 :OFDR:FILTer:GAUSsian[:STATe]?

```
> :OFDR:FILTer:GAUSsian[:STATe]?
< <NR1>
```

This query returns the current state of the Gaussian filter. The response shall either be 0 to indicate the filter is turned off or 1 to indicate it is turned on.

Note that OFDR is an alias for CALCulate[1]. These program mnemonics may be used interchangeably.

5.5.2.3 :OFDR:FILTer:GAUSsian:WIDTh

```
> :OFDR:FILTer:GAUSsian:WIDTh <numeric_value>{<SUFFIX>}
```

This command sets the filter width for the Gaussian filter to the specified value. The default units are millimeters.

Note that OFDR is an alias for CALCulate[1]. These program mnemonics may be used interchangeably.

If a startup configuration file is enabled, then the *RST command sets the Gaussian filter width to the value from the startup configuration file. Otherwise, the *RST command sets the Gaussian filter width to 10.24mm.

5.5.2.4 :OFDR:FILTer:GAUSsian:WIDTh?

```
> :OFDR:FILTer:GAUSsian:WIDTh?
< <NR2>
```

This query returns the current filter width of the Gaussian filter. The response is always in units of millimeters.

Note that OFDR is an alias for CALCulate[1]. These program mnemonics may be used interchangeably.

5.5.3 Measurement Instructions

5.5.3.1 :CONFigure?

```
> :CONFigure?
< <function> <parameters>
```

This query returns the measurement function and configuration parameters for the most recently configured measurement function. The parameters follow the format of the corresponding CONFigure query for the indicated measurement function.

If no measurement function has been configured, then this query produces no response other than the response message terminator.

5.5.3.2 :CONFigure:RL

```
> :CONFigure:RL <numeric_value>[<SUFFIX>],<numeric_value>[<SUFFIX>]
```

This command sets return loss as the current measurement and optionally sets the current return loss center location to the value of the first parameter and the return loss width to the value of the second parameter. The default units are meters ("m"). Other possible units include millimeters ("mm"), feet ("ft"), and inches ("in"). Parameters can also be defaulted to their current value by omitting them from right-to-left, or by using the special parameter DEFault.

If a startup configuration file is enabled, then the *RST command sets the return loss center location and width to the values from the startup configuration file. Otherwise, the *RST command sets the return loss center location to 0.0m and the width to 0.05m.

5.5.3.3 :CONFigure:RL?

```
> :CONFigure:RL?
< <NR2>,<NR2>
```

This query returns the current return loss configuration. The first response is the current return loss center location and the second response is the current return loss width. Both values are always in units of meters.

5.5.3.4 :CONFigure:IL

```
> :CONFigure:IL <numeric_value>[<SUFFIX>],<numeric_value>[<SUFFIX>],
  <numeric_value>[<SUFFIX>]
```

This command sets insertion loss as the current measurement and optionally sets the current insertion loss center location to the value of the first parameter, the insertion loss width to the value of the second parameter and the return loss width to the value of the third parameter. The default

units are meters ("m"). Other possible units include millimeters ("mm"), feet ("ft"), and inches ("in"). Parameters can also be defaulted to their current value by omitting them from right-to-left, or by using the special parameter DEFault.

If a startup configuration file is enabled, then the *RST command sets the insertion loss center location and width to the values from the startup configuration file. Otherwise, the *RST command sets the insertion loss center location to 0.0m and the width to 0.2m.

5.5.3.5 :CONFigure:IL?

```
> :CONFigure:IL?
< <NR2>,<NR2>,<NR2>
```

This query returns the current insertion loss configuration. The first response is the current insertion loss center location, the second response is the current insertion loss width and the third response is the current return loss width. All values are always in units of meters.

5.5.3.6 :CONFigure:OFDR

```
> :CONFigure:OFDR [<measurement id>],[<start>,<end>]
```

This command sets the amplitude data from the OFDR graph as the current measurement.

The optional <measurement id> parameter is an integer indicating which measurement should be returned from FETC:OFDR? and FETC:DIST? queries. Currently the only valid value is 0.

The optional <start> and <end> parameters are floating point values indicating the start and end location for the measurement segment that will be returned.

5.5.3.7 :CONFigure:DISTance

```
> :CONFigure:DISTance [<measurement id>],[<start>,<end>]
```

This command sets the distance data from the OFDR graph as the current measurement.

The optional <measurement id> parameter is an integer indicating which measurement should be returned from FETC:OFDR? and FETC:DIST? queries. Currently the only valid value is 0.

The optional <start> and <end> parameters are floating point values indicating the start and end location for the measurement segment that will be returned.

5.5.3.8 :CONFigure:SPECtral

```
> :CONFigure:SPECtral <numeric_value>[<SUFFIX>],<numeric_value>[<SUFFIX>]
```

This command sets the return loss data from the spectral graph as the current measurement and optionally sets the current spectral center location to the value of the first parameter and the current spectral width to the value of the second parameter. The default units are meters ("m"). Other possible units include millimeters ("mm"), feet ("ft"), and inches ("in"). Parameters can also be defaulted to their current value by omitting them from right-to-left, or by using the special parameter DEFault.

If a startup configuration file is enabled, then the *RST command sets the spectral center location and width to the values from the startup configuration file. Otherwise, the *RST command sets the spectral center location to 0.0m and the width to 0.5m.

This command is only available on units with the spectral feature key installed.

5.5.3.9 :CONFigure:SPECtral?

```
> :CONFigure:SPECtral?
< <NR2>
```

This query returns the current spectral configuration. The first response is the current spectral center location and the second response is the current spectral width. Both values are always in units of meters.

This query is only available on units with the spectral feature key installed.

5.5.3.10 :CONFigure:WAVelength

```
> :CONFigure:WAVelength
```

This command sets the wavelength data from the spectral graph as the current measurement. There are no parameters.

This command is only available on units with the spectral feature key installed.

5.5.3.11 :CONFigure:EVENt

```
> :CONFigure:EVENt <numeric_value>[<SUFFIX>],<numeric_value>[<SUFFIX>],
  <numeric_value>[dB],<numeric_value>[dB]
```

This command sets event detection as the current measurement and optionally sets the minimum event location to the first parameter, the maximum event location to the second parameter, the RL threshold to the third parameter and the IL threshold to the fourth parameter. The default units for the minimum and maximum event locations are meters ("m"). Other possible units include millimeters ("mm"), feet ("ft"), and inches ("in"). The default units for the RL and IL thresholds are

decibels ("dB"). Parameters can also be defaulted to their current value by omitting them from right-to-left, or by using the special parameter DEFault.

If a startup configuration file is enabled, then the *RST command sets the minimum event location, maximum event location, RL threshold and IL threshold to the values from the startup configuration file. Otherwise, the *RST command sets the minimum event location to -1.0m, the maximum event location to 20.0m, the RL threshold to -4.0dB and the IL threshold to 2.0dB.

5.5.3.12 :CONFigure:EVENt?

```
> :CONFigure:EVENt?
< <NR2>,<NR2>,<NR2>,<NR2>
```

This query returns the current event configuration. The first response is the minimum event location, the second response is the maximum event location, the third response is the RL threshold and the fourth response is the IL threshold. The minimum and maximum event locations are always in units of meters and the RL and IL thresholds are always in units of decibels.

5.5.3.13 :FETCh?

```
> :FETCh? <parameters>
< (see the corresponding :FETCh:<function>? query for the response format)
```

The last measurement function FETChed, READ or MEASured will be fetched.

If no measurement function has been used, then this query produces no response other than the response message terminator.

5.5.3.14 :FETCh:RL?

```
> :FETCh:RL? <numeric_value>[<SUFFIX>],<numeric_value>[<SUFFIX>]
< <NR2>
```

This query waits for a measurement to complete and returns the measured return loss in dB. The command also optionally sets the return loss center location to the value of the first parameter and the return loss width to the value of the second parameter. The default units are meters ("m"). Other possible units include millimeters ("m"), feet ("ft"), and inches ("in"). Parameters can also be defaulted to their current value by omitting them from right-to-left, or by using the special parameter DEFault.

5.5.3.15 :FETCh:IL?

```
> :FETCh:IL? <numeric_value>[<SUFFIX>],<numeric_value>[<SUFFIX>]
< <NR2>
```

This query waits for a measurement to complete and returns the measured insertion loss in dB. The command also optionally sets the insertion loss center location to the value of the first parameter and the insertion loss width to the value of the second parameter. The default units are meters ("m"). Other possible units include millimeters ("m"), feet ("ft"), and inches ("in"). Parameters can also be defaulted to their current value by omitting them from right-to-left, or by using the special parameter DEFault.

5.5.3.16 :FETCh:OFDR?

```
> :FETCh:OFDR? [<measurement id>],[<start>,<end>]
< <NR2>{,<NR2>}
```

This query waits for a measurement to complete and returns the amplitude data from the OFDR graph. Each data point is always in units of decibels. Note that the corresponding distance coordinate values for this data can be returned by using the :FETCh:DISTance? query.

The optional <measurement id> parameter is an integer indicating which measurement should be saved. Currently the only valid value is 0.

The optional <start> and <end> parameters are floating point values indicating the start and end location for the measurement segment that will be returned.

5.5.3.17 :FETCh:DISTance?

```
> :FETCh:DISTance? [<measurement id>],[<start>,<end>]
< <NR2>{,<NR2>}
```

This query waits for a measurement to complete and returns the distance data from the OFDR graph. Each data point is always in units of meters. Note that the corresponding amplitude coordinate values for this data can be returned by using the :FETCh:OFDR? query.

The optional <measurement id> parameter is an integer indicating which measurement should be saved. Currently the only valid value is 0.

The optional <start> and <end> parameters are floating point values indicating the start and end location for the measurement segment that will be returned.

5.5.3.18 :FETCh:SPECtral?

```
> :FETCh:SPECtral <numeric_value>[<SUFFIX>],<numeric_value>[<SUFFIX>]
< <NR2>{,<NR2>}
```

This query waits for a measurement to complete and returns the return loss data from the spectral graph. Each data point is always in units of decibels. Note that the corresponding wavelength coordinate values for this data can be returned by using the :FETCh:WAVelength? query. The command also optionally sets the current spectral center location to the value of the first parameter, and the current spectral width to the value of the second parameter. The default units are meters ("m"). Other possible units include millimeters ("m"), feet ("ft"), and inches ("in"). Parameters can also be defaulted to their current value by omitting them from right-to-left, or by using the special parameter DEFault.

This query is only available on units with the spectral feature key installed.

5.5.3.19 :FETCh:WAVelength?

```
> :FETCh:WAVelength?
< <NR2>{,<NR2>}
```

This query waits for a measurement to complete and returns the wavelength data from the OFDR graph. Each data point is always in units of nanometers. Note that the corresponding return loss coordinate values for this data can be returned by using the :FETCh:SPECtral? query.

This query is only available on units with the spectral feature key installed.

5.5.3.20 :FETCh:EVENt?

```
> :FETCh:EVENt?
< <EXPR>{,<EXPR>}
```

This query returns a list of events for the current measurement. Each <EXPR> result is formatted as:

(<NR2>,<NR1>,<NR2>,<NR2>)

The values in each <EXPR> represent, in order, the following values:

location of the event in meters
event type as an integer (0 for a return loss event, 1 for an insertion loss event)
return loss at the event location in dB
insertion loss at the event location in dB

5.5.3.21 :READ[:<function>]?

```
> :READ[:<function>]? <parameters>
< (see the corresponding :FETCh:<function>? query for the response format)
```

This query is identical to:

```
ABORt;
INITiate;
FETCh[:<function>]? <parameters>
```

If the <function> is not specified in the query, then the last measurement function FETChed, READ or MEASured will be read.

If no measurement function has been used, then this query produces no response other than the response message terminator.

5.5.3.22 :MEASure[:<function>]?

```
> :MEASure[:<function>]? <parameters>
< (see the corresponding :FETCh:<function>? query for the response format)
```

This query is identical to:

```
ABORt;
CONFigure:<function> <parameters>;
READ:<function>? <parameters>[,<source list>];
```

If the <function> is not specified in the query, then the last measurement function FETChed, READ or MEASured will be measured.

If no measurement function has been used, then this query produces no response other than the response message terminator.

5.5.4 TRIGger Subsystem

5.5.4.1 :ABORt

```
> :ABORt
```

This command aborts the current measurement in progress (if any) and discards all results. If the measurement cannot be aborted immediately, then this command will wait until the measurement has finished aborting.

5.5.4.2 :INITiate[:ALL]

```
> :INITiate[:ALL]
```

This command acquires a single measurement. Error -213 "Init ignored" is generated if the instrument is not ready or if a measurement is already in progress.

5.5.5 MMEMory Subsystem

5.5.5.1 :MMEMory:LOAD:STATe

```
> :MMEMory:LOAD:STATe <numeric_value>,<file_name>
```

This command loads instrument configuration data from a file. The <numeric_value> is the memory register number where the configuration data will be loaded into the instrument. Memory register 0 represents the current configuration in use by the instrument. Memory register 1 represents the default settings that will be used whenever the application on the PC is launched. The <file_name> is a quoted string representing the filename of the configuration file to load. If the filename does not end with the extension ".config", then ".config" will be appended to the filename.

5.5.5.2 :MMEMory:STORe:STATe

```
> :MMEMory:STORe:STATe <numeric_value>,<file_name>
```

This command saves instrument configuration data to a file. The <numeric_value> is the memory register number containing the instrument configuration to be saved to the file. Memory register 0 represents the current configuration in use by the instrument. Memory register 1 represents the default settings that will be used whenever the application on the PC is launched. The <file_name> is a quoted string representing the filename of the configuration file to save. If the filename does not end with the extension ".config", then ".config" will be appended to the filename.

If an attempt to store memory register 1 is made and no startup configuration file is currently selected, then this command will return error -314.

5.5.5.3 :MMEMory:LOAD[:CUSTom]

```
> :MMEMory:LOAD[:CUSTom] <label>,<file_name>
```

This command loads the current measurement data from a file. The only currently valid <label> is OFDR. The <file_name> is a quoted string representing the name of the file to load. If the filename does not end with the extension ".ofdr", then ".ofdr" will be appended to the filename.

Loading memory register 1 will set the startup configuration file to the specified filename.

5.5.5.4 :MMEMory:STORe[:CUSTom]

```
> :MMEMory:STORe[:CUSTom] <label>,<file_name>,[<measurement
id>],[<start>,<end>]
```

This command stores the current measurement data to a file. The <label> identifies what type of file will be stored:

OFDR	OFDR measurement file
TSV	Tab-separated value file containing only the header
TSV_E	Tab-separated value file containing the events detected
TSV_S	Tab-separated value file containing the spectral data
TSV_SE	Tab-separated value file containing the spectral data and the events detected
TSV_O	Tab-separated value file containing the OFDR data
TSV_OE	Tab-separated value file containing the OFDR data and the events detected
TSV_OS	Tab-separated value file containing the OFDR data and the spectral data
TSV_OSE	Tab-separated value file containing all the data

The <file_name> is a quoted string representing the name of the file to save. If the <label> is OFDR and the filename does not end with the extension ".ofdr", then ".ofdr" will be appended to the filename. If <label> starts with TSV and the filename does not end with the extension ".tsv", then ".tsv" will be appended to the filename.

The optional <measurement id> parameter is an integer indicating which measurement should be saved. Currently the only valid value is 0.

The optional <start> and <end> parameters are floating point values indicating the start and end location for the measurement segment that should be saved. This only affects the OFDR data written to the TSV file.

5.5.6 SYSTem Subsystem

5.5.6.1 :SYSTem:ERRor[:NEXT]?

```
> :SYSTem:ERRor[:NEXT]?

< <NR1>,<STRING RESPONSE DATA>
```

This query removes the next item from the Error/Event Queue and returns it in the response.

The <NR1> number is an Error/Event number in the range of -327678 through 32767. The <STRING> is a description of the Error/Event.

If there are no entries in the Error/Event Queue, then the response is:

0,"No error"

The Error/Event Queue shall be cleared by the *CLS command or by reading the last item from the queue.

5.5.6.2 :SYSTem:VERSion?

```
> :SYSTem:VERSion?
< <NR2>
```

This query returns the SCPI version number for which the instrument complies in the response.

The response is always 1999.0.

5.5.7 STATus Subsystem

5.5.7.1 :STATus:OPERation:CONDition?

```
> :STATus:OPERation:CONDition?
< <NR1>
```

This query returns the value of the OPERation:CONDition register. The response shall be in the range of 0 through 32767.

The SCPI standard defines the following bits for the OPERation:CONDition register.

Bit	Meaning
	1 if the instrument is…
0: CALibrating	…currently performing a calibration
1: SETTling	…waiting for signals it controls to stabilize enough to begin measurements
2: RANGing	…currently changing its range
3: SWEeping	…performing a sweep operation that's still in progress
4: MEASuring	…actively measuring
5: Waiting for TRIG	…in a "wait for trigger" state of the trigger model
6: Waiting for ARM	…in a "wait for arm" state of the trigger model
7: CORRecting	…currently performing a correction
8: <unused>	Available for instrument-defined use
9: <unused>	Available for instrument-defined use
10: <unused>	Available for instrument-defined use
11: <unused>	Available for instrument-defined use
12: <unused>	Available for instrument-defined use
13: INSTrument Summary	1 if one of n multiple logical instruments is reporting OPERational status
14: PROGram running	1 if a user-defined programming is currently in the run state
15: <always 0>	Always 0 because some controllers can't handle responses larger than 32767

Only the following bits are currently used by the instrument.

Bit	Meaning
1: SETTling	1 if the instrument is waiting for the laser to stabilize
2: RANGing	1 if the instrument is changing laser modes
4: MEASuring	1 if the instrument is taking a measurement
7: CORRecting	1 if the instrument is automatically aligning or adjusting gains

| 8: INITializing | 1 if the instrument is initializing |
| All Other Bits | Always 0 |

The OPERation:CONDition register is not affected by the *CLS or *RST commands.

The OPERation:CONDition register is cleared when the application on the PC is started.

5.5.7.2 :STATus:OPERation[:EVENt]?

```
> :STATus:OPERation[:EVENt]?
< <NR1>
```

This query returns the value of the OPERation:EVENt register. The response shall be in the range of 0 through 32767.

Bits in this register are latched to a 1 if the corresponding bit in the OPERation:CONDition register becomes a 1. Refer to the description of the :STATus:OPERation:CONDition? query for details on how each bit is defined.

The OPERation:EVENt register is not affected by the *RST command.

The OPERation:EVENt register is cleared by the STATus:OPERation[:EVENt]? query, the *CLS command or when the application on the PC is started.

5.5.7.3 :STATus:OPERation:ENABle

```
> :Status:OPERation:ENABle <NRf> | <non-decimal numeric>
```

This command sets the bits of the OPERation:ENABle register. The <NRf> value (when rounded to an integer value) or the <non-decimal numeric> should be in the range of 0 through 32767.

Bit	Meaning
	Set the OPERation Summary bit in the Status Byte if…
1: SETTling Enable	…the SETTling bit is set in OPERation:CONDition
2: RANGing Enable	…the RANGing bit is set in OPERation:CONDition
4: MEASuring Enable	…the MEASuring bit is set in OPERation:CONDition
7: CORRecting Enable	…the CORRecting bit is set in OPERation:CONDition
8: INITializing Enable	…the INITializing bit is set in OPERation:CONDition
15: <always 0>	Always 0 because some controllers can't handle responses larger than 32767
All Other Bits	Can be set to 0 or 1, but the value is ignored because the corresponding bit in OPERation:CONDition is 0

The OPERation:ENABle register is not affected by the *CLS or *RST commands.

The OPERation:ENABle register is cleared when the application on the PC is started.

5.5.7.4 :STATus:OPERation:ENABle?

```
> :STATUS:OPERation:ENABle?
< <NR1>
```

This query returns the value of the OPERation:ENABle register. The result shall be in the range of 0 through 32767. Refer to the description of the :STATus:OPERation:ENABLe command for details on how each bit is defined.

5.5.7.5 :STATus:QUEStionable:CONDition?

```
> :STATus:QUEStionable:CONDition?
< <NR1>
```

This query returns the value of the QUEStionable:CONDition register. The response shall be in the range of 0 through 32767.

The SCPI standard defines the following bits for the QUEStionable:CONDition register.

Bit	Meaning
	1 if the accuracy of the…
0: VOLTage	…voltage acquired/generated was of questionable quality
1: CURRent	…current acquired/generated was of questionable quality
2: TIME	…time acquired/generated was of questionable quality
3: POWer	…power acquired/generated was of questionable quality
4: TEMPerature	…temperature acquired/generated was of questionable quality
5: FREQuency	…frequency acquired/generated was of questionable quality
6: PHASe	…phase acquired/generated was of questionable quality
7: MODulation	…modulation acquired/generated was of questionable quality
8: CALibration	…calibration acquired/generated was of questionable quality
9: <unused>	Available for instrument-defined use
10: <unused>	Available for instrument-defined use
11: <unused>	Available for instrument-defined use
12: <unused>	Available for instrument-defined use
13: INSTrument Summary	1 if one of n multiple logical instruments is reporting QUEStionable status
14: Command Warning	1 if the command/query completed successfully but may deviate in some manner
15: <always 0>	Always 0 because some controllers can't handle responses larger than 32767

Only the following bits are currently used by the instrument.

Bit	Meaning
All Bits	Always 0

The QUEStionable:CONDition register is not affected by the *CLS or *RST commands.

The QUEStionable:CONDition register is cleared when the application on the PC is started.

5.5.7.6 :STATus:QUEStionable[:EVENt]?

```
> :STATus:QUEStionable[:EVENt]?
< <NR1>
```

This query returns the value of the QUEStionable:EVENt register. The response shall be in the range of 0 through 32767.

Bits in this register are latched to a 1 if the corresponding bit in the QUEStionable:CONDition register becomes a 1. Refer to the description of the :Status:QUEStionable:CONDition? query for details on how each bit is defined.

The QUEStionable:EVENt register is not affected by the *RST command.

The QUEStionable:EVENt register is cleared by the STATus:QUEStionable[:EVENt]? query, the *CLS command or when the application on the PC is started.

5.5.7.7 :STATus:QUEStionable:ENABle

```
> :STATus:QUEStionable:ENABle <NRf> | <non-decimal numeric>
```

This command sets the bits of the QUEStionable:ENABle register. The <NRf> value (when rounded to an integer value) or the <non-decimal numeric> should be in the range of 0 through 32767.

Bit	Meaning
15: <always 0>	Always 0 because some controllers cannot handle responses larger than 32767
All Other Bits	Can be set to 0 or 1, but the value is ignored because the corresponding bit in QUEStionable:CONDition is 0

The QUEStionable:ENABle register is not affected by the *CLS or *RST commands.

The QUEStionable:ENABle register is cleared when the application on the PC is started.

5.5.7.8 :STATus:QUEStionable:ENABle?

```
> :STATus:QUEStionable:ENABle?
< <NR1>
```

This query returns the value of the QUEStionable:ENABle register. The result shall be in the range of 0 through 32767. Refer to the description of the :STATus:QUEStionable:ENABLe command for details on how each bit is defined.

5.5.7.9 :STATus:PRESet

```
> :STATus:PRESet
```

This command configures SCPI such that only device-dependent events are reported through the standard status-reporting mechanism.

This command performs the following actions:

(1) For SCPI mandatory status data structures, set the ENABle register to all 0's and set the transition filter registers to only recognize positive transitions (PTR to all 1's and NTR to all 0's). This includes OPERation:ENABle/PTR/NTR, QUEStionable:ENABle/PTR/NTR and ISUMmary:ENABle/PTR/NTR (required only for instruments with multiple devices).
(2) For all other device-dependent status data structures, set the enable register to all 1's and the transition registers to a device-dependent state. This includes INSTrument:ENABle/PTR/NTR and any other ENABle/PTR/NTR registers defined by the instrument.
(3) Sets the Error/Event Queue enable to only report errors.

This command does NOT perform any of the following actions:

(1) Change the state of any IEEE 488.2 register, including STB, SRE, ESR or ESE.
(2) Change the state of any EVENt register.
(3) Clear any item from the Error/Event Queue.

To extend the concept of only reporting device-dependent events, the following sequence of commands would be needed to alter both the IEEE 488.2 and SCPI status reporting structures:

```
*CLS
*SRE 0
*ERE 0
STATus:PRESet
```

Not all the registers described above are available on this instrument. To be more specific, this instrument only performs the following actions when receiving the STATus:PRESet command:

(1) OPERation:ENABle and QUEStionable:ENABle are set to 0.
(2) The Error/Event Queue is not affected because it only reports errors by default.

5.5.8 Common Commands and Queries

5.5.8.1 *STB? – Read Status Byte Query

```
> *STB?
< <NR1>
```

This query returns the value of the Status Byte Register. The response shall be in the range of 0 through 255.

Bit	Meaning	See Also
0: <reserved>	always reads as 0	
1: <reserved>	always reads as 0	
2: Error/Event Queue Summary	1 if not empty	SYSTem:ERRor?
3: QUEStionable Summary	1 if any enabled bit is set in QUEStionable:EVEnt	STATus:QUEStionable:*
4: Message Available (MAV)	1 if any characters are available in the Output Queue	
5: Event Status Bit (ESB)	1 if any enabled bit is set in the ESR	*ESR, *ESR?, *ESE, *ESE?
6: Master Status Summary (MSS)	1 if any enabled bit is set in the Status Byte	*STB?, *SRE, *SRE?
7: OPERation Summary	1 if any enabled bit is set in OPERation:EVEnt	STATus:OPERation:*

There is currently no separate control channel for emulating GPIB handshaking using the MSS/RQS bit.

IEEE 488.2 section 11.2.1.2 recommends documenting any device-specific behavior of the MAV bit. The MAV bit is simply an instantaneous indication of whether or not the Output Queue is empty. There is no attempt to "improve performance" by delaying the clearing of MAV until after the Response Message Terminator (RMT) is sent. However, the MAV bit is of limited usefulness over an Ethernet connection.

Additional information on how some of these bits change state is summarized in the table below:

Bit	How the current state is computed	How it can be cleared
ESB	(ESR & ESE) != 0	*CLS *ESR? *ESE 0
MSS	(STB & SRE) != 0	*CLS *SRE 0 service all enabled status bits
QUEStionable Summary	(QUEStionable:EVEnt & QUEStionable:ENABle) != 0	*CLS :QUEStionable:EVEnt? :QUEStionable:ENABle 0
OPERation Summary	(OPERation:EVEnt & OPERation:ENABle) != 0	*CLS :OPERation:EVEnt? :OPERation:ENABle 0

Note that the ESR, QUEStionable:EVEnt and OPERation:EVEnt registers are latching, so the summary bit is not automatically cleared when the condition that originally caused it goes away.

The STB register is not explicitly cleared by the *CLS command. However, the *CLS command will clear other registers and queues which will indirectly clear all bits in the STB register except for the MAV bit. If the *CLS command immediately follows a program message terminator (a linefeed character), then the MAV bit will also be cleared because any new command after a program message terminator clears the Output Queue.

The STB register is not affected by the *RST command.

The STB register is cleared when the application on the PC is started.

5.5.8.2 *SRE -- Service Request Enable Command

```
> *SRE <NRf>
```

This command sets the bits of the Service Request Enable Register. The <NRf> value (when rounded to an integer value) should be in the range of 0 through 255.

Bit	Meaning
	Set the MSS bit in the Status Byte if the…
0: <reserved>	Can be set to 0 or 1, but the value is ignored because bit 0 in the STB is always 0
1: <reserved>	Can be set to 0 or 1, but the value is ignored because bit 1 in the STB is always 0
2: Error/Event Queue Enable	…Error/Event Queue Status bit is set in the Status Byte
3: QUEStionable Enable	…QUEStionable Summary bit is set in the Status Byte
4: MAV Enable	…MAV bit is set in the Status Byte
5: ESB Enable	…ESB bit is set in the Status Byte
6: <unused>	Always reads as 0; cannot be set to 1
7: OPERation Enable	…OPERation:Summary bit is set in the Status Byte

The SRE register is not affected by the *CLS or *RST commands.

The SRE register is cleared when the application on the PC is started.

5.5.8.3 *SRE? -- Service Request Enable Query

```
> *SRE?
< <NR1>
```

This query returns the value of the Service Request Enable Register. The result shall be in the range of 0 through 63 or 128 through 191. Refer to the description of the *SRE command for details on how each bit is defined.

5.5.8.4 *ESR? -- Standard Event Status Register Query

```
> *ESR?
< <NR1>
```

This query returns the value of the Standard Event Status Register. The result shall be in the range of 0 through 255.

Bit	Meaning
0: Power On (PON)	The PC application was (re-)started.
1: User Request (URQ)	A User Request control has been activated -- **Always 0**
2: Command Error (CME)	A Command Error was detected by the parser
3: Execution Error (E)	An Execution Error was detected by the parser
4: Device Dependent Error (DDE)	A Device Dependent Error was detected by the parser
5: Query Error (QYE)	A Query Error was detected by the parser
6: Request Control (RQC)	Device requests permission to become the active IEEE488.1 controller-in-charge -- **Always 0**
7: Operation Complete (OPC)	The device has completed all selected pending operations, in response to the *OPC command
8-15: <reserved>	These bits are explicitly reserved for future use by IEEE 488.2 -- **Always 0**

The ESR register is not affected by the *RST command.

The ESR register is cleared by the *ESR? query, the *CLS command or when the application on the PC is started.

5.5.8.5 *ESE -- Standard Event Status Enable Command

```
> *ESE <NRf>
```

This command sets the bits of the Standard Event Status Enable Register. The <NRf> value (when rounded to an integer value) should be in the range of 0 through 255.

Bit	Meaning
	Set the ESB in the Status Byte if the…
0: Power On (PON) Enable	…Power On bit is set in the ESR
1: User Request (URQ) Enable	…User Request bit is set in the ESR
2: Command Error (CME) Enable	…Command Error bit is set in the ESR
3: Execution Error (E) Enable	…Execution Error bit is set in the ESR
4: Device Dependent Error (DDE) Enable	…Device Dependent Error bit is set in the ESR
5: Query Error (QYE) Enable	…Query Error bit is set in the ESR
6: Request Control (RQC) Enable	…Request Control bit is set in the ESR
7: Operation Complete (OPC) Enable	…Operation Complete bit is set in the ESR
8-15: <reserved>	These bits are explicitly reserved for future use by IEEE 488.2 – **Always 0**

The ESE register is not affected by the *CLS or *RST commands.

The ESE register is cleared when the application on the PC is started.

5.5.8.6 *ESE? -- Standard Event Status Enable Query

```
> *ESE?
< <NR1>
```

This query returns the value of the Standard Event Status Register. The result shall be in the range of 0 through 255. Refer to the description of the *ESE command for details on how each bit is defined.

5.5.8.7 *WAI -- Wait-to-Continue Command

```
> *WAI
```

This command shall prevent the device from executing any further commands until all pending selected device operations (overlapped commands) have completed.

If the device only implements sequential commands, then the *WAI command does nothing and continues executing any subsequent commands immediately.

5.5.8.8 *OPC -- Operation Complete Command

```
> *OPC
```

This command causes the device to set the Operation Complete bit (bit 7) in the ESR register when all pending selected device operations (overlapped commands) have completed. Unlike the *WAI command, the device will continue to execute commands after the *OPC command.

If the device only implements sequential commands, then the *OPC command simply sets the OPC bit (bit 7) in the ESR register immediately.

5.5.8.9 *OPC? -- Operation Complete Query

```
> *OPC?
< <NR1>
```

This query shall wait until all pending selected device operations (overlapped commands) have completed and then responds with a result of "1". More specifically, it will place a single ASCII character "1" in the Output Queue. The *OPC? query is a sequential command. Therefore, like the *WAI command, the *OPC? query shall prevent the device from executing any further commands until all pending selected device operations (overlapped commands) have completed.

If the device only implements sequential commands, then the *OPC? query responds immediately with a "1".

5.5.8.10 *CLS -- Clear Status Command

```
> *CLS
```

This command performs the following actions:

(1) Sets all event status registers to zero. On this instrument, this includes ESR, OPERation:EVENt and QUEStionable:EVENt.
(2) Aborts any active *OPC command. Another *OPC command will need to be executed to set the OPC bit in the ESR register.
(3) Clears the Error/Event Queue, which will also clear the Error/Event Queue Summary bit in the STB register.

The Clear Status Command does NOT perform any of the following actions:

(1) Change the state of the STB register (except indirectly).
(2) Change the state of the SRE register.
(3) Change the state of any event enable registers. On this instrument, this includes ESE, OPERation:ENABle and QUEStionable:ENABle.

5.5.8.11 *RST -- Reset Command

```
> *RST
```

This command performs the following actions:

(1) Aborts any active *OPC command. Another *OPC command will need to be executed to set the OPC bit in the ESR register.
(2) Sets all device settings to their default state. All device settings in this document will define their *RST state.

The Reset Command does NOT perform any of the following actions:

(1) Change the state of the STB register.
(2) Change the state of the SRE register.
(3) Change the state of any event enable registers. On this instrument, this includes ESE, OPERation:ENABle and QUEStionable:ENABle.
(4) Change the state of any event status registers. On this instrument, this includes ESR, OPERation:EVENt and QUEStionable:EVENt.
(5) Change the state of the Error/Event Queue.

5.5.8.12 *IDN? -- Identification Query

```
> *IDN?
< <ARBITRARY ASCII RESPONSE DATA>
```

This query requests the device to provide a unique identification for itself. The response is organized into four fields separated by commas as follows:

<manufacturer>,<model>,<serial_number>,<firmware_level>

For the 6415, the response looks like this:

`Luna,6415,`**<serial_number>,<firmware_level>**

For the Luna 6415, the **<firmware_level>** looks like this:

`controller:`**<controller_software_version>**[**<controller_build_date>**– **<controller_build_time>**]

`+embedded:` **<embedded_software_version>**[**<embedded_build_date>**– **<embedded_build_time>**]

`+fpga:` **<fpga_version>**[**<fpga_build_date>**–**<fpga_build_time>**]

Note that there are no newlines in the response, except at the end of the message. The line breaks above were only added to make the output more readable in this document.

5.5.8.13 *TST? -- Self-Test Query

```
> *TST?
< <NR1>
```

This query causes an internal self-test to be performed on the device. The response shall be in the range of -32767 to 32767. A result of 0 indicates that the self-test passed and any other result indicates that the self-test failed.

All device settings will be returned to their values prior to execution of the *TST command.

Currently, this device does not perform any self-tests. Therefore, this command does nothing except return a result of "0".

5.5.8.14 *RCL – Recall Command

```
> *RCL <NRf>
```

This command loads the current instrument configuration data from memory register number specified by the parameter. Memory register 0 represents the current configuration in use by the instrument. Memory register 1 represents the default settings that will be used whenever the

application on the PC is launched. Therefore, *RCL 1 will load the default instrument configuration. Note that *RCL 0 effectively does nothing.

If no startup configuration file is currently selected, then *RCL 1 will return error -314 "Save/recall memory lost".

5.5.8.15 *SAV – Save Command

```
> *SAV <NRf>
```

This command saves the current instrument configuration data to memory register number specified by the parameter. Memory register 0 represents the current configuration in use by the instrument. Memory register 1 represents the default settings that will be used whenever the application on the PC is launched. Therefore, *SAV 1 will overwrite the default instrument configuration with the current settings. Note that *SAV 0 effectively does nothing.

If no startup configuration file is currently selected, then *SAV 1 will return error -314 "Save/recall memory lost".

Appendix A Theory of Operation

The LUNA 6415 utilizes swept-wavelength interferometry to measure the device or system under test. Swept wavelength interferometry provides for a zero dead-zone, extremely high-resolution measurement of the light reflected (or transmitted) through the device under test (DUT).

Interference

When multiple sources of light of differing frequency (wavelength) interact, they generate an interference pattern. The resulting interference pattern has an amplitude envelope with a frequency that is proportional to the difference in the frequencies of the two source waves.
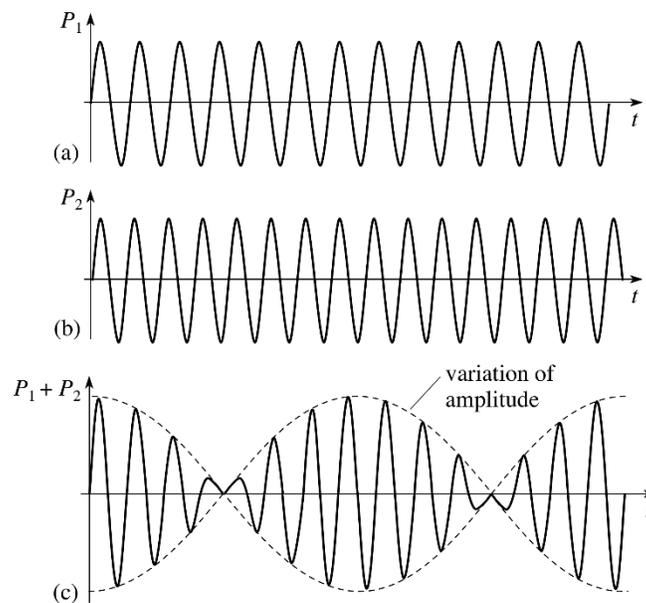

Figure 24 Interference patter from two waves of differing frequency

Swept Wavelength Interferometry

A fiber optic interferometer utilizes two paths, a reference, and a measurement, to split and recombine light. Light is sent into the optical network from a laser before it is split into two paths using an optical coupler. The paths are recombined using another optical coupler where the light interferes, and the resulting interference pattern is converted to an electrical signal using a photodetector.

The tunable laser is configured to perform a linear sweep through a range of optical frequencies. Due to this linear sweep, any length differences between the reference and measurement paths of the interferometer will cause an interference pattern to appear at the detector. The interference frequency is proportional to the path length difference (time of flight) and the optical frequency tuning rate of the laser. The optical network shown above would generate an interference pattern with a single frequency.

Path Length
Difference

Laser
Tuning Rate

$$f = \tau \frac{\partial v}{\partial t}$$

Figure 26 OFDR interference frequency is proportional to the time of flight difference and the tuning rate of the laser

Optical Frequency Domain Reflectometry (OFDR)

The OBR uses the principles of swept wavelength interferometry to make measurements of optical networks in reflection. This means that the OBR is configured to characterize the light that is reflected back through a network from things such as connectors, lenses, fiber breaks, etc. To do this, a circulator is added to the measurement path of the interferometer. Reflections from user connected DUTs pass back into the interferometer and interfere with light from the reference path.
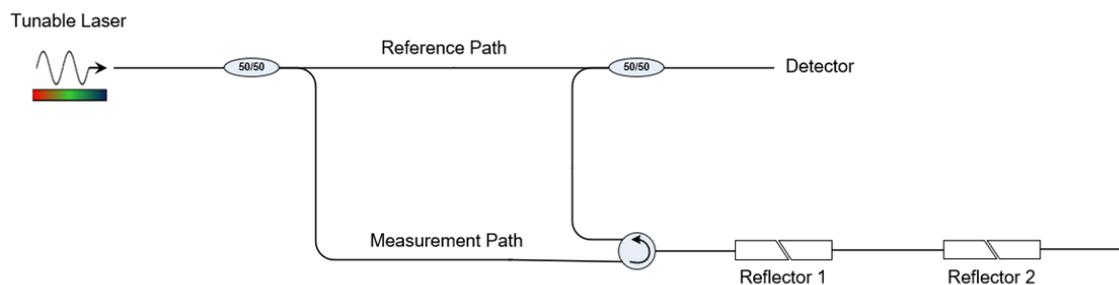

Figure 27 Basic OBR Optical Network with two partial reflectors (connectors)

In the example above, two partial reflectors (connectors) reflect a small portion of the measurement path light back into the network and to the detector. Since there is a path length difference associated with each reflector, they will both generate interference fringes at different frequencies. The detector will receive the superposition of these two interference fringes (shown below).
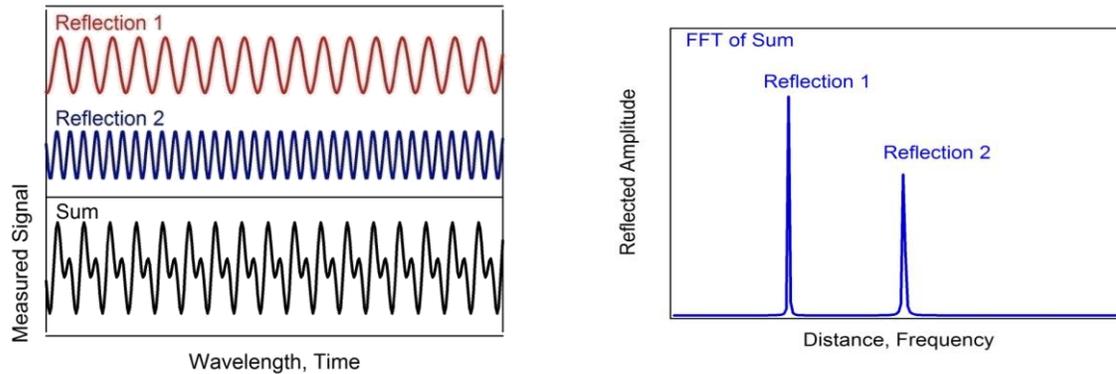
Figure 28 Resulting interference pattern from two reflectors at different locations

By taking a Fourier transform of this interference pattern, we can look at a plot which shows the reflected light vs optical time of flight (fiber length). The amplitude of each of these peaks is proportional to the amount of light reflected at any point in the fiber network. Once calibrated, the amplitude data is scaled to show the reflectance (return loss) as a function of fiber length.

Important OFDR Terms

Delay Domain – This is the domain which shows the reflections vs optical time of flight (delay). This delay can be scaled into length if the group index of refraction for the optical path is known.

Return Loss (RL) – Often used interchangeably with reflectance in the optics industry, the return loss is the logarithmic scaling of the reflected power to the incident power.

$$RL = 10log\left(\frac{P_{reflected}}{P_{incident}}\right)$$

Insertion Loss (IL) – The insertion loss describes how much light does not pass through a portion of the optical network. The IL is the logarithmic scaling of the transmitted to the incident power.

$$IL = 10log\left(\frac{P_{transmitted}}{P_{incident}}\right)$$

Amplitude – The amplitude of the delay domain data displayed by the OBR is the return loss at every data point. Data points are often smaller than physical elements of the DUT (fiber bends, lenses, etc.) so the RL of an element will be the summation of the amplitude over all the data points in the event.

Measuring RL

Each datapoint in the delay domain data represents the RL over a small length (<0.1mm). In order to characterize the RL for an entire event, the OBR software allows users to integrate the amplitude data over a user defined length. The integrated region will be shown in the delay domain plot as a highlighted region around the cursor(s).
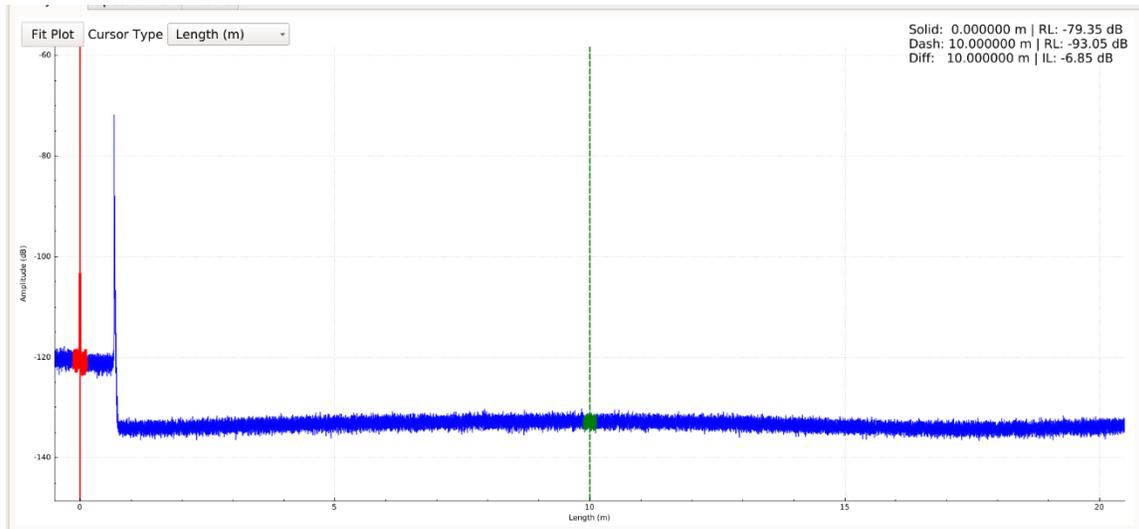

Figure 29 RL measurement using 0.25m RL integration width

Due to its electrical detection limitations, there is a limit for the difference between the largest and smallest reflections that can be observed in a single measurement. This is referred to as the return loss dynamic range. When no bright reflections are present, the OBR delay domain data has a noise floor (sensitivity) located at -129dB.
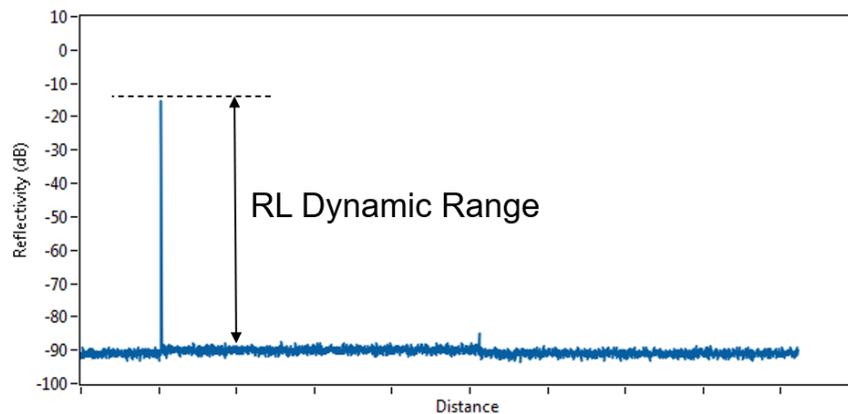

Figure 30 RL dynamic range limitation

Measuring IL

The OBR makes insertion loss measurements by comparing the return loss of the unaltered fiber on either side of an event in the delay domain data. The unaltered fiber reflects a small portion of light back to the instrument due to the process of Rayleigh scattering. This scattering is uniform over the length of standard telecom fibers and does not change in amplitude over time.

Configure the integration width of the cursors to cover a 0.25m or larger region of the Rayleigh scatter. Position the two cursors on either side of the event to be characterized. The IL is shown in the upper right corner of the delay domain plot.
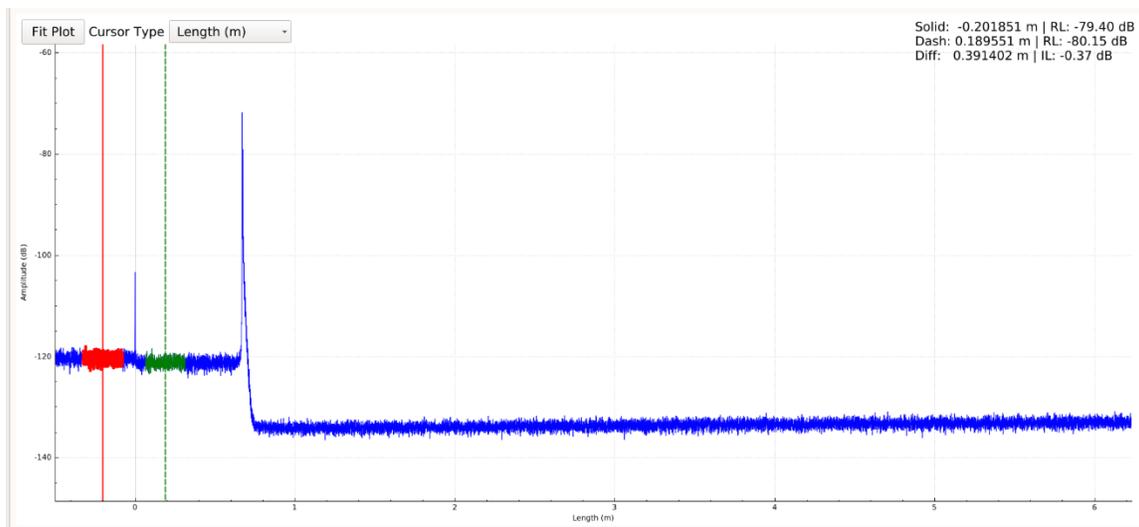

Figure 31 Insertion loss measurement shown across an APC fiber connector. (IL is shown in upper right corner)

The IL shown is the single pass insertion loss. This means it is an estimate of the loss that occurred as the light passed through the event in one direction.

Insertion loss measurements can only be made while the Rayleigh scattering of the surrounding fiber is visible. If the scattering on any side of the event is obscured (elevated noise floor, reflection peaks, etc.) the IL reading will be incorrect.