



User's Guide | OBR 6225

Class 1 Laser Product
Appareil Laser Classe 1
Laser Produkt Klass 1
IEC60825-1, 2014

Maximum Power – 4mW
Wavelengths Emitted – 1510nm to 1570nm

Intended for Indoor or Outdoor Use

| | |
|--|--------------------------------|
| Operating Temperature | -20C to 35C |
| Operating Temperature (Battery Charging) | 0C to 35C |
| Storage Temperature | -20C to 60C |
| Humidity | 10% to 95% RH (non-condensing) |
| Operating Altitude | 0m to 2500m |
| Storage Altitude | 0m to 3000m |

IP65

System meets requirements for Ingress Protection 65
Protected against dust ingress
Protected against low pressure jets of water



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 *OBR 6225*
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1 Safety



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 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.

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 Hardware and Physical Setup

The Luna 6200 is a standalone, battery powered device that does not need to be connected to any PC or other device to perform measurements.

3.1 Starting the System

To start the system, press the power button on the top. The power button will light, and the touch screen will activate. The system will then automatically go into its application user interface (UI).

3.2 Shutting the System Down

To turn off the system, press and hold the power button for a ½ second. If the system does not begin to shut down, press and hold the power button for 5 seconds to force the system to turn off.

3.3 Charging the System

The system should be charged using the included USB type C cable and AC power adapter. For fastest charging and maximum battery life, the system should be charged while powered off.



Figure 1 USB C Charging Connection

4 User Interface

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

4.1 UI Layout Overview

When you power on the system, the application UI screen appears automatically. The image below (Figure 2) is an illustration of a typical UI screen after the system is first started by completing the initiation procedures and taking a measurement.

The lower section of UI screen is the Delay Plot (LEFT side) along with an optional Event Table (RIGHT side).

The upper section of UI screen is for the display of measurement controls and information, as well as access to the menu for file operations

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

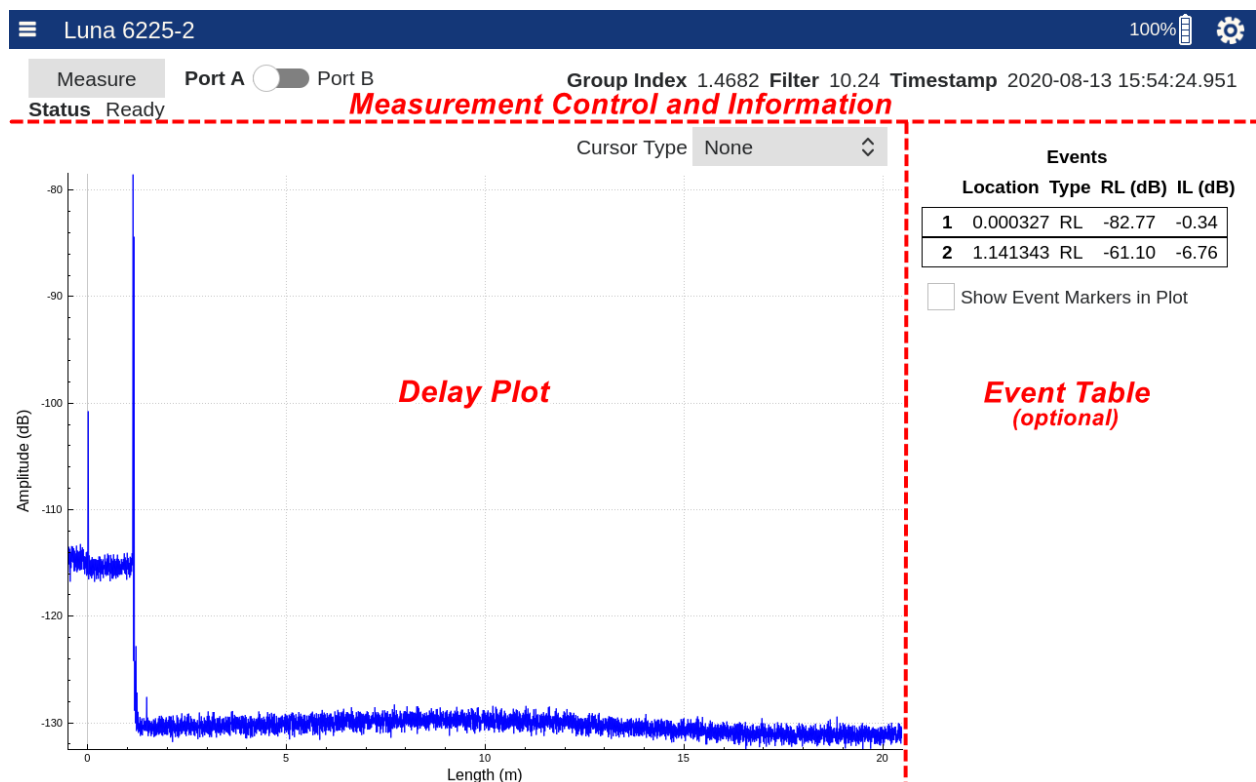


Figure 2 UI Screen Layout

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 length).

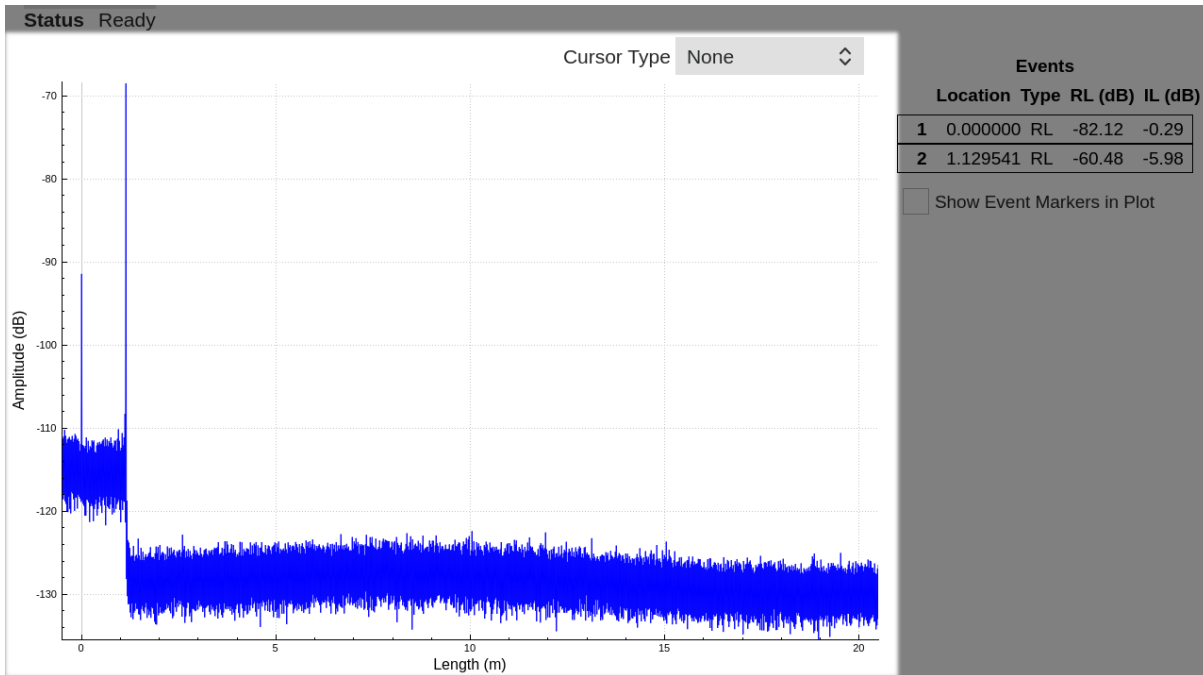


Figure 3 Delay Plot

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

Cursors can be moved by dragging them across the screen. 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). Tapping 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 OBR 6200 user interface can all be manipulated through touch actions on the instrument's screen.

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.

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

Plot Rescaling – Double press 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 “4.4.2.1 Measurement Tab”).

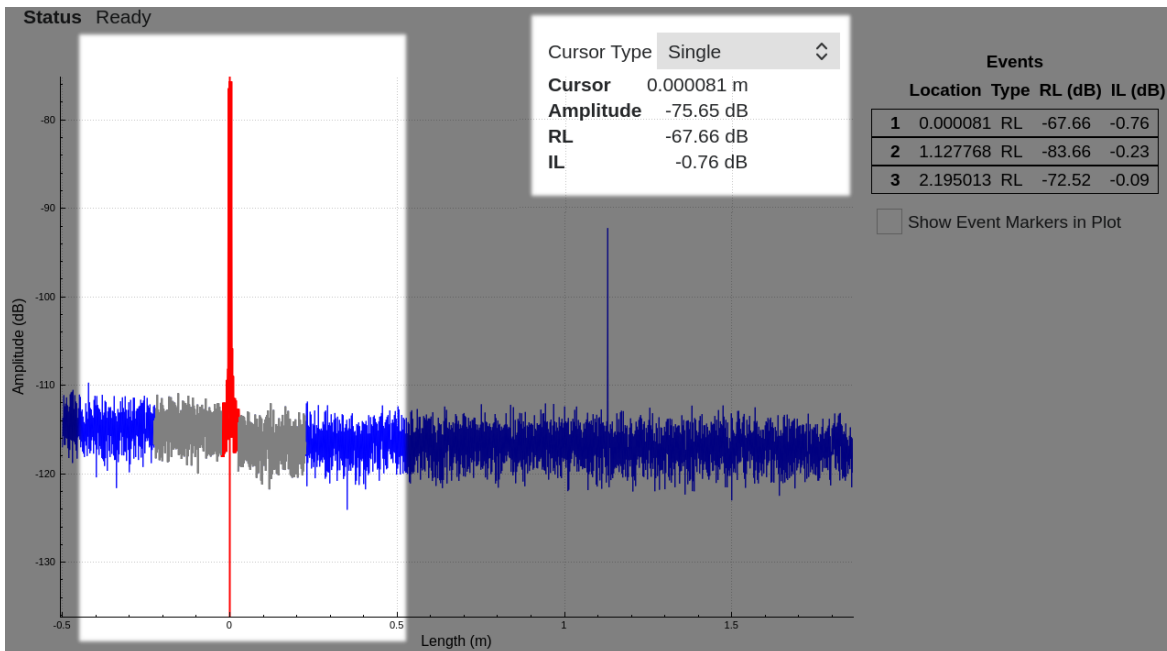


Figure 4 Single Cursor view

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.

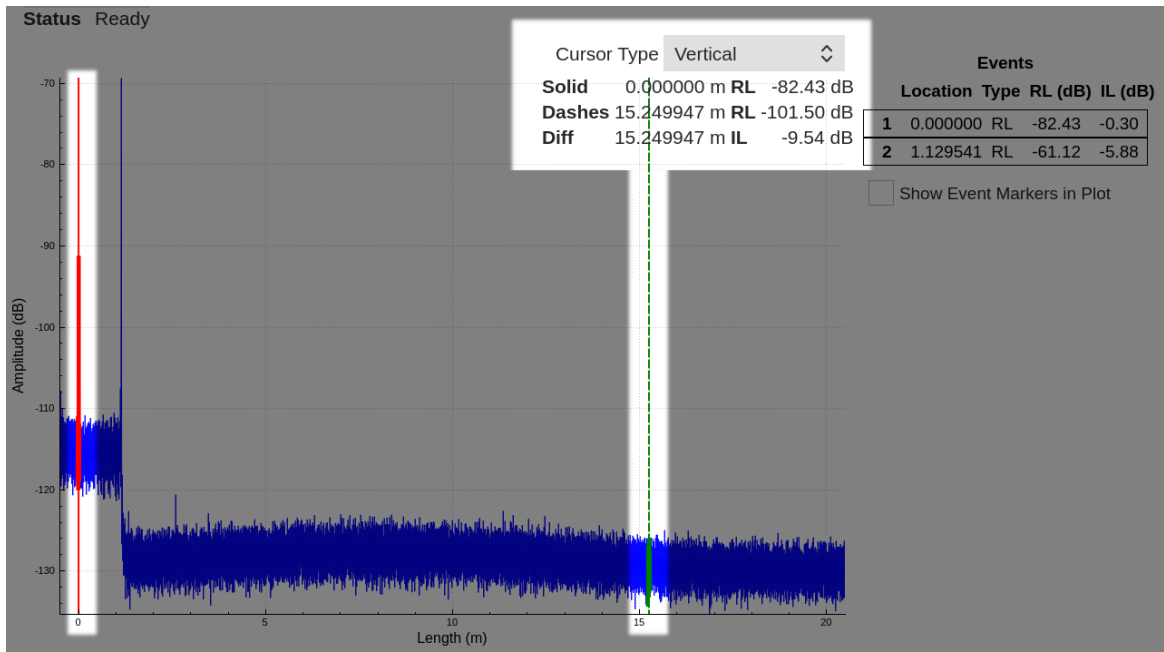


Figure 5 Vertical Cursor view

4.2.4 Horizontal Cursors

The horizontal cursors are used to compare the amplitude of two events in the data.

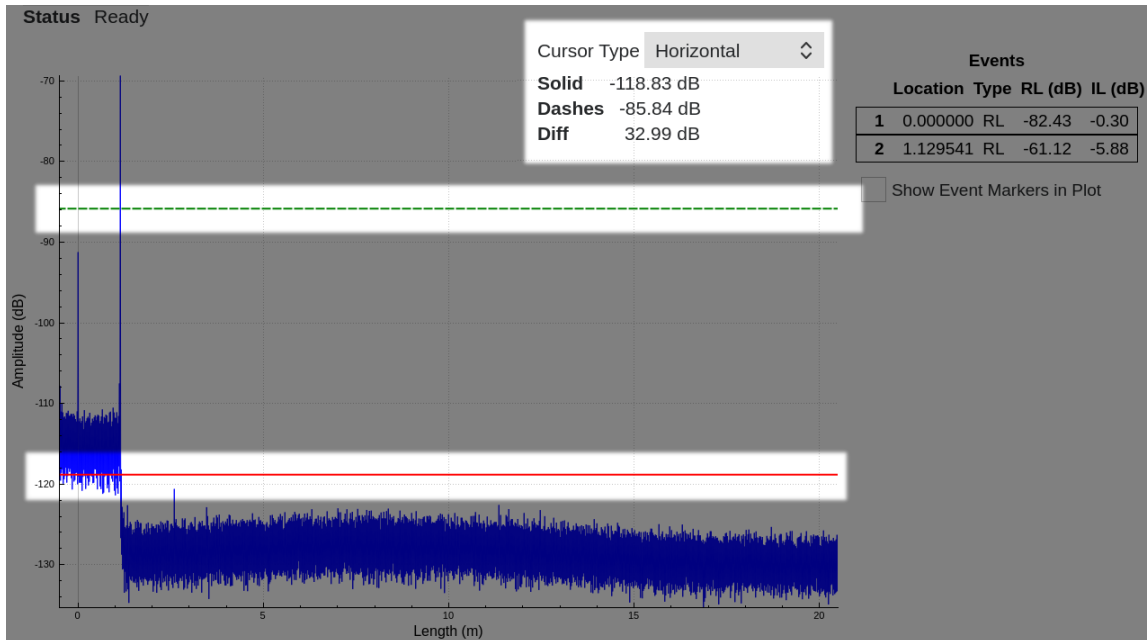


Figure 6 Horizontal Cursor view

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.

4.3 Event Table

The Event Table of the Luna 6200 software displays the 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.

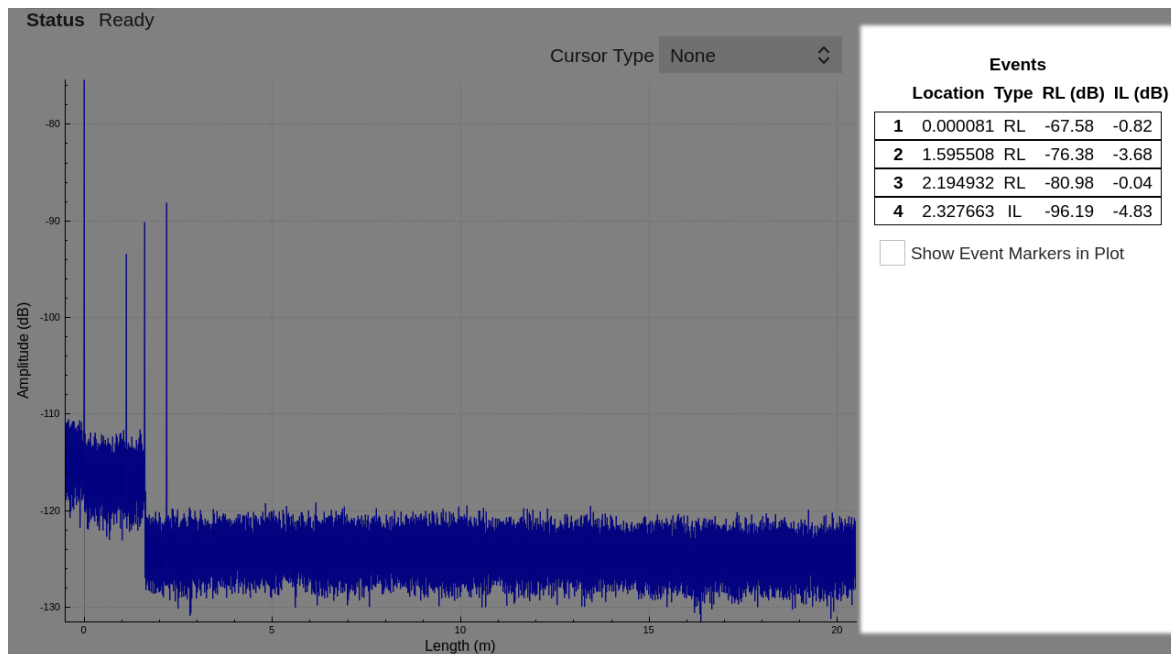


Figure 7 Event Table

4.3.1 Events

Events are determined using the measured return loss and insertion loss. The 6200 reports two types of events: Return Loss and Insertion Loss Events.

A return loss event occurs when the measured return loss rises by the amount specified in the *RL Threshold (dB)* control (For the *RL Threshold (dB)* control, refer to “4.4.2.1 Measurement Tab”).

An insertion loss event occurs when there is a significant amount of insertion loss that is not associated with a return loss event. Insertion loss is calculated as half the difference between the return loss before and after an event. (For *IL Threshold (dB)* control, please refer to “4.4.2.1 Measurement Tab”)

Note that most return loss events will also have an insertion loss that may pass the insertion loss threshold. In these cases, the return loss event will take precedence, and the 6200 will mark only a return loss event rather than creating a return loss event and an insertion loss event at the same location.

The *RL Width (m)* control how wide of an area is used to calculate the return loss. This can have the effect of combining closely spaced peaks into a single event. If desired, the *RL Width* can be adjusted to a smaller value to make closely spaced peaks register as separate events. Likewise, the *IL Width (m)* control has the similar effects on calculated insertion loss and IL events.

4.3.2 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 “4.4.2.1 Measurement Tab”). You can turn the Event Table display back on, by checking the “Events” view control in Settings and Tools.

4.3.3 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.

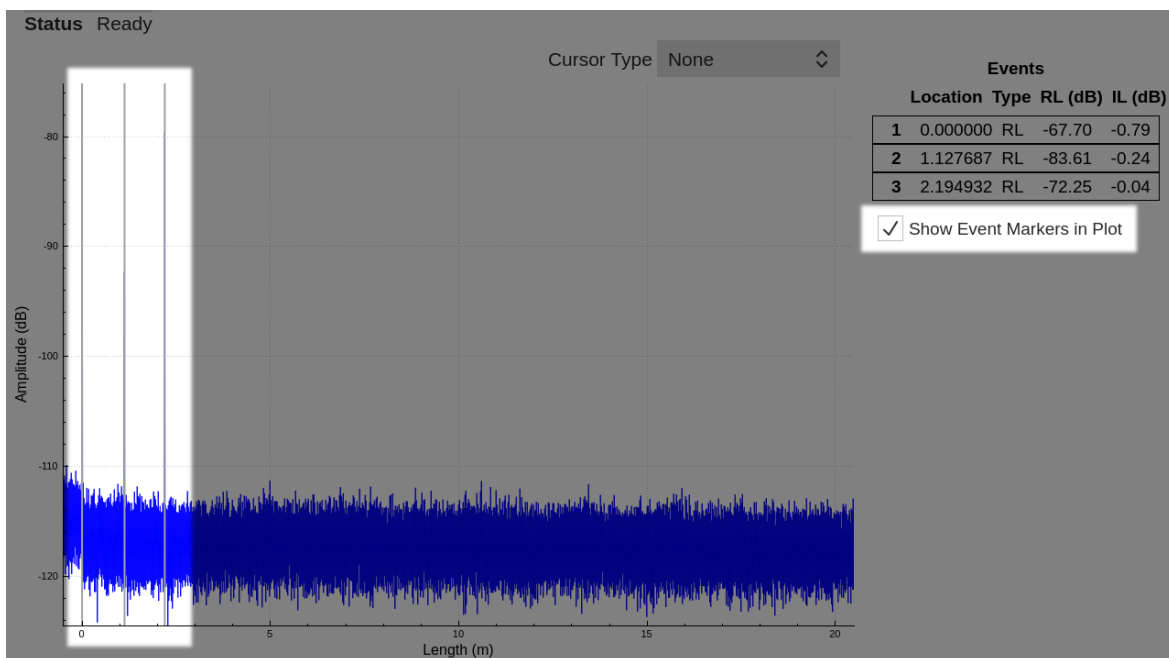


Figure 8 “Show Event Markers in Plot” enabled, showing vertical markers on all event locations.

Touching an individual event draws a marker at that event location. Touching the event again removes the marker. If you are using Single, or Vertical cursors, touching an Event table entry snaps the closest cursor to that event location.

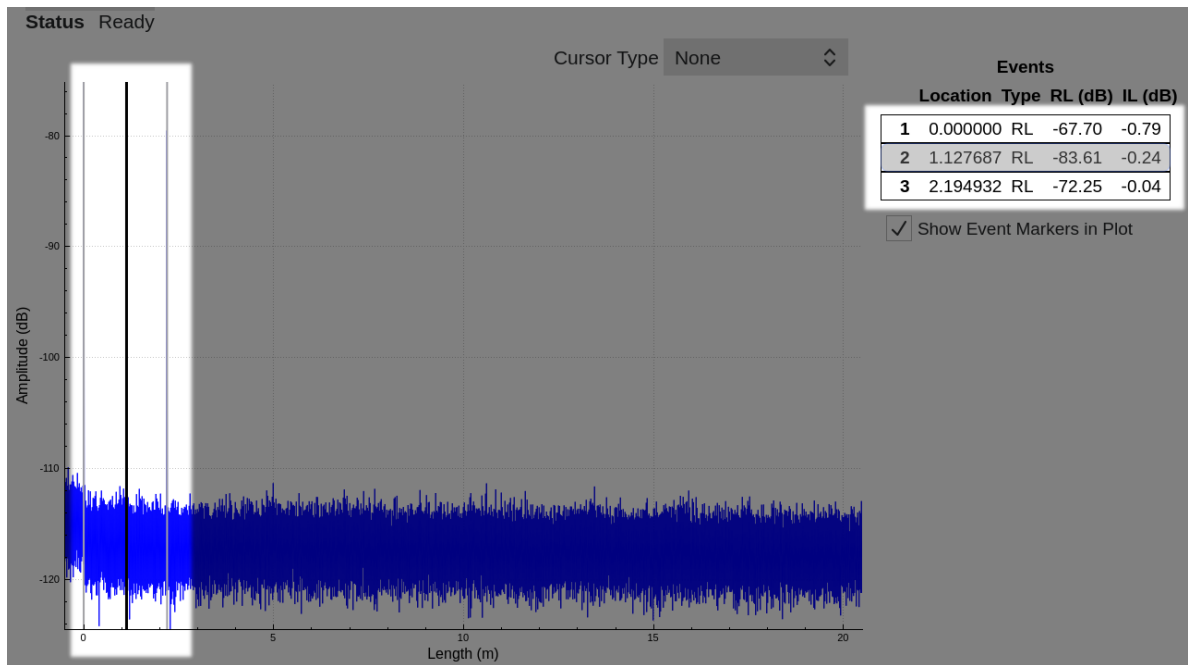


Figure 9 Touching an individual event draws a mark at that event location (event 2 in example)

Double tapping an entry in the event table zooms the plot to that event's location.

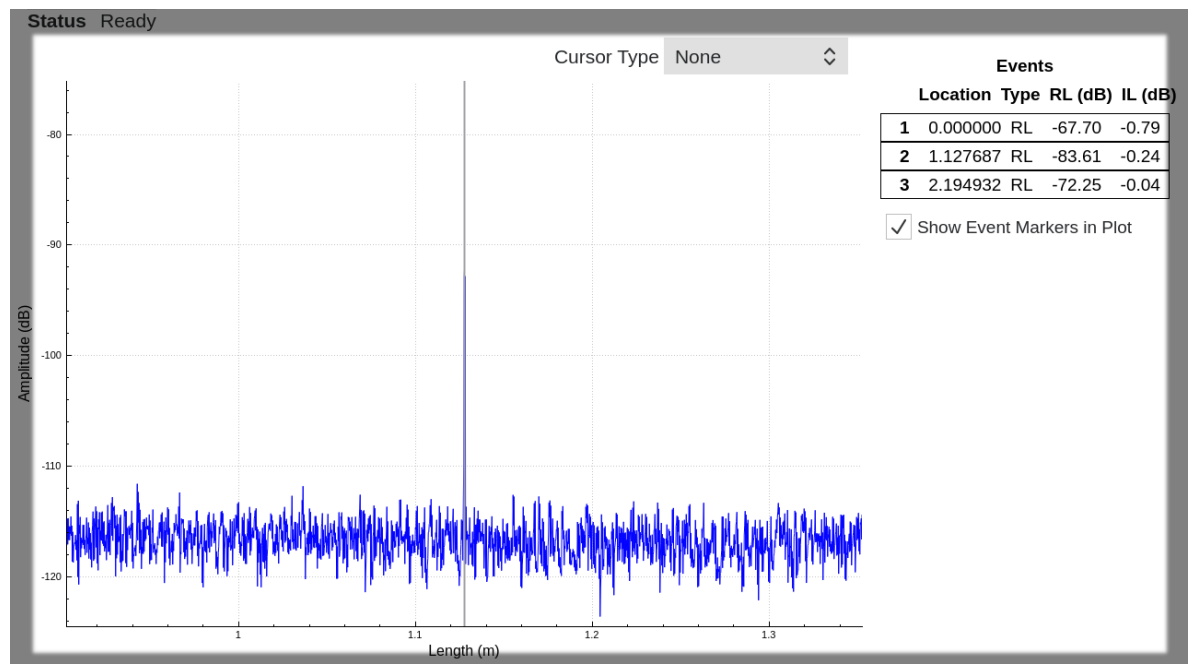


Figure 10 Zooms plot to an individual event's location by double tapping its entry in event table (event 2 in example)

4.4 Measurement Control and Information

4.4.1 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 option to change the channel that is being measured (*Port A* or *Port B*), 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 taping the Gear Tool Icon on the upper right corner of the screen; and 2) the “File Operations” menu can be opened by either taping the Menu Button Icon on the upper left corner of the screen or swiping gesture from left side edge of the screen to inside

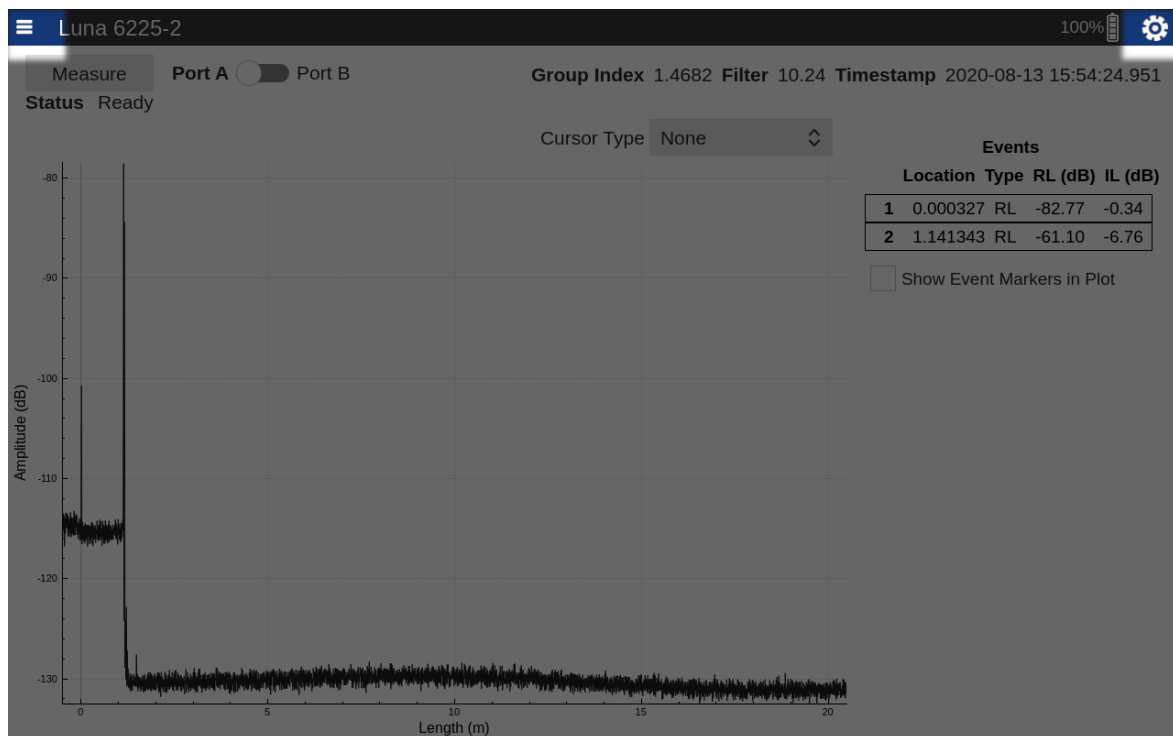


Figure 11 “Settings and Tools” can be opened by tapping on the gear tool icon in upper-right corner of the screen; and “File Operation” menu can be opened by tapping on Menu button icon in the upper-left corner of the screen.

4.4.2 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 tapping the tab titles on the top or by swiping the tab screen to right/left.

4.4.2.1 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 between 20 meter and 50 meter.

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 0.64mm, 1.28mm(default), 2.56mm, 5.12mm and 10.24mm.
- *Events* – If checked (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).

| Measurement | System | About |
|---|--|--|
| <p>Measurement Options</p> <p>Group Index <input type="text" value="1.4682"/></p> <p>RL Width (m) <input type="text" value="0.05"/></p> <p>IL Width (m) <input type="text" value="0.2"/></p> <p>Length (m) <input type="text" value="20"/></p> | <p>Event Options</p> <p>Min Location (m) <input type="text" value="-1"/></p> <p>Max Location (m) <input type="text" value="20"/></p> <p>RL Threshold (dB) <input type="text" value="4"/></p> <p>IL Threshold (dB) <input type="text" value="-2"/></p> | <p>View</p> <p><input checked="" type="checkbox"/> Gaussian Filter</p> <p>Filter Width <input type="text" value="10.24"/></p> <p><input checked="" type="checkbox"/> Events</p> |
| ••• | | |
| OK | | Cancel |

Figure 12 Measurement tab

4.4.2.2 System Tab

The System tab screen provides the ability for the user to change the screen brightness (lower brightness setting will allow system to run for longer time before battery run out), set the date and time of the system.

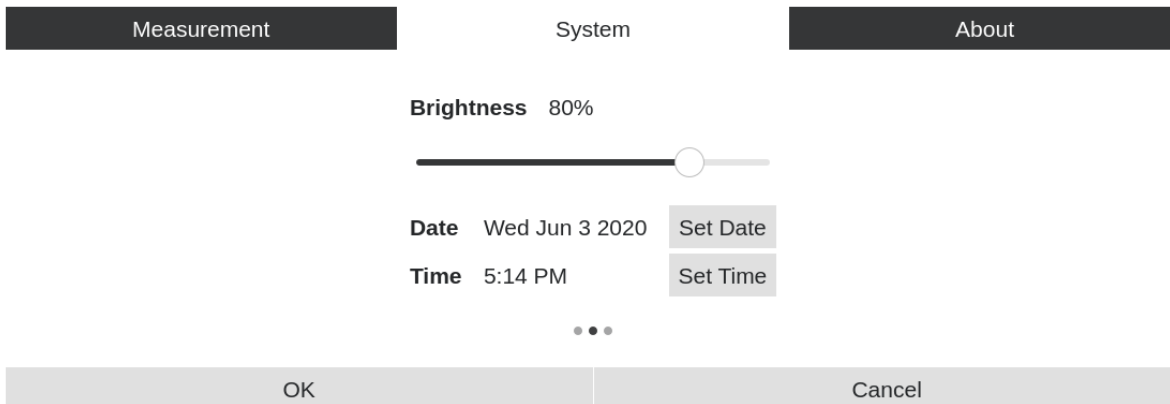


Figure 13 System tab

4.4.2.3 About Tab

The About tab screen displays the system model (Luna 6200), installed Software version and Firmware (FPGA and FX3) version information. It also provides a control for Software Update.

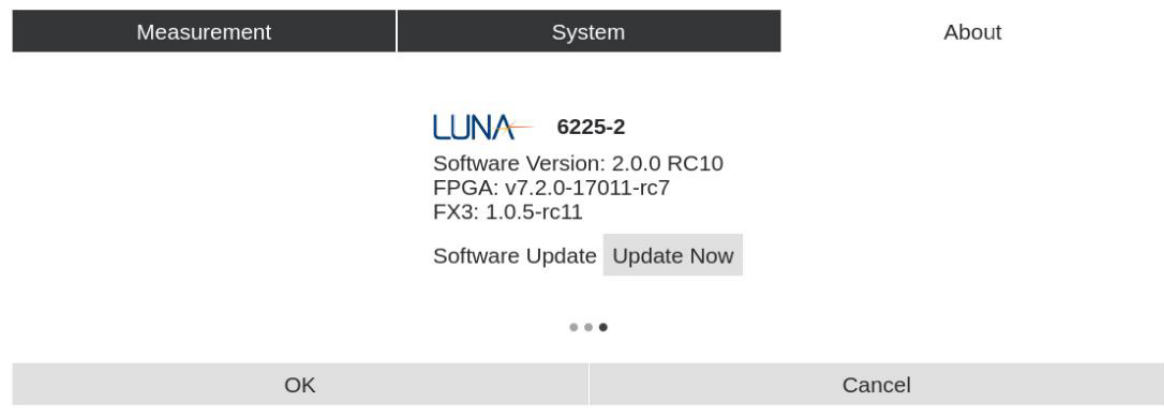


Figure 14 About Tab

Software Update: You will need a software update USB drive to perform the update. The instrument must first be charged to at least 50% battery. Once this is done, the “Update Now” button can be pressed to initiate the update. The system will power off and restart. Once restarted, the screen will turn blue and a text message will show up on screen requesting the user to Please insert update media... Connect the USB type A to USB type C adapter to the instrument and then unlock and insert the USB drive containing the software update. The instrument will automatically update the software and will show the message Software updated

successfully once completed. Remove the USB drive and adapter and power cycle the instrument to complete the update.

4.4.3 File Operations

The “File Operations” menu can be opened by either 1) tapping the Menu Button Icon on the upper left corner of the screen or 2) swiping gesture from left side edge of the screen to inside.

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

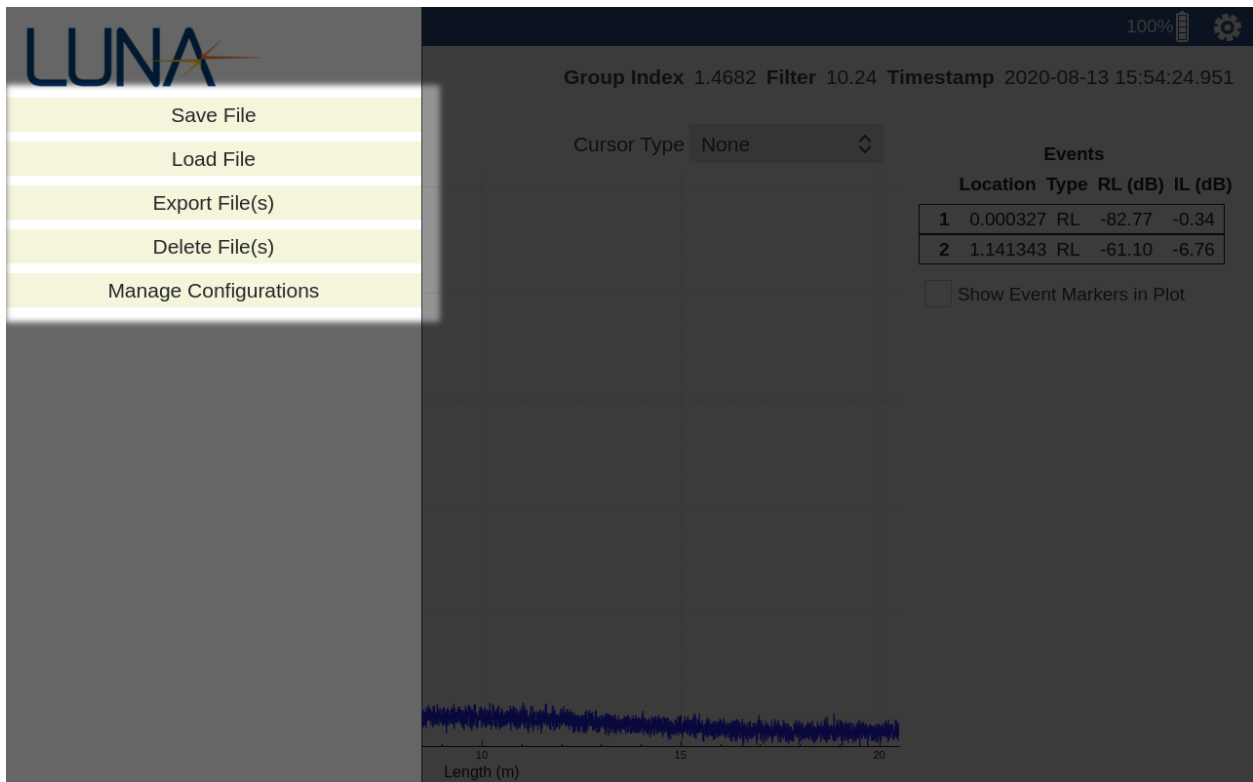


Figure 15 File Operation Menu

4.4.3.1 Save File

Tapping “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 the Delay Domain Plot result and/or the Events result.

Save Measurement File

Filename

Measurement File

TSV Data File

Delay Domain Plot

Events

Figure 16 Save Measurement File dialogue

4.4.3.2 Load File

Taping “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.

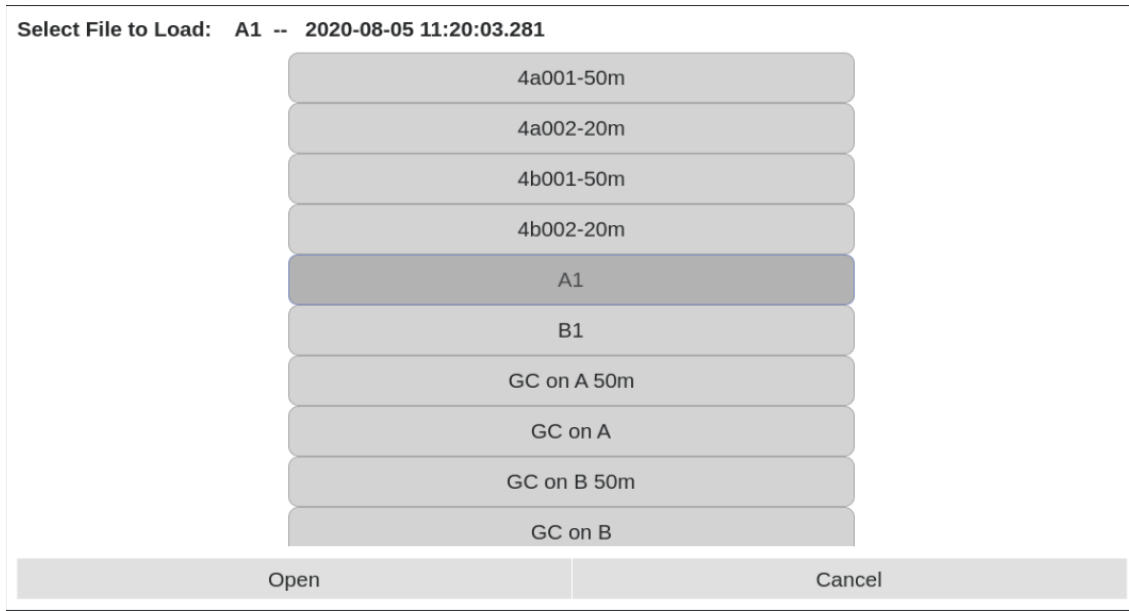


Figure 17 Load File dialogue

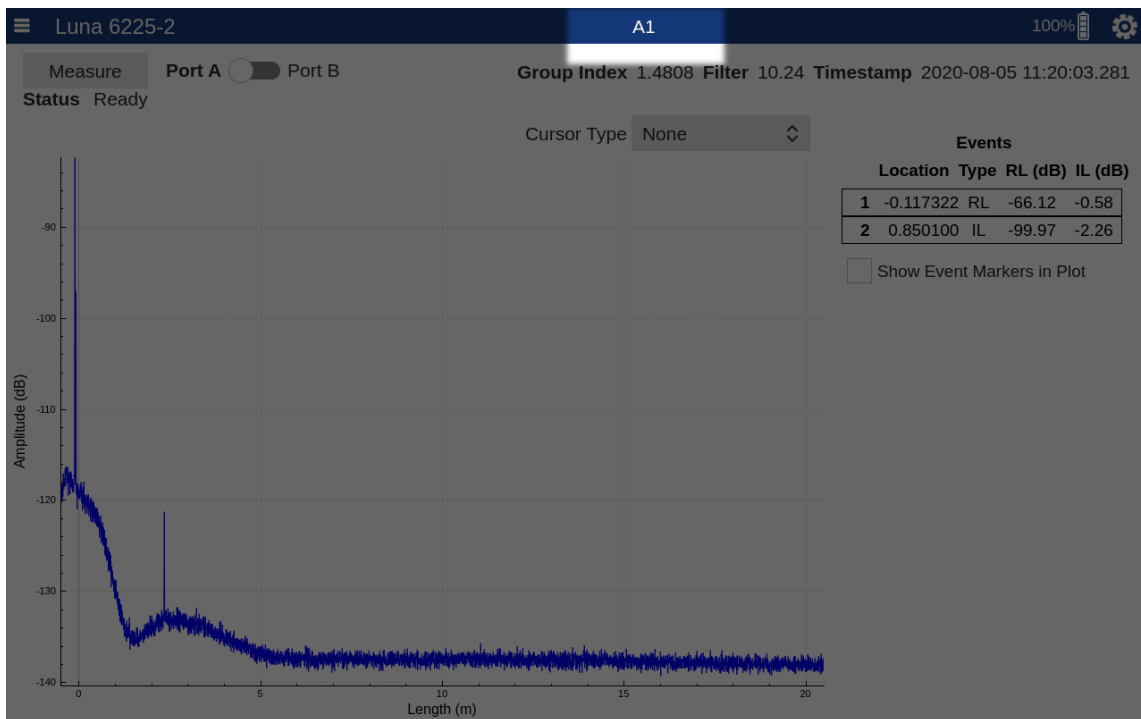


Figure 18 Test name is displayed on the top of screen after a test file is loaded

4.4.3.3 Export File

Taping “Export File” menu item, the users open the “Select File to Export to USB Drive” dialogue screen (The users need to connect an USB Drive to the system’s USB C port. Adapter maybe needed. The Drive should be pre-formatted to one of the filesystems that is compatible to Linux.).

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. After the program completed the file export operation, an “Export complete” message would be displayed to inform the users that “all files have been exported to external drive and the drive can now be removed”.

Select Files to Export to USB Drive

| | |
|-------------------------------------|-------------|
| <input type="checkbox"/> | 4a001-50m |
| <input type="checkbox"/> | 4a002-20m |
| <input type="checkbox"/> | 4b001-50m |
| <input type="checkbox"/> | 4b002-20m |
| <input checked="" type="checkbox"/> | A1 |
| <input checked="" type="checkbox"/> | B1 |
| <input type="checkbox"/> | GC on A |
| <input type="checkbox"/> | GC on A 50m |
| <input type="checkbox"/> | GC on B |
| <input type="checkbox"/> | GC on B 50m |

OK Cancel

Figure 19 Export file(s) dialogue

4.4.3.4 Delete File

Taping “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.

| File Name | Selected |
|-------------|-------------------------------------|
| 001 | <input checked="" type="checkbox"/> |
| 002 | <input checked="" type="checkbox"/> |
| 4a001-50m | <input type="checkbox"/> |
| 4a002-20m | <input type="checkbox"/> |
| 4b001-50m | <input type="checkbox"/> |
| 4b002-20m | <input type="checkbox"/> |
| A1 | <input type="checkbox"/> |
| B1 | <input type="checkbox"/> |
| GC on A | <input type="checkbox"/> |
| GC on A 50m | <input type="checkbox"/> |

OK Cancel

Figure 20 Delete File dialogue

4.4.3.5 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 tapping the tab titles on the top or by swiping the tab screen to right/left.

4.4.3.5.1 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.

Save Configuration Load Configuration Startup Configuration Delete Configuration(s)

Configuration name

Config1

••••

OK Cancel

Figure 21 Save Configuration Tab

4.4.3.5.2 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.

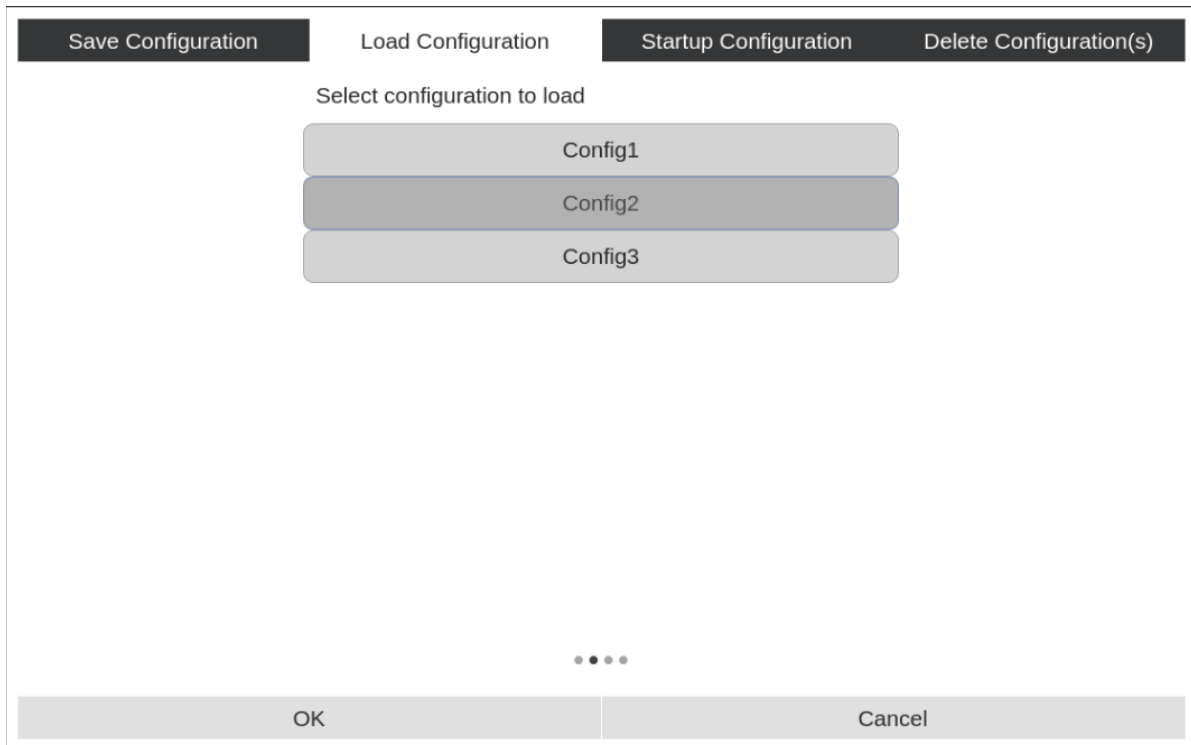


Figure 22 Load Configuration Tab

4.4.3.5.3 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 (taping 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.

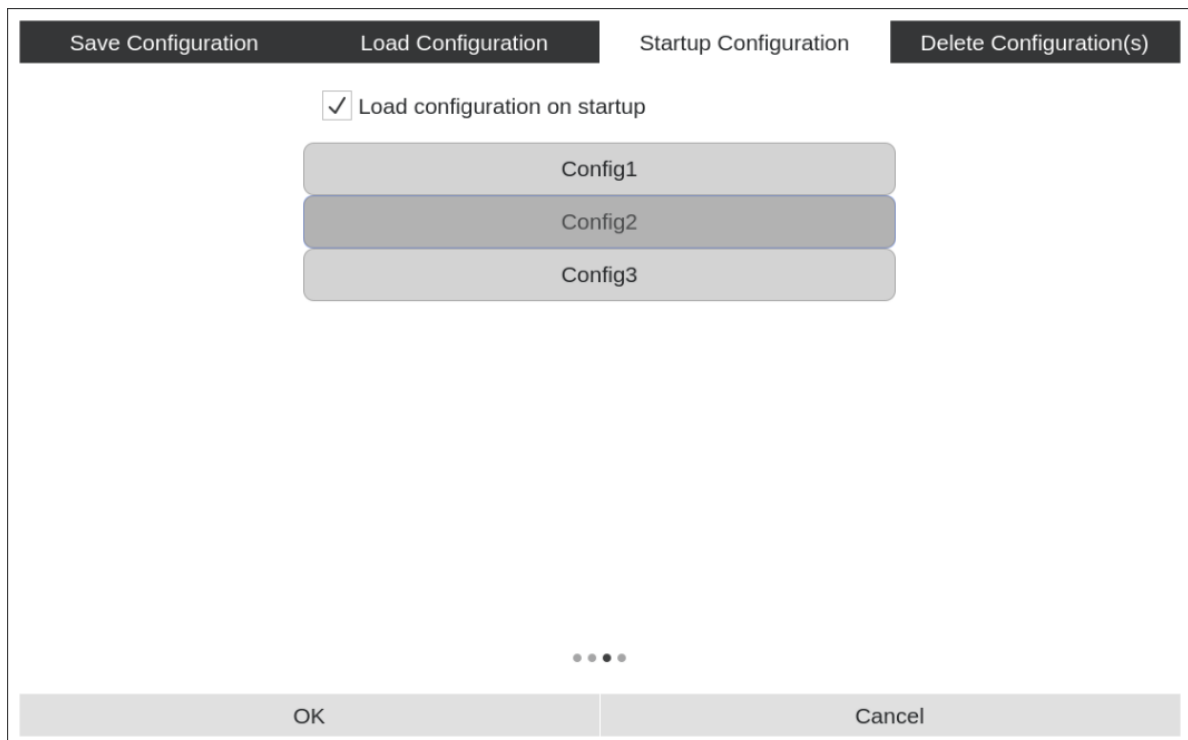


Figure 23 Startup Configuration Tab

4.4.3.5.4 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 24 Delete Configuration Tab

Appendix A Theory of Operation

The Luna OBR 6200 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.

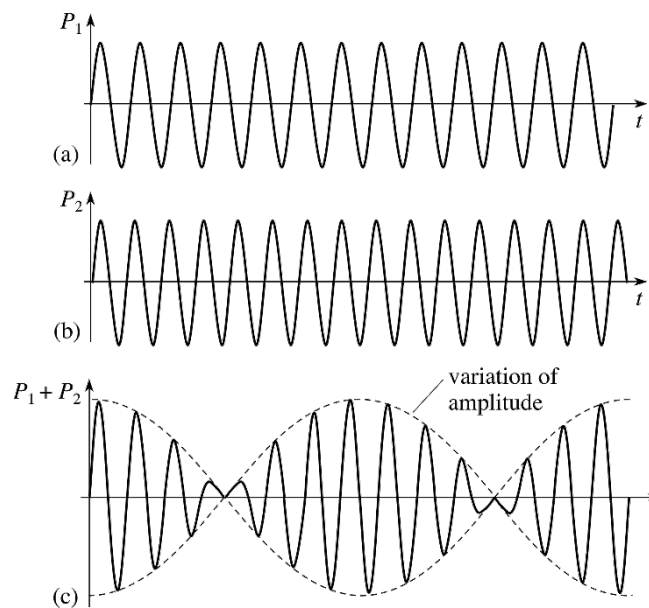


Figure 25 Interference pattern from two waves of differing frequency

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.

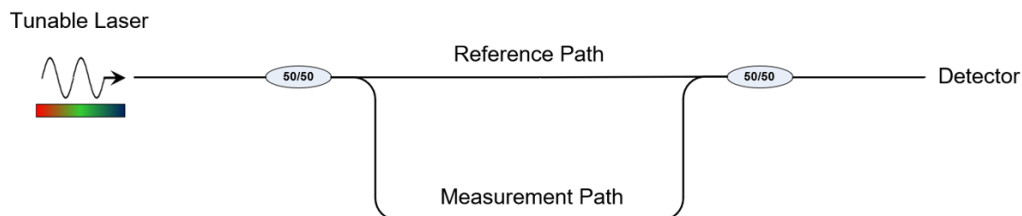


Figure 26 Fiber Optic Interferometer Network

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.

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

Path Length Difference
Laser Tuning Rate

Figure 27 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.

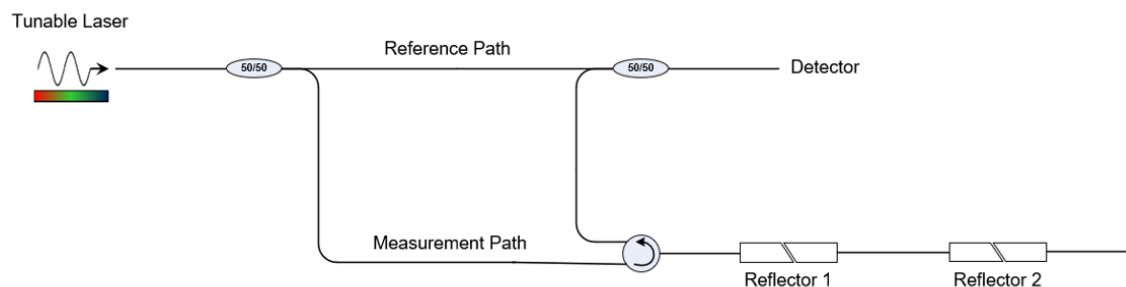


Figure 28 Basic OFDR Optical Network with two partial reflectors (connectors)

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).

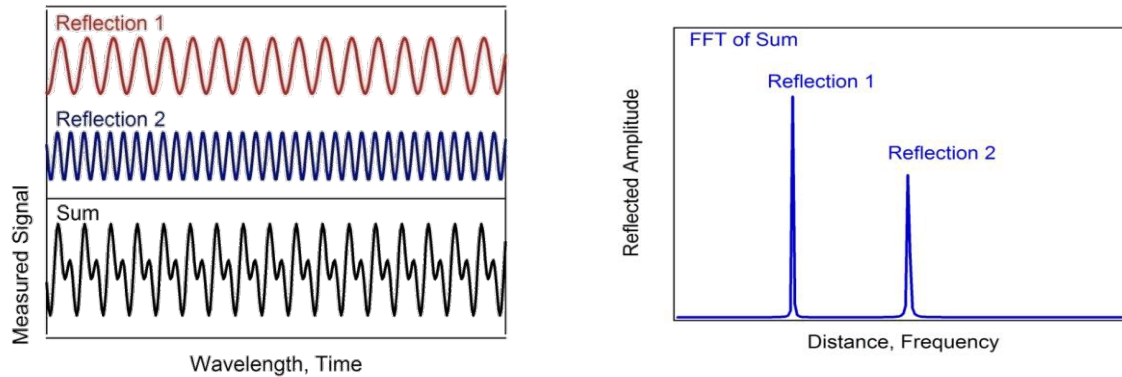


Figure 29 Resulting interference pattern from two reflectors at different locations

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.

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

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.

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

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).

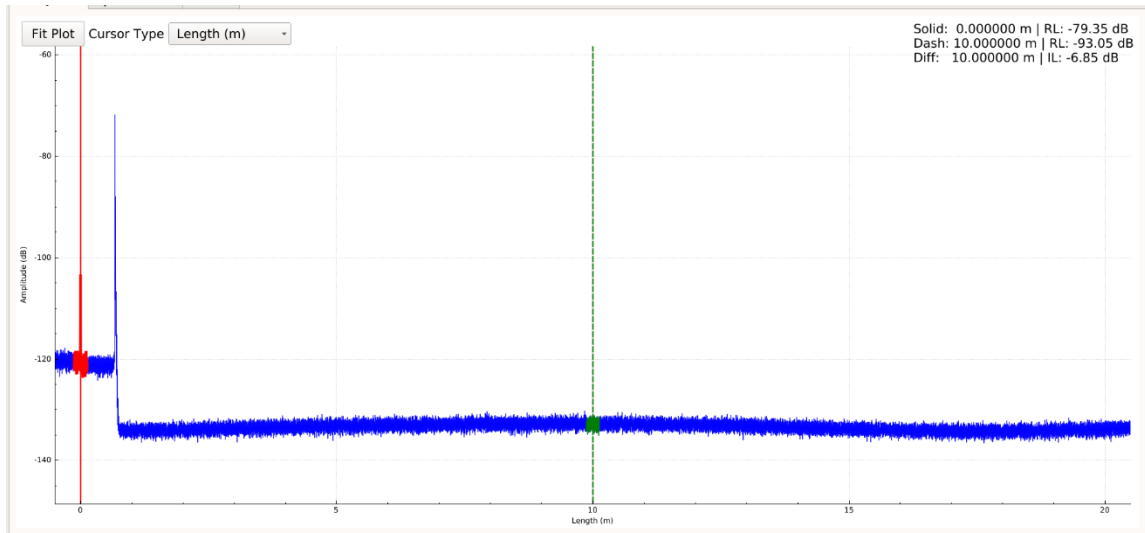


Figure 30 RL measurement using 0.25m RL integration width

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.

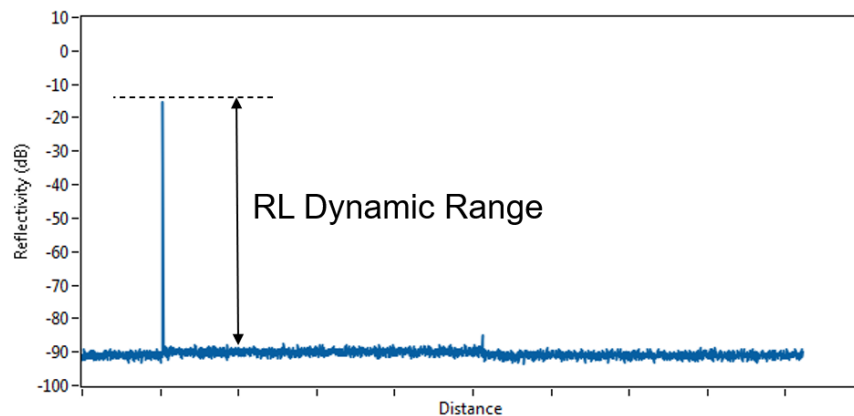


Figure 31 RL dynamic range limitation

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.

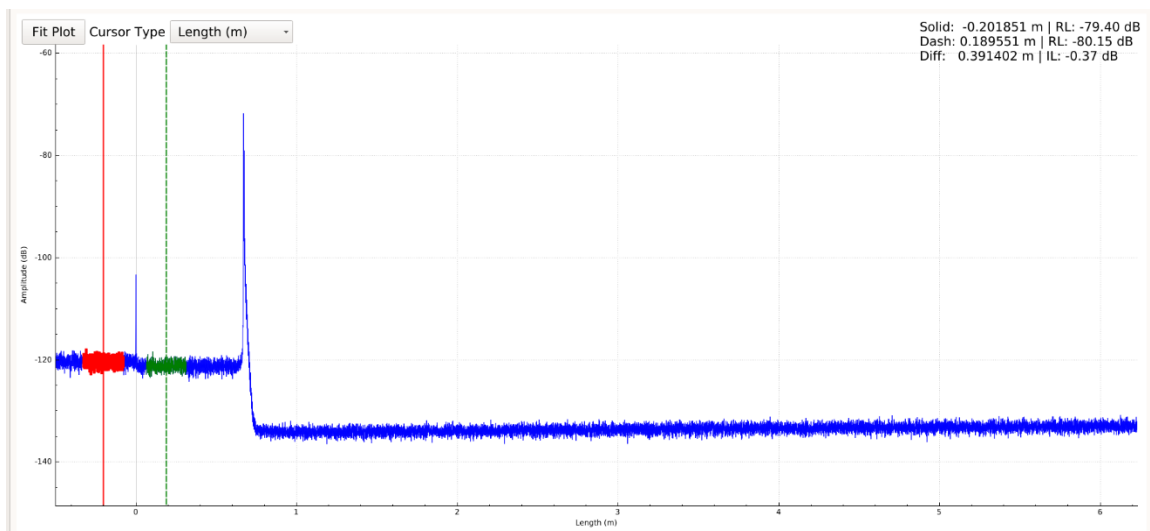


Figure 32 Insertion loss measurement shown across an APC fiber connector. (IL is shown in upper right corner)

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.