User's Guide | ODiSI 6

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*.

Optical Distributed Sensor Interrogator Model ODiSI 6:
User's Guide *ODiSI 6* Software

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

Table of Contents

1 Glossary ... 5
2 Safety ... 7
3 System Overview ... 7
3.1 ODiSI Instrument Specifications ... 8
3.2 Hardware and Physical Setup ... 10
3.3 Assembly ... 10
4 Software Overview ... 12
4.1 Operational Parameters ... 12
4.2 Manage the Sensor Repository ... 13
4.3 View and Evaluate Sensor Status ... 13
4.4 Set Up the ODiSI for Data Logging ... 13
4.5 Run a Test ... 13
4.6 View Test Data ... 14
5 Software Quick Start Guide ... 14
5.1 Operational Parameters ... 14
5.2 Installing a Sensor ... 15
5.3 View and Evaluate Sensor Status ... 16
5.4 Set Up the ODiSI for Data Logging ... 19
5.5 Run a Test ... 21
5.6 View Test Data ... 24
6 Using the ODiSI 6 Software ... 28
6.1 Operational Parameters ... 28
6.1.1 Instrument Status ... 28
6.1.2 Operational Parameters ... 28
6.1.3 Channel Status ... 32
6.1.4 Example: Operational Parameters ... 35
6.2 Manage Sensors ... 36
6.3 View and Evaluate Sensor Status ... 37
6.3.1 Sensor Tare ... 38
6.3.2 Sensor Key ... 38
6.3.3 Define Gages ... 39
6.3.4 Plot Navigation ... 40

6.4 Set Up the ODiSI for Data Logging 41
6.4.1 File Saving 41
6.4.2 Managing Test Data Files 43
6.4.3 Copy Test Data 44
6.4.4 Copying Test Data TSV Files. 45
6.4.5 Settings Menu 47
6.5 Run a Test 56
6.5.1 Sensor Plot 56
6.5.2 Gage Plot 57
6.6 View Test Data 58
6.6.1 Play Back Test Data 58
6.6.2 Generate TSV File 62
6.7 Manage Configuration 66
6.8 Update Feature Keys 68
6.9 Time Synchronization Settings 68
6.10 Help 69
6.10.1 Documentation 69
6.10.2 Send us feedback 70
6.10.3 Update 71
6.10.4 Language 72
6.10.5 About 73
7 ODiSI Remote Operation 74
7.1 ODiSI Remote Application 74
7.1.1 Remotely Control an ODiSI 74
7.1.2 Stream in ODiSI Measurement Data 74
7.2 ODiSI Remote-control Interface 75
7.2.1 ODiSI Remote-control Commands 75
7.2.2 ODiSI Controller Status 76
7.2.3 ODiSI Remote-control Workflow 78
8 ODiSI Measurement Streaming Protocol (OMSP) 81
8.1 Terminology 81
8.1.1 Channel 81
8.1.2 Sensor 81
8.1.3 Gage 81

8.1.4 Segment Vector 82
8.2 Streaming Connection 82
8.3 Message Types 82
8.4 Metadata Messages 83
8.4.1 Contents 83
8.4.2 Example 86
8.5 Measurement Message 87
8.5.1 Contents 87
8.5.2 Example 89
8.6 Tare Message 89
8.6.1 Contents 89
8.6.2 Example 91
8.7 Receiving Messages Across TCP Packets 91
9 Additional Information 92
9.1 Sensing Results near the Fiber Termination 92
9.2 System Operation Guidelines 93
9.3 Vibration Tolerance 93
9.3.1 Test Setup 93
9.3.2 Strain Test Setup 93
9.3.3 Troubleshooting Dropouts 93
9.3.4 General Troubleshooting 95
10 Product Support Contact Information 98

1 Glossary

Term	Definition
Channel	A port on the front panel of the ODiSI instrument. There is a maximum of 8 channels on an ODiSI.
Configuration	A set of Luna defined hardware and software parameters that change the measurement capabilities of the ODiSI instrument. Measurement parameters that change between configurations include (but are not limited to): measurement rate, maximum sensor length, and gage pitch. The ODiSI software automatically selects the fastest measurement rate based on the maximum sensor length detected and user-selected Gage Pitch.
Gage	Subset of a fiber sensor that is used to make a single strain or temperature measurement. A fiber sensor is divided into numerous gages which provide distributed measurements of strain or temperature along the fiber.
Gage Pitch	Length of fiber between the center of a single gage and the center of a neighboring gage.
High-Definition (HD) Sensor	A fiber sensor that provides a unique Rayleigh scatter signature that the ODiSI instrument can use to make distributed strain or temperature measurements.
Measurement Rate	This is the rate (in Hz) at which the ODiSI provides strain or temperature measurements.
ODiSI Measurement Streaming Protocol (OMSP)	JSON based protocol for the transfer of ODiSI strain or temperature data to another PC.
Sensor Key/Reference	Data set containing the unique Rayleigh scatter pattern of a single fiber sensor. This is compared to measurement scans to calculate strain or temperature. When a sensor is rekeyed, a new reference data set is captured. Once installed or generated, these files are stored in the Sensor Repository on the ODiSI controller.
Standard Length Remote Module	Supports sensor lengths from 1 m to 20 m.
Extended Length Remote Module	Supports sensor lengths from 1 m to 50 m.
RLC	Ruggedized LC connector. These connectors are used for the connections between the standoff cable and ODiSI instrument as well as between the standoff cable and the remote module.

Segment	A collection of Gages defined by a Start Gage and an End Gage.
Sensor (Strain)	A fiber optic cable sensitive to strain.
Sensor (CFG)	Continuous Fiber Grating (CFG) fiber sensor sold by Luna. Rather than utilizing the intrinsic Rayleigh backscattering of the fiber, fiber Bragg gratings are written into the fiber and utilized by the ODiSI system to make distributed measurements.
Sensor (Temperature)	A fiber optic cable sensitive to temperature.
Sensor (SC Temperature)	A fiber optic cable sensitive to temperature with strain compensation.
Sensor Length	Length of the sensing region of the fiber optic sensor.
Sensor Repository	Directory on the ODiSI controller that contains sensor specific data such as reference files, Tares, and Gage and Segment definitions. Installing and uninstalling sensors adds or removes this sensor data.
Standoff Cable	Length of optical fiber placed between the ODiSI instrument and the remote module. This length does not count toward the system's sensor length. The ODiSI instrument can be used with several different standoff cable lengths with RLC connectors on each end: 10 m, 50 m, 100 m, 150 m, and 200 m. The longer lengths can be achieved by connecting two shorter standoff cables together using a Luna provided connector.
Strain Coefficients	Polynomial coefficients used to accurately scale optical frequency measurements into strain. These coefficients can vary between sensors and are calibrated at the factory.
Temperature Coefficients	Polynomial coefficients used to accurately scale optical frequency measurements into temperature. These coefficients can vary between sensors and are calibrated at the factory.
Test Data	Binary file containing measurement data from an ODiSI.
Time Stamp	The time at which a raw (optical) data acquisition was collected by the ODiSI instrument. Time stamps are always with reference to UTC.
Touch to Locate	The process of sequentially identifying individual Gage locations using a hot or cold input.
TSV File	Tab separated value data file containing measurement data from an ODiSI.

2 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.

3 System Overview

Luna Innovations' Optical Distributed Sensor Interrogator (ODiSI 6) is a strain and temperature measurement system designed to meet the needs of engineers and scientists who are performing material characterization, process control, structural testing, and service life monitoring of vehicles, components, power systems, and a variety of other applications.

The ODiSI employs an optical frequency domain reflectometry (OFDR) technique to interpret the signal from fiber optic sensors to make strain and temperature measurements on a test article.

The ODiSI's fiber optic sensors range from 1 m to 100 m in length for distributed strain measurements and 1 m to 5 m for temperature measurements. Optical fiber's flexibility and small diameter (< 0.2 mm) lends itself to being located and routed through and inside parts and locations not typically accessible with foil gages and thermocouples.

Because optical fibers undergo well defined local optical changes as a result of changes in strain and temperature, the ODiSI is able to interpret the reflected signal along a sensor into independent strain or temperature measurements throughout the length of the fiber at intervals as low as 0.65 mm.

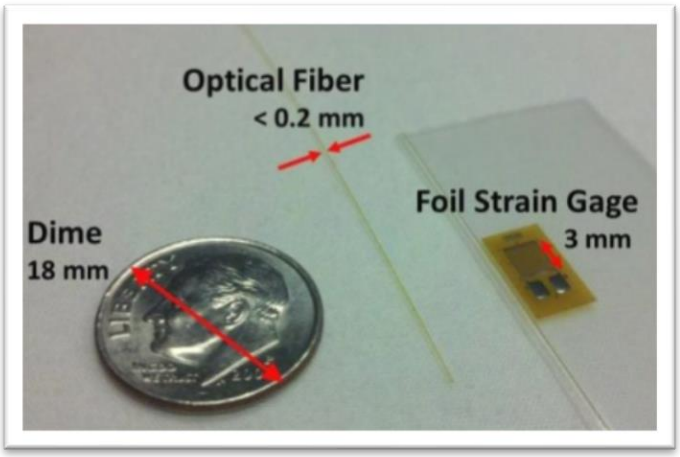


Figure 3-1 ODiSI sensor fiber.

3.1 ODiSI Instrument Specifications

The ODiSI platform is available in several channel configurations. Channels are sampled serially at the maximum allowable data rate for the specific sensor length and number of active channels. Both temperature (not SC Temperature) and strain sensors can be used on different channels during the same test. A test with SC Temperature sensors cannot contain other sensor types. A test with Luna CFG sensors cannot contain other sensor types.

The table below outlines the performance specifications for different configurations. Further details can be found in the product data sheet, which is available on the Luna website (www.lunainc.com).

PERFORMANCE

Parameter		Specification			Units
Gage Pitch[1]		0.65 mm	1.3 mm	2.6 mm	
Number of channels		1, 2, 4 or 8 channels			
Maximum sensor length per channel		10 (Standard) or 50 (Extended range)			m
Gages (measurement locations) per meter of sensor		1,538	768	384	gages/m
Measurement rates (Rates are aggregate; divide by number of active channels to determine the per-channel rate)	2.5 m mode	62.5	125	250	Hz
	5 m mode	40	80	160	Hz
	10 m mode	25	50	100	Hz
	20 m mode	12.5	25	50	Hz
	50 m mode	-	10	20	Hz
Standoff cable length		10, 50 or 100			m
Maximum patch cord length[2] (patch cords can be added between remote module and sensor)	Standard	9			m
	Extended range	6			m
HD Strain Measurement					
Strain measurement range		±12,000			με
Resolution		1			με
Instrument accuracy		±1			με
System (instrument and sensor) accuracy[3]		±25	±30	±30	με
Measurement uncertainty at zero strain[4]	Standard	±10	±6	±4	με
	Extended range	±14	±7	±4	με
Measurement uncertainty across full strain range[4]		±22	±16	±6	με
Dynamic loading rate		1	2.5	5	Hz
HD Temperature Measurement					
Temperature measurement range (standard sensor)		-40 to 200			°C
Resolution		0.1			°C
Measurement uncertainty		±2.2	±1.6	±0.6	°C
Environmental and Physical[5]					
Class 1 laser		<10			mW
Operating temperature range		5 to 40			°C
Storage temperature range		0 to 40			°C
Operating and storage relative humidity (non-condensing)		10 to 90			% RH
Operating altitude		-15 to 3,000			m
Dimensions — mainframe (W x D x H)		34 x 35 x 11			cm
Dimensions — laptop controller (W x D x H)		36 x 24 x 17			cm
Weight (mainframe and controller)		17 (7.8)			lb (kg)
Power (mainframe and controller)		160			W
Certifications					

NOTES

1. Gage pitch is the distance between centerpoints of consecutive gages.
2. Total length of the patch cord plus the active sensor fiber must not exceed 10 m for Standard length configuration or 50 m for Extended Range configuration.
3. Accuracy reflects ODiSI measurements compared to NIST-traceable extensometer measurements. Data based on average of 150 measurements at each of seven increments of strain, from 0 to maximum strain. System accuracy includes errors from ODiSI instrument and Luna strain sensors.
4. Measurement uncertainty is equal to twice the standard deviation calculated from a set of 1000 measurements. Measurement uncertainty includes the effects of the

This User’s Guide uses examples and graphics from a setup with multiple sensors. It is important to note, however, that whether the system is set up for one or multiple sensors, the hardware setup and the application interface remain consistent.

3.2 Hardware and Physical Setup

The ODiSI 6 system is shipped with the following key components:

Optical Distributed Sensor Interrogator (ODiSI 6)

Dedicated Instrument Controller

Standoff Cable(s)

Remote Module(s)

Optical Fiber Bulkhead Cleaners

Optical Fiber Connector Cleaner

Flash drive with user guides and recovery software

ODiSI Power Cord

Laptop Power Adapter

USB3 Type A to B cable

3.3 Assembly

1. Remove all the components from the packaging and verify that the components are undamaged.
2. Place the unit on a stable surface capable of supporting the entire weight of the unit.
3. Confirm that airflow into and out of the vents at the side and rear of the unit is not obstructed.

4. Clean the duplex LC-APC connectors at the ends of the standoff cable using the provided Cletop connector cleaner (see Setup Guide for cleaning instructions).
5. Connect one end of the standoff cable to one of the front panel ports on the ODiSI.
6. Connect the other end of the standoff cable to the remote module.

Note: Repeat steps 5 and 6 for each remote module that came with the configuration.

7. Unpack and set up the instrument controller (laptop) according to the manufacturer's instructions.
8. Connect the ODiSI 6 to the controller using the supplied ***USB 3.1 Gen I*** cable.
9. Attach the power cords to the controller and ODiSI 6.
10. Turn on the ODiSI 6 and the instrument controller (laptop).

Note: The ODiSI 6 can be restarted without restarting the laptop.

11. Log into the laptop using the following credentials:

User Name: odisi

Password: odisi

12. Launch the ODiSI software by double clicking on the OD6 desktop icon.

4 Software Overview

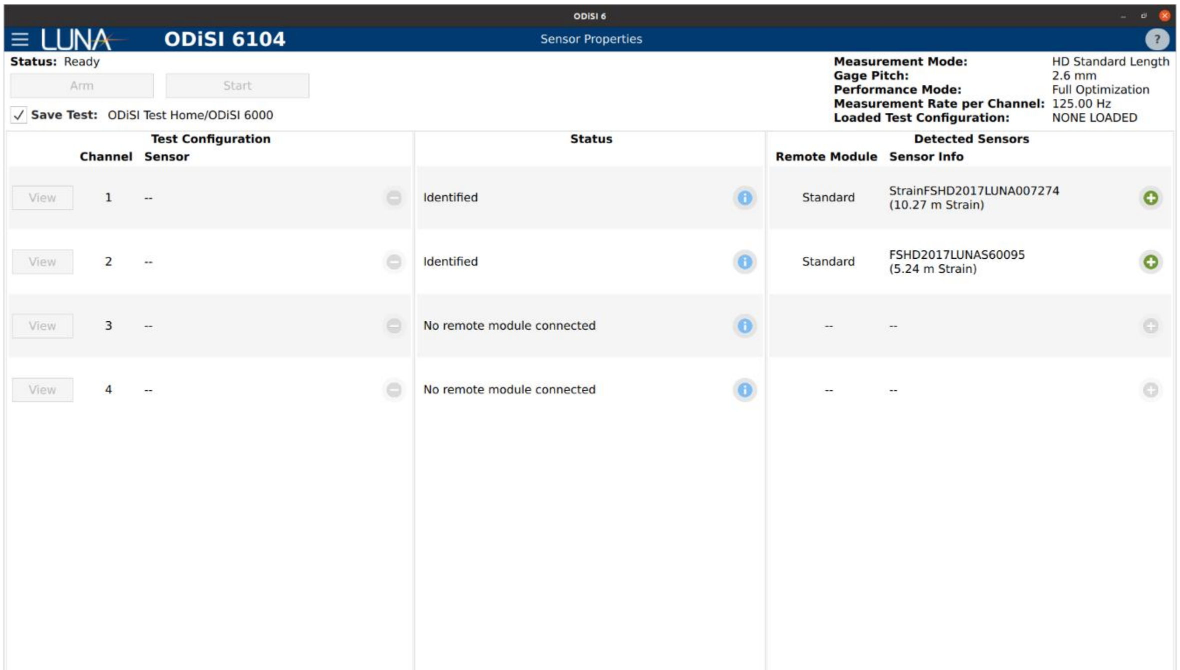


Figure 4-1: Main screen of the user software

This chapter provides an overview of the functionalities available in the ODiSI 6 user software. Instructions for how to quickly set up a test and log data are found in the next chapter (Software Quick Start Guide). Following that is a detailed explanation of all the ODiSI 6 software functionalities (Using the ODiSI 6 Software).

The functionalities provided by the software relate to the following main actions:

1. Configure operational parameters
2. Install sensors
3. View and evaluate sensor performance
4. Set up the ODiSI for data logging
5. Run a test
6. View test data

4.1 Operational Parameters

When the software is first launched, the software will go through an initialization process. Once completed, the main user interface will be displayed, showing the status of the system as well as each channel on the ODiSI. Other information on display in the main software interface include the measurement mode of the system, the gage pitch, the performance mode of the system, the associated per channel measurement rate, and the loaded test configuration as well as the sensor types connected on each channel.

4.2 Manage the Sensor Repository

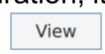
The ODiSI is configured for use with Luna's fiber optic strain and temperature sensors. Each sensor has a unique optical signature which is used to

1. Characterize the sensor's strain or temperature state, and
2. Automatically identify the sensor (for most Luna fiber sensor types).

This reference file is also called a sensor key and is contained in Luna-labeled flash drives shipped with each sensor. In order for an ODiSI to make measurements from a sensor, that sensor's key needs to be installed onto the controller prior to use. Once installed, these files are stored in the Sensor Repository on the controller.

Actions related to installing sensors and managing the Sensor Repository can be accessed from the "Tools → Manager Sensors" menu. These actions include installing sensors, renaming sensors, deactivating sensors, deleting deactivated sensors, and exporting sensors. For more information, see Manage the Sensor Repository.

4.3 View and Evaluate Sensor Status

Once a sensor is identified and added to a particular Channel's configuration, its performance can be viewed for evaluation by clicking the associated "View" 

button. The subsequent interface provides a look at the strain or temperature profile along the sensor. Other actions that can be accessed from this interface include creating and selecting a Tare, defining individual gages and segments for data logging and streaming, as well as Rekeying the sensor.

4.4 Set Up the ODiSI for Data Logging

Once satisfied with the sensor performance on each channel, the ODiSI can be set up for logging test data. Data logging rates, trigger settings, as well as data streaming settings are accessed through the Settings menu. The test naming is accessed through the "File → Set Test Data File Save Options" menu.

4.5 Run a Test

Clicking on the "Arm" 

button prepares the ODiSI for running a test. This will initially display the Sensor Plot screen.

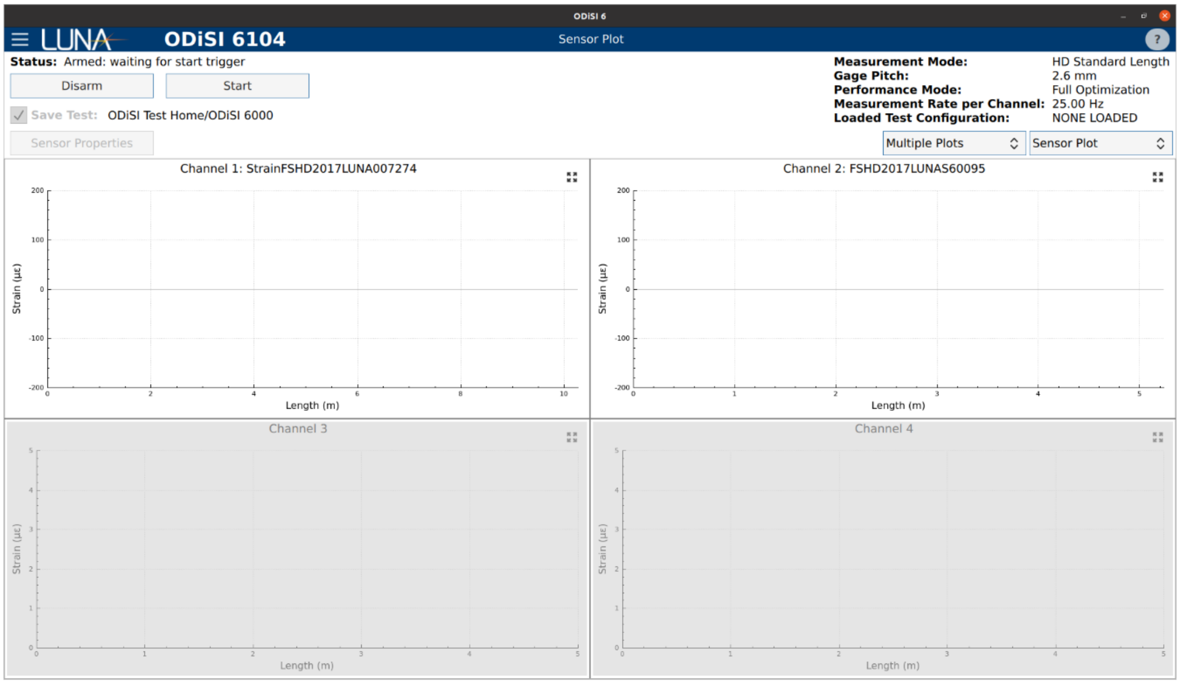


Figure 4-2: Arming a test shows the Sensor Plot screen

When a test is running, the Sensor Plot and Gage Plot visualizations are available. The Sensor Plot allows viewing of the strain or temperature along all sensors, and the “Gage Plot” allows viewing strain or temperature measurements from select individual gage locations along all sensors, over time.

4.6 View Test Data

Test data is logged in binary files that are stored in the Test Data folder on the controller. Test data can be played back through the “Play Back Test Data” function and can be converted to human readable tab delimited .tsv files through the “Generate Test Data TSV Files” function. These TSV files can be opened in external programs such as Excel or Matlab for further data analysis.

5 Software Quick Start Guide

This chapter quickly goes through the process of setting up a single channel ODiSI test with test data file logging enabled. The test data file is then opened for playback afterwards.

5.1 Operational Parameters

1. Launch the software.
    a. Double click the “OD6” desktop shortcut. The application window will display an “Initializing” status. Once this reaches 100%, the main software interface is active.
2. Check that the “Status” is updated to “Ready”.

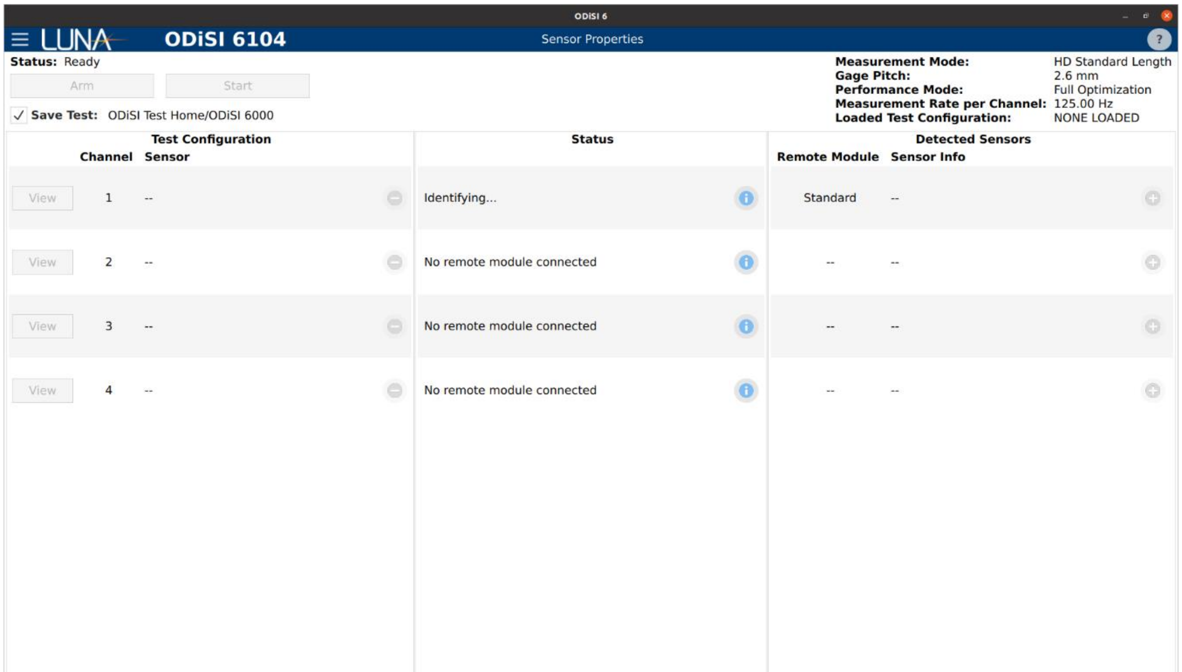


Figure 5-1: Main screen of the user software after successful initialization, status field shows “Ready”

5.2 Installing a Sensor

1. Install a sensor.
    a. Plug the flash drive containing the sensor key into a USB port of the ODiSI controller.
    b. Open the menu by clicking the button in the top-left corner.
    c. Click on “Tools → Manager Sensors” to bring up the Manage Sensor Dialog as show in the figure.

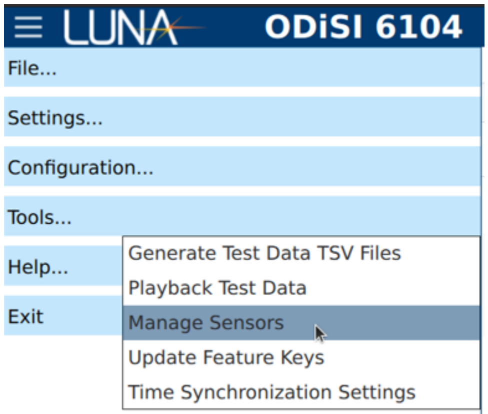
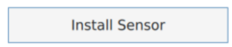


Figure 5-2: Manage Sensors menu item

d. Click on the "Install Sensor" 

button.

e. Navigate to where the sensor key is located, select it and click the "Open" button.

f. Click "Close" to exit the "Manager Sensors" window.

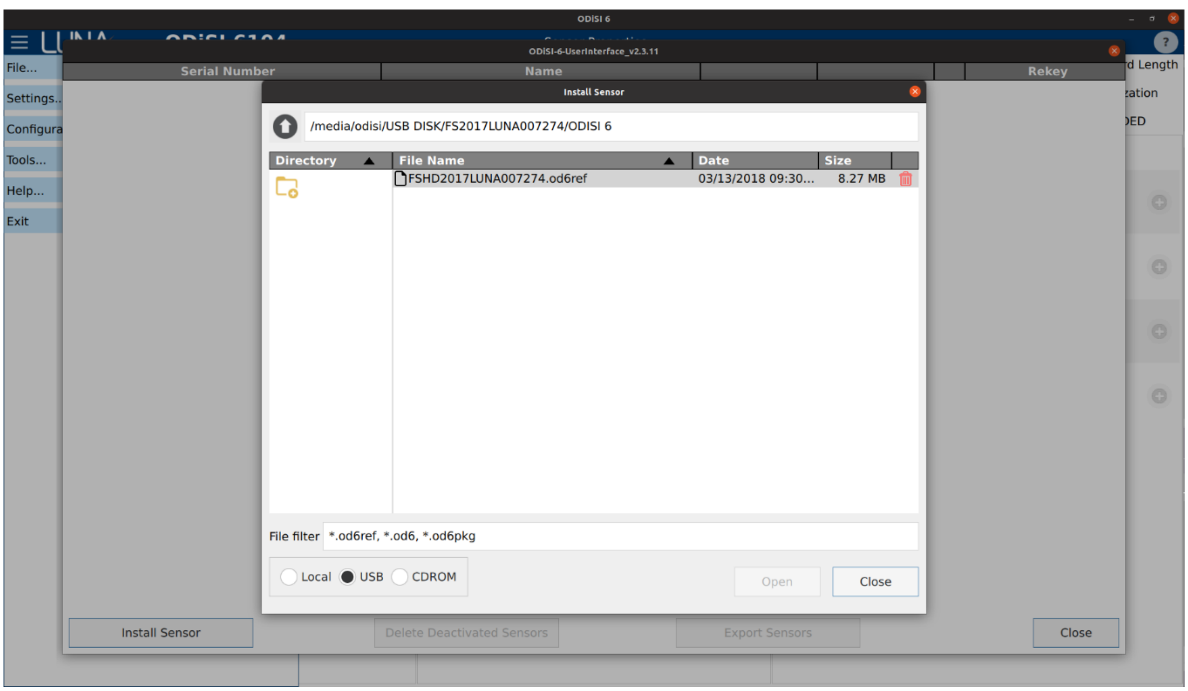


Figure 5-3: Manager Sensors window with Install Sensor dialog

5.3 View and Evaluate Sensor Status

1. Add the identified sensor to the channel configuration. Do this by clicking the  button beside the identified sensor.

2. For the ODiSI 6100 Series, measurements can be taken with the 1.3 mm Gage Pitch. To change the gage pitch, select the “Settings → General” menu item to open the “General Settings” dialog and then choose “1.3 mm” from the Gage Pitch drop-down. For the ODiSI 6000 Series, choose “5.2 mm” from the Gage Pitch drop-down.

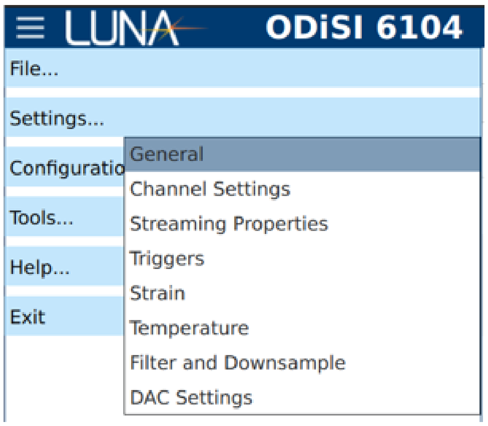


Figure 5-4: General Settings menu item

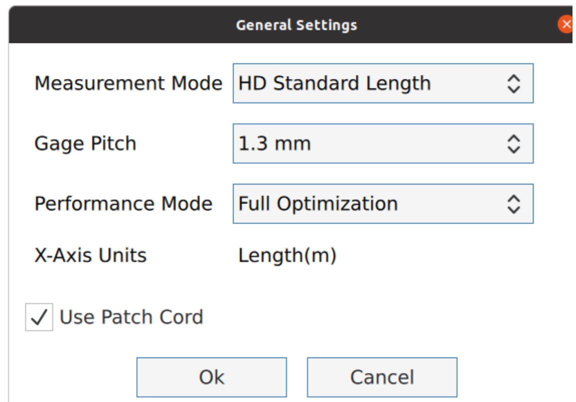
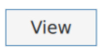


Figure 5-5: General Settings dialog

3. Click on the “View” 

button.

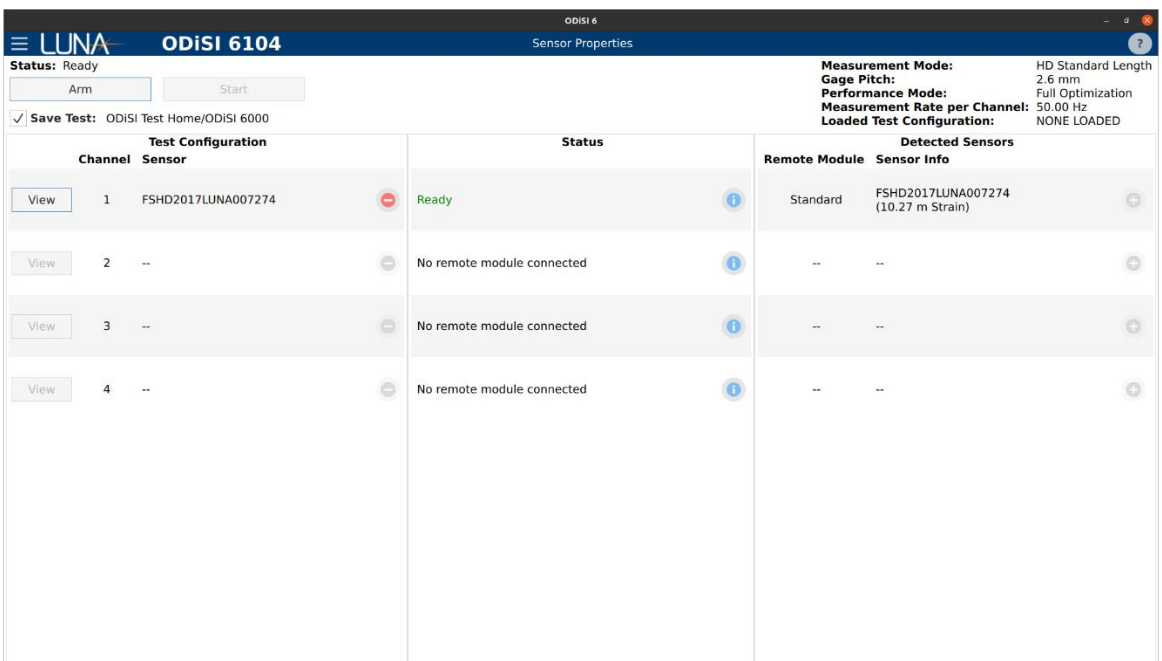


Figure 5-6: Added identified sensor to test configuration on channel 1, View button enabled

4. Click the “Fit Plot” button to auto-scale the measurement vs. length plot.

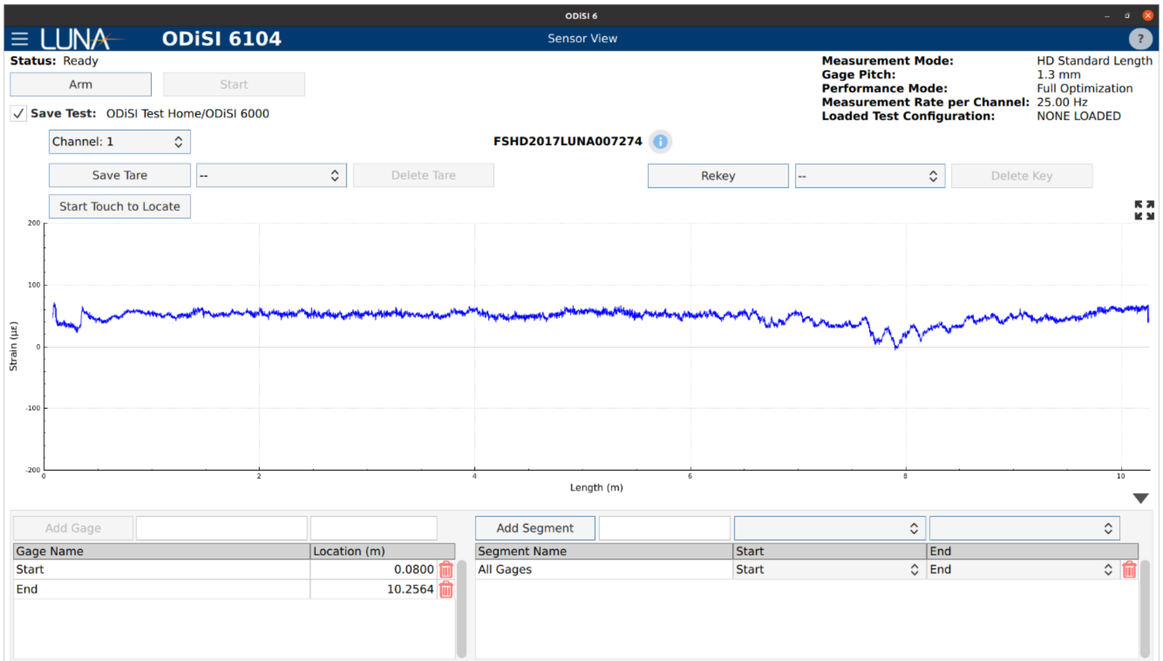
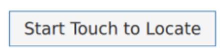


Figure 5-7: View strain along the length of the sensor

5. Confirm that the measurement length matches the expected sensor length.
6. Zero out residual strains along the sensor. Click on the “Save Tare” 

button and give the Tare a name.
7. Define additional Gages and Segments using Touch to Locate.
    a. Click on the “Start Touch to Locate” 

button.
    b. Apply a localized hot or cold touch to the sensor at the gage location of interest.
    c. A red vertical cursor will appear at the touch location.
    d. Click the “Add Gage” button.
    e. Repeat the above steps for other gages of interest.

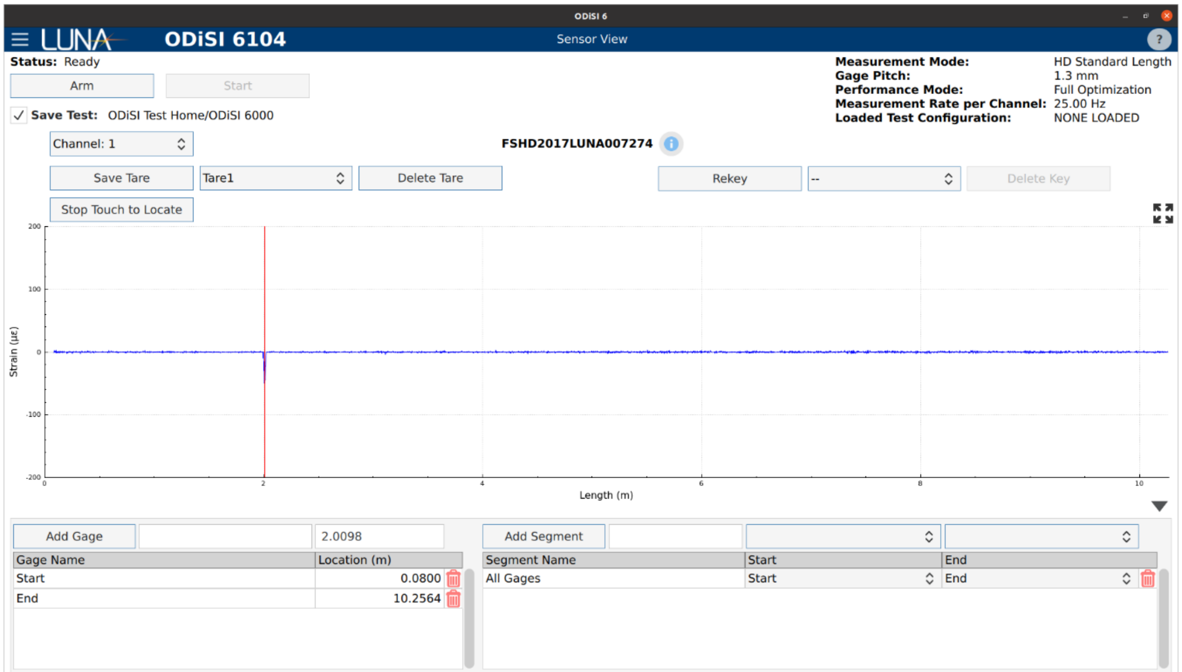


Figure 5-8: Define Gages and Segments

5.4 Set Up the ODiSI for Data Logging

1. Set up test data file saving.
   a. Ensure “Save Test” is checked.

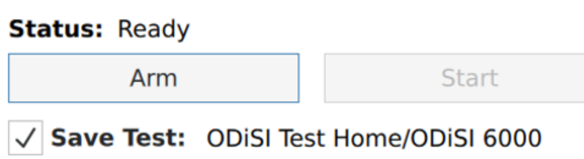


Figure 5-9: Check the "Save Test" checkbox

   b. Click on “File → Set Test Data File Save Options” to specify the test name, notes and destination folder.

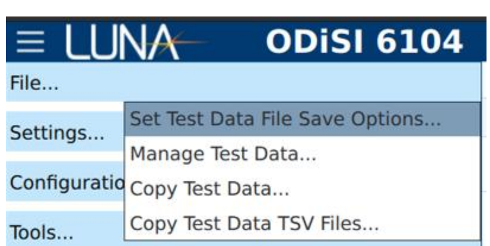


Figure 5-10: Menu item for test data file saving options

c. Enter the “Test Name”, “Notes” and click the “Browse” button to select the destination folder.

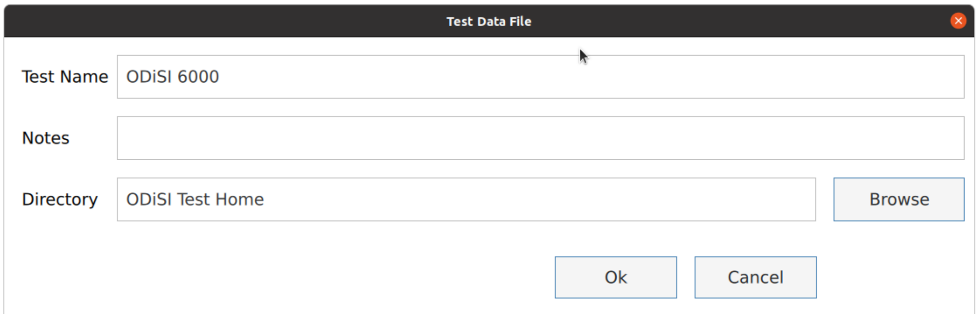


Figure 5-11: Test data file saving properties

2. Adjust measurement rate

a. Click the “File → Filter and Downsample” menu item.

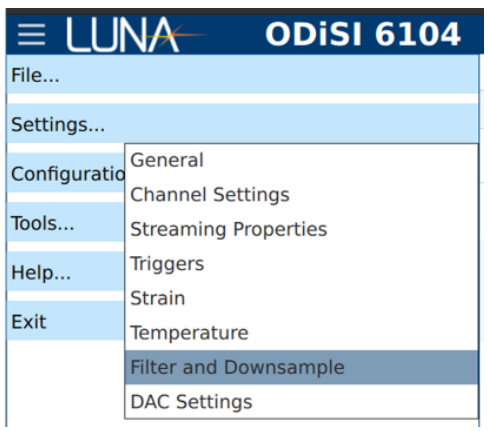


Figure 5-12: Filter and Downsample menu item

b. Click the check box next to “Temporal Downsampling Factor” and specify the “Temporal Downsampling Factor” to down-sample from the full data rate.

c. Click “OK” to save these settings and close the dialog.

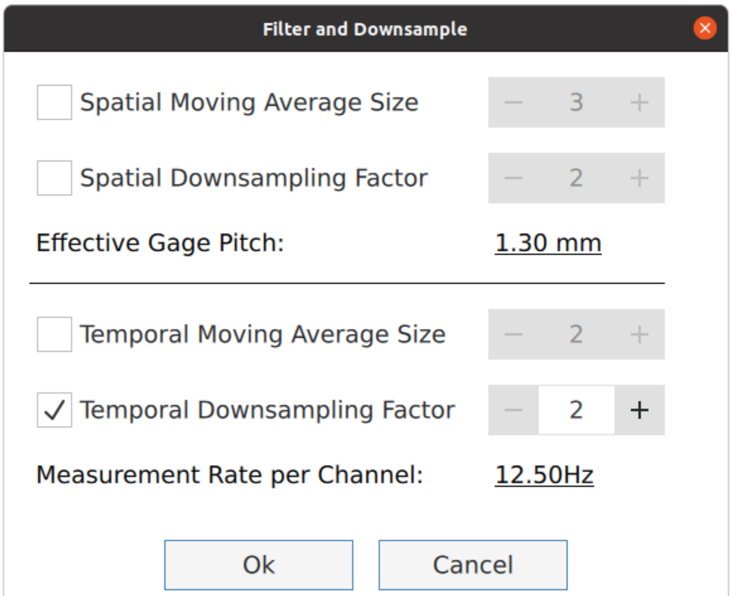
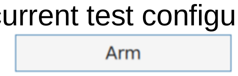
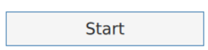


Figure 5-13: Set a temporal downsampling factor

5.5 Run a Test

1. Lock the current test configuration and prepeare the ODiSI to acquire data by clicking the “Arm” 

button. The Sensor Plot screen will be displayed.
2. Click the “Start” 

button to start logging data. You can view the measurement versus length in the “Sensor Plot” screen.

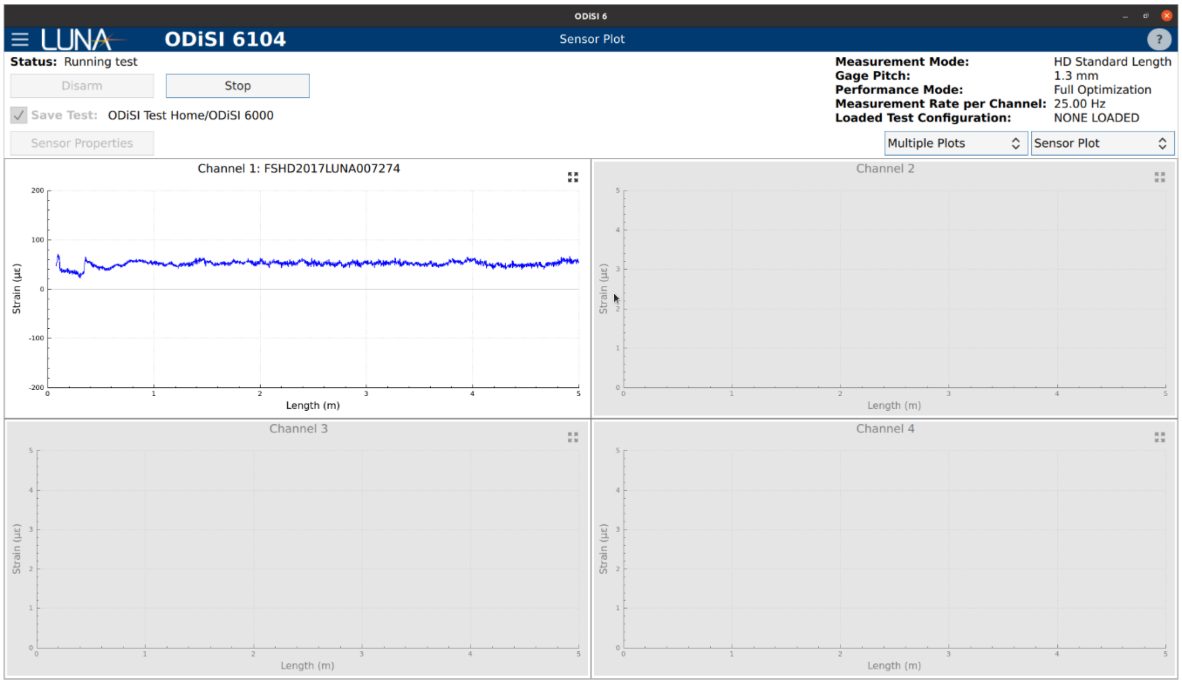


Figure 5-14: Sensor Plot screen updates with live data after clicking Start

3. View sensor single plot screen by selecting the “Single Plot” from the associated drop-down menu.

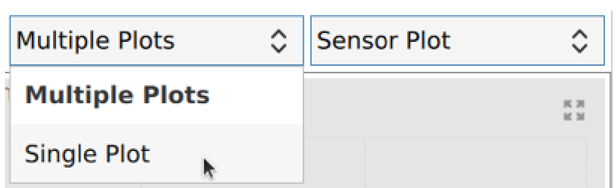


Figure 5-15: Plot type selection

4. The sensor single plot screen will be displayed.

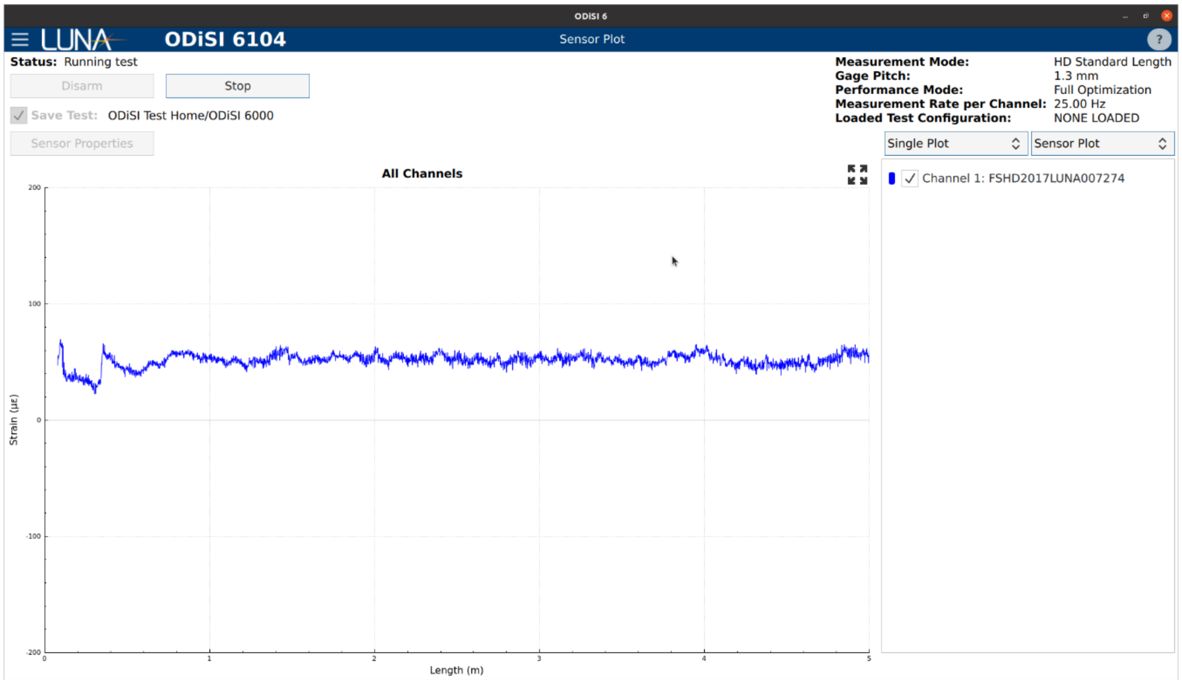


Figure 5-16: View Single Plot

5. View individual gages versus time by selecting the “Gage Plot” screen in the drop-down menu.

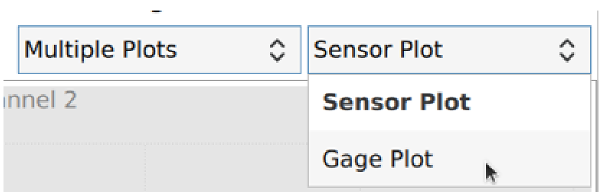


Figure 5-17: Select Gage Plot

6. The Gage Plot will be displayed. Enable plotting for individual gages on the “Gage Plot” by checking the corresponding checkboxes in the list. The color for a particular gage line can be changed by clicking the corresponding color square and selecting the desired color in the dialog that appears.

Figure 5-18: Enable plotting for some gages

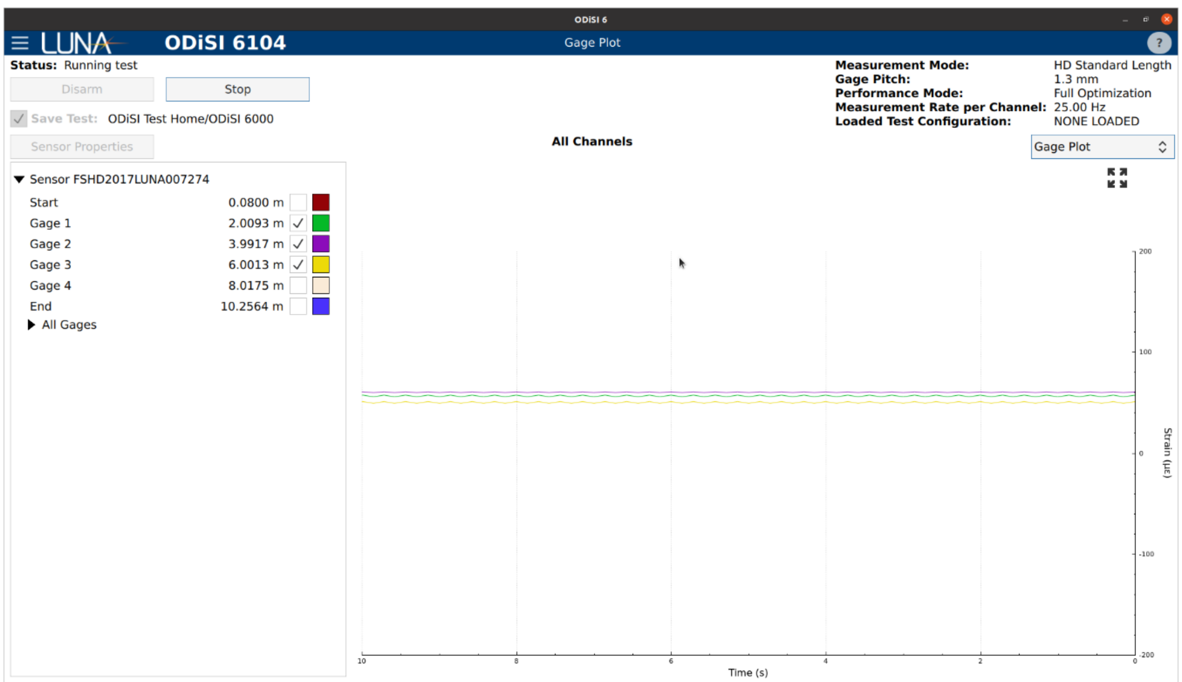


Figure 5-19: Live plot for the enabled gages over time

7. Click the "Stop" Stop button once the test is complete.

5.6 View Test Data

1. Play back test data.
    a. Click the "Tools → Playback Test Data" menu to display the ODiSI Player

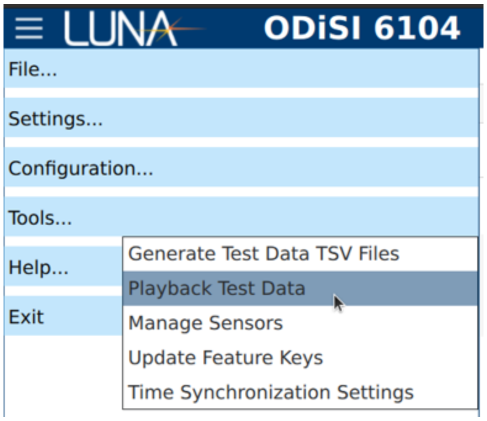


Figure 5-20: Playback Test Data menu item

b. Select the Test Data file to view.

c. Play back or scroll through the test data using the navigation buttons.

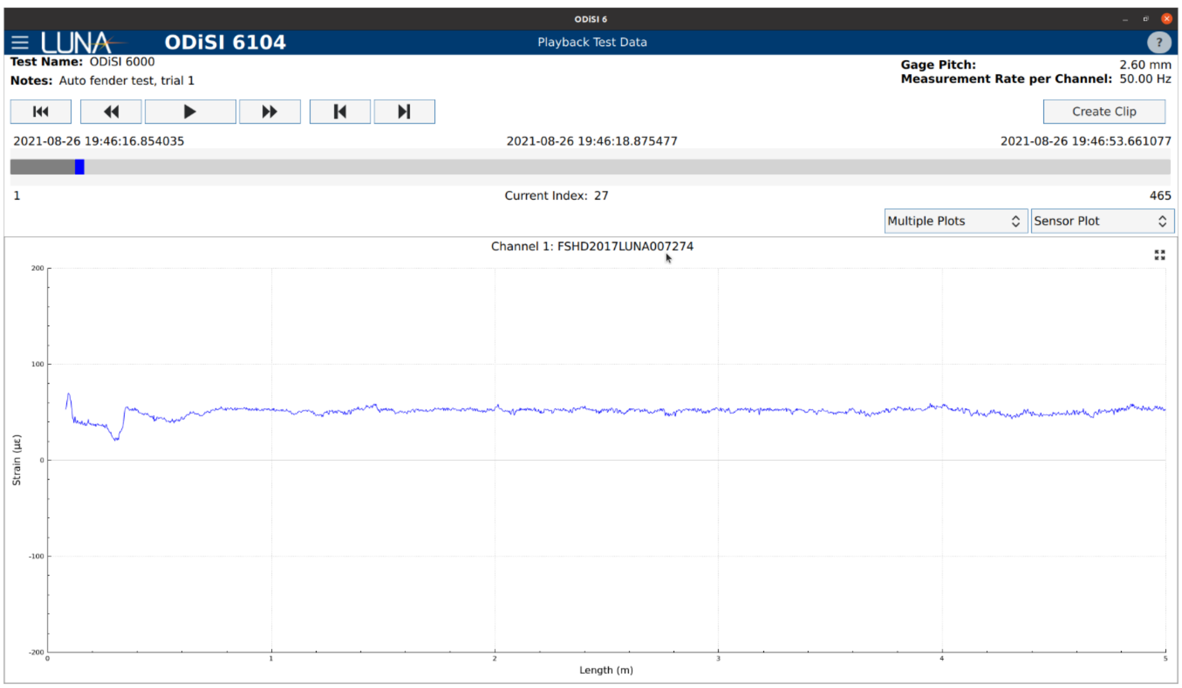


Figure 5-21: Playing back the test data

2. Convert binary test data into ASCII format.

   a. Click the “Tools → Generate Test Data TSV Files” menu item to open the “Generate Test Data TSV Files Dialog”.

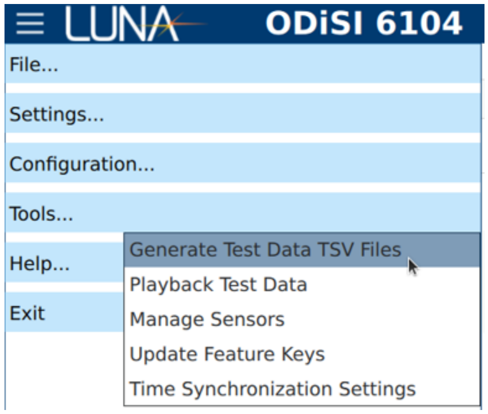


Figure 5-22: Generate Test Data TSV Files menu option

b. Select the desired Test Data file(s). Add them individually or in a batch. Then click “Save”.

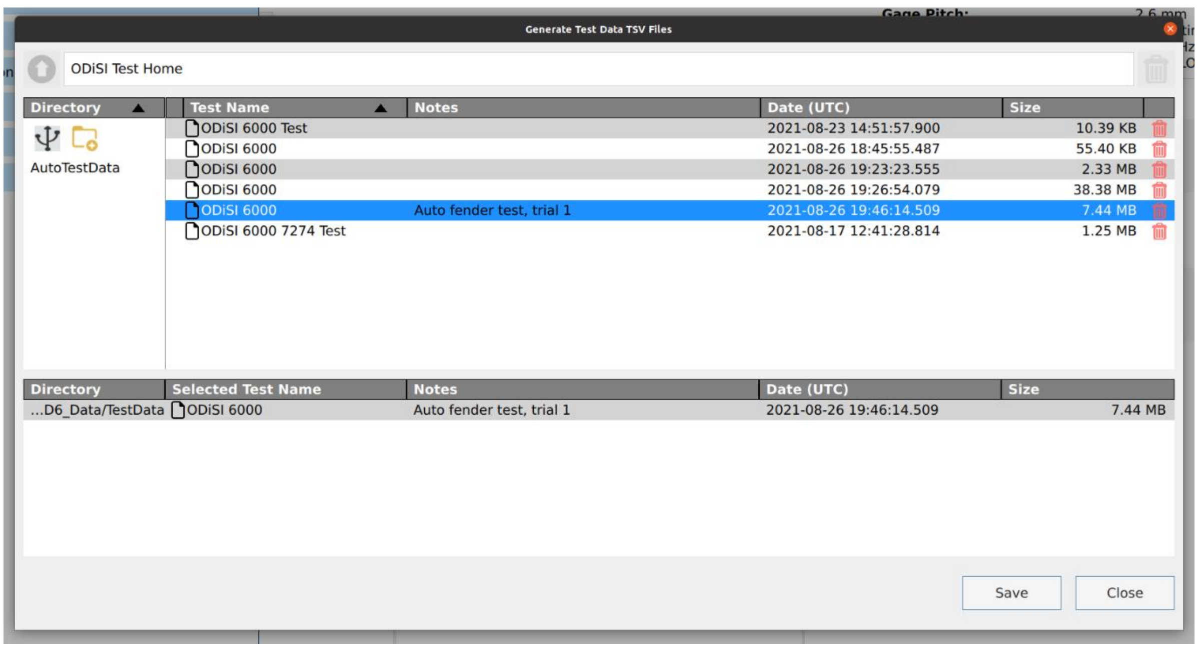


Figure 5-23: Select Test Data file(s) for conversion to TSV file(s)

c. Select the folder to which TSV files will be written. Then click “Save”.

d. Once file conversion is complete, the status will be indicated in a pop-up window.

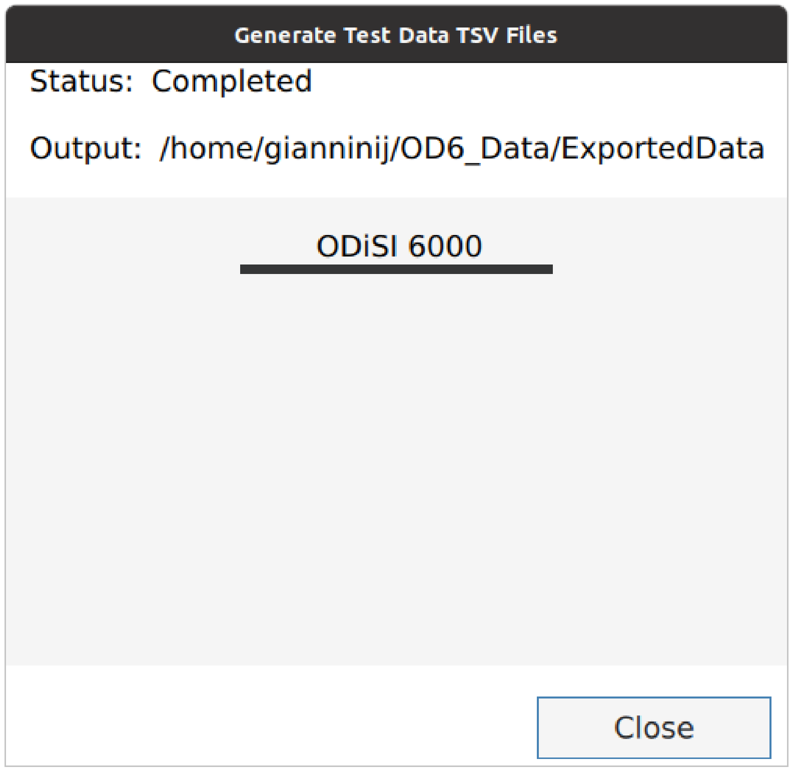


Figure 5-24: Completion status for generating TSV file(s)

6 Using the ODiSI 6 Software

This section describes in detail all the functionality of the ODiSI 6 Software.

6.1 Operational Parameters

When first launched, the user interface displays the system Status and Sensor Properties. Among other things, the "Sensor Properties" screen displays the current state of the system including information on the configuration of each channel and detailed information for each sensor.

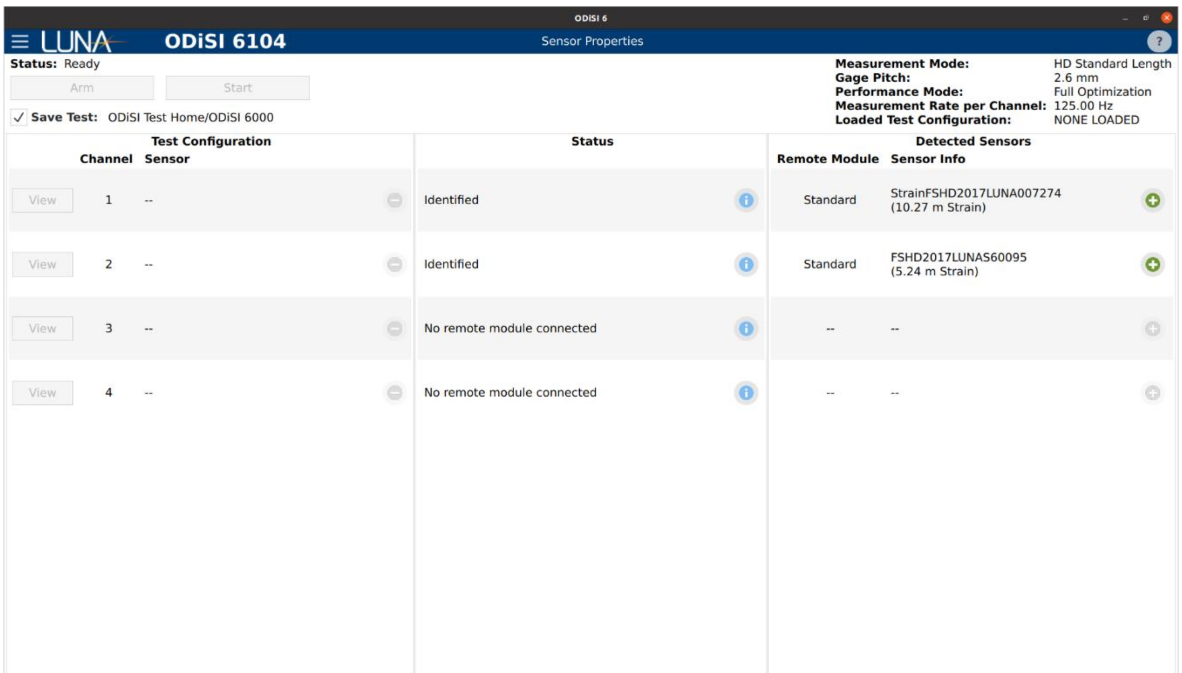


Figure 6-1: Main Sensor Properties screen

6.1.1 Instrument Status

The system Status is indicated in the top left corner. The status displayed is one of the following:

- **Initializing**: The software has just been launched and is connecting to and configuring the hardware.
- **Ready**: The software is ready to start making measurements using the fiber sensors.
- **Running Test**: The system is currently making measurements for a test.

6.1.2 Operational Parameters

6.1.2.1 Measurement Mode

The ODiSI 6 provides three different Measurement Mode options to choose from. The Measurement Mode setting is accessed by clicking on the "Settings → General" menu item.

HD Standard Length: High Definition Standard Length remote modules are used with sensors that are less than 20 m long, or combinations of sensor and patch cord that are less than a total of 20 m long.

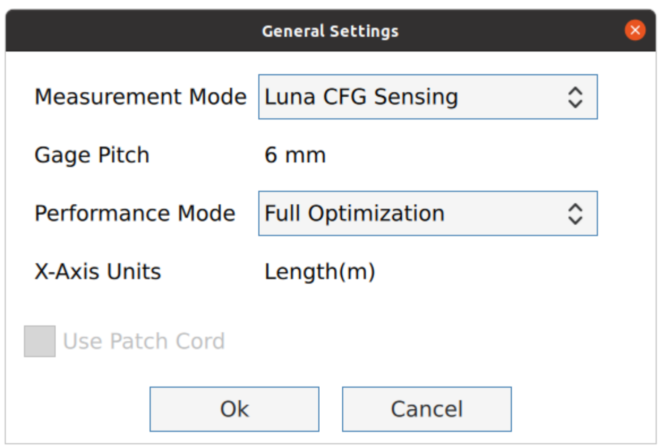
HD Extended Length: High Definition Extended Length remote modules can be used with sensors that are 1 m and up to 100 m long or with a patch cord (maximum length 19 m) where the combinations of sensor and patch cord are less than a total of 100 m long.

> *Note: The system can only operate in either standard or extended length mode. Standard length and extended length remote modules cannot be used simultaneously during the same test configuration*.

Luna CFG Sensing: Continuous Fiber Grating (CFG) sensors sold by Luna. Rather than utilizing the intrinsic Rayleigh backscattering of the fiber, fiber Bragg gratings are written into the fiber and utilized by the ODiSI system to make distributed measurements. This mode functionality provides a fixed 6 mm gage pitch and requires slightly different operation than other ODiSI 6000 sensors which requires that CFG sensors cannot be used with other sensors.

6.1.2.2 Luna CFG Sensing

Select “Settings → General” as described above and select the “Luna CFG Sensing” option from the “Measurement Mode” drop-down.



Note that the Gage Pitch selected is 6 mm and it cannot be changed. Upon clicking “Ok”, the CFG Sensor Properties Screen is displayed.

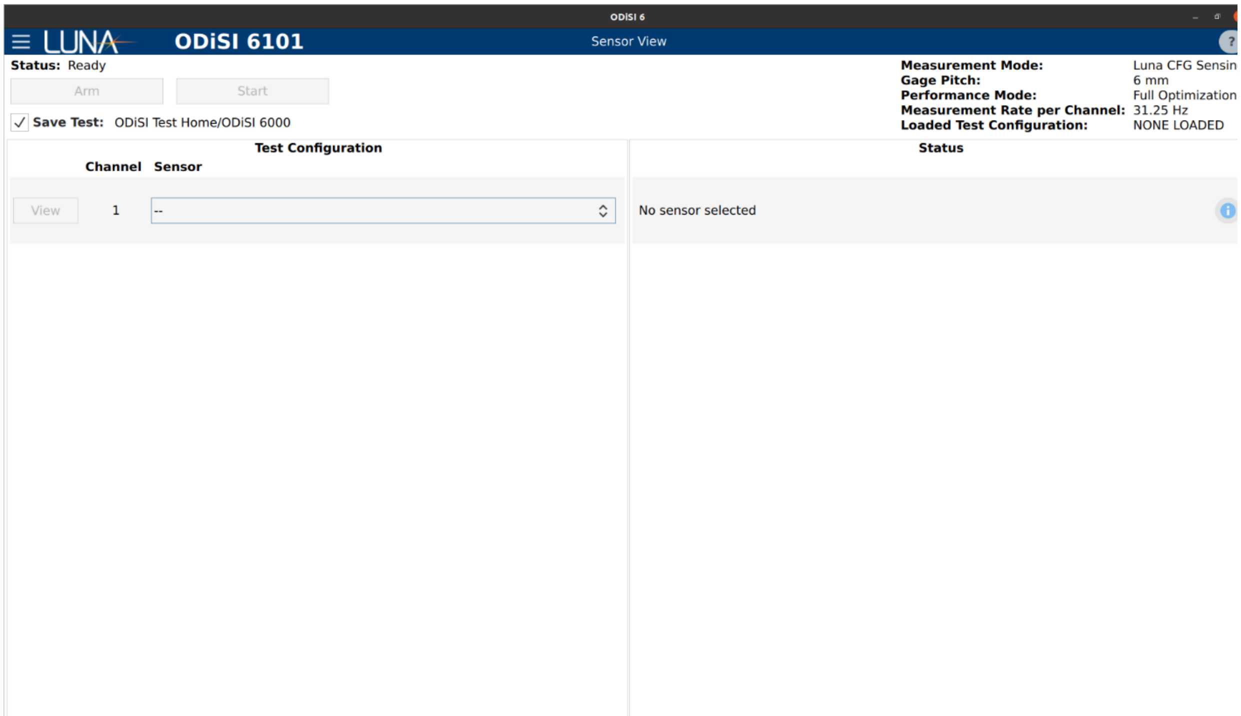


Figure 6-2: Sensor Properties screen when using Luna CFG Sensing

The user must manually select the sensor that is connected to a given channel on the ODiSI. It is recommended to name the installed CFG sensors so that they are more recognizable to the user. See the Manage the Sensor Repository section for more information on installing and renaming sensors. Once the sensor is successfully selected, the status will show a green "Ready"

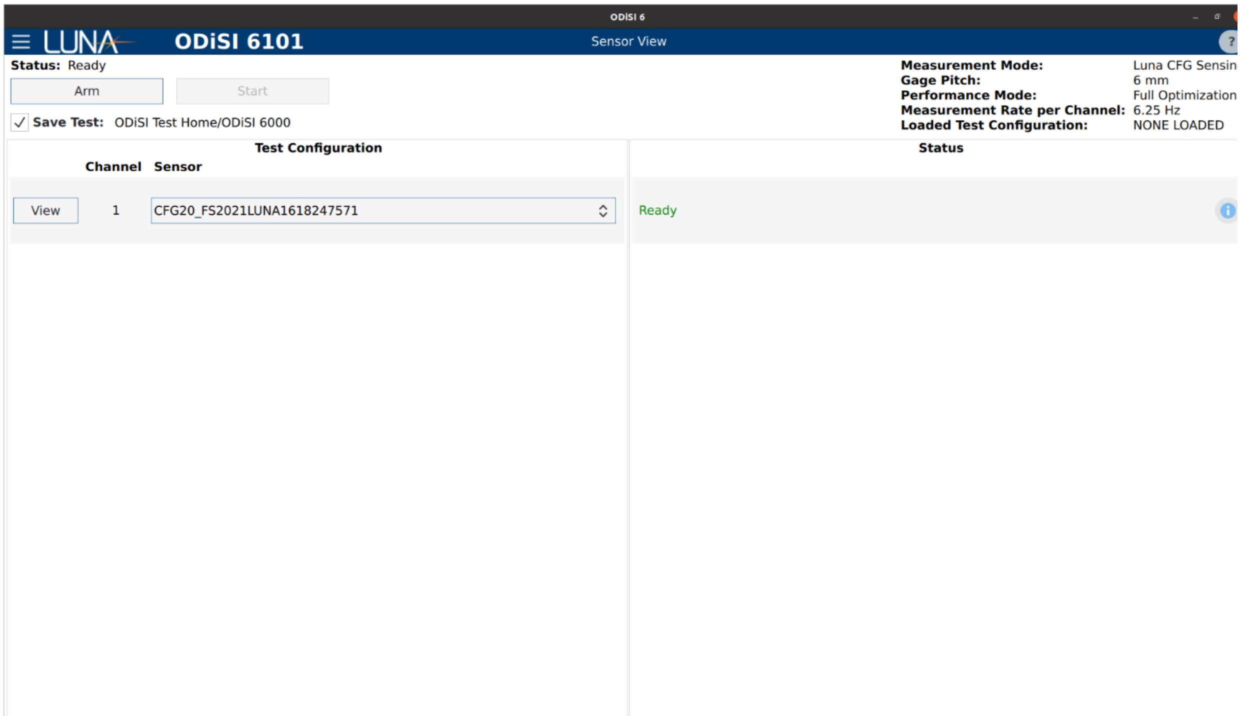


Figure 6-3: Luna CFG sensor is ready

All other operations such as viewing the sensor, defining gages and segments, and running a test are the same as other sensor types. Note that when viewing a sensor plot, the 0-meter x-axis position for these CFG sensors corresponds to the first grating for which results are returned; the 0-meter x-axis position is not the fiber sensor connector.

6.1.2.3 Gage Pitch

The “Gage Pitch” selection specifies the distance between the center of one gage and its nearest neighbor. For the ODiSI 6100 Series, there are five Gage Pitch selections: 1.04 cm (only for SC Temperature sensors), 5.2 mm, 2.6 mm, 1.3 mm (not available for sensors longer than 50 m), and 0.65 mm (not available for sensors longer than 20 m long). For the ODiSI 6000 Series, there are two Gage Pitch selections: 1.04 cm (only for SC Temperature sensors) and 5.2 mm. Select the Gage Pitch most suitable for the test by clicking the “Settings → General” menu item.

6.1.2.3.1 Advantages of a Smaller Gage Pitch

A smaller gage pitch setting can be used to see smaller features in the strain data that would normally be hidden within a single gage when viewed with a larger pitch. Additionally, a smaller gage pitch setting can improve the ability of the system to make measurements in areas of high strain gradients (large strain change over a small distance).

6.1.2.3.2 Gage Pitch and Measurement Rate

A given gage pitch setting presents a tradeoff between measurement rate and the measurement density. Choosing a larger gage pitch automatically increases the measurement rate.

6.1.2.3.3 Gage Pitch, Sensor Length, and Measurement Rate

The sensor length also has an impact on the measurement rate of the system. Generally, as the sensor length increases, the measurement rate for a given gage pitch decreases. For this reason, it is often preferable to use multiple shorter sensors rather than a single longer sensor.

6.1.2.4 Performance Mode

The Performance Mode selection determines the processing capability of the instrument. Select the Performance Mode most suitable for the test by clicking the "Settings → General" menu item. For the ODiSI 6000 Series, this selection is not available; the Full Optimization mode is always used.

Maximum Rate: The ODiSI outputs measurements at the fastest rate possible, given the Measurement Mode, sensor length, and Gage Pitch selections.

Full Optimization: The ODiSI optimizes measurements to provide the highest quality results at half the maximum measurement rate, given the Measurement Mode, sensor length, and Gage Pitch selections.

6.1.2.5 Measurement Rate Per Channel

Displays the measurement rate that will be achieved on each channel. This rate depends on the sensor length, Measurement Mode, Gage Pitch, Performance Mode, and number of channels.

6.1.2.6 Loaded Test Configuration

Displays the name of the configuration file that was loaded through the "Configuration → Load Configuration" menu or displays the default configuration that is loaded on start up. If no configuration is loaded, then "NONE LOADED" is displayed. If a configuration is loaded and the configuration is changed, the configuration name will be displayed in red.

6.1.3 Channel Status

The status of each channel is indicated in the main body of the control software.

View: The "View" button for each channel becomes active once a channel has been correctly configured. Click to display a preview of the strain or temperature along a single sensor.

Channel: Lists the number of channels the instrument is configured for

Sensor: Lists the name of the sensor added to the configuration of each channel. Click on the ⛔ button to remove the sensor from the configuration of the specific channel.

Status: Indicates the status of each channel. Below are various text strings that could be listed for each channel, with multiples possible, separated by dashes:

- "Identifying..."
- "Remote module type does not match Measurement Mode setting"
- "No remote module connected"
- "No sensor connected"
- "Identified"

- "Sensor connected via # m patch cord"
- "Sensor length/Remote module type mismatch"
- "Total length/Remote module type mismatch"
- "Total length requires Extended Length remote module"
- "The 0.65 mm gage pitch cannot be used with sensors longer than 20 m"
- "Sensors longer than 50 m must use the 2.6 mm or 5.2 mm gage pitch"

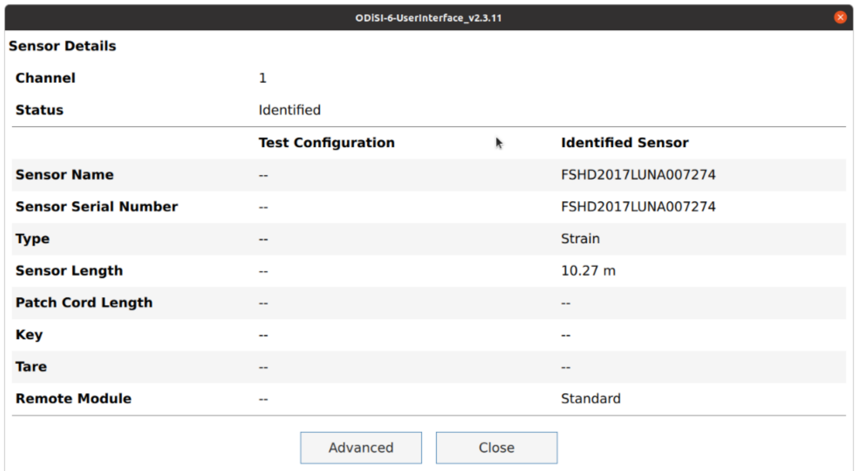
Status messages in green indicate that the channel setup is part of the active test configuration.

Status messages in black indicate that the channel setup is not part of the active test configuration.

Status messages in red indicate that the channel is part of the active test configuration, but there is a problem that needs to be resolved before making measurements.

Information button : Displays detailed information for the specific channel, comparing the expected configuration parameters to actual detected parameters. These details include:

- The Channel of the ODiSI for which the information is being displayed.
- The Status of that channel.
- The user-defined Sensor Name.
- The Sensor Serial Number issued when the sensor key was created.
- The Sensor Type (Strain, Temperature, or SC Temperature).
- The Sensor Length (in meters).
- The Patch Cord Length of any detected patch cord on that channel.
- The Key being used for the identified sensor (if a sensor has been rekeyed).
- The Tare being used for the identified sensor.
- The type of Remote Module being used on that channel, either Standard or Extended.



ODiSI-6-UserInterface_v2.3.11

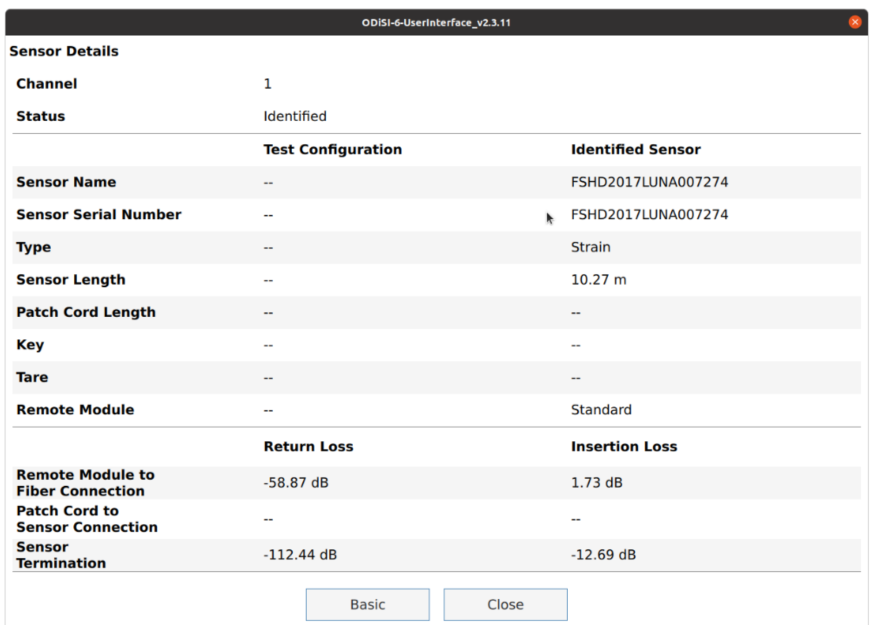
Sensor Details

Channel	1	
Status	Identified	
	Test Configuration	**Identified Sensor**
Sensor Name	--	FSHD2017LUNA007274
Sensor Serial Number	--	FSHD2017LUNA007274
Type	--	Strain
Sensor Length	--	10.27 m
Patch Cord Length	--	--
Key	--	--
Tare	--	--
Remote Module	--	Standard

Advanced | Close

Figure 6-4: Clicking the information button gives details for a particular channel

Clicking the "Advanced" button provides additional optical information about the connected sensor.



ODiSI-6-UserInterface_v2.3.11

Sensor Details

Channel	1	
Status	Identified	
	Test Configuration	**Identified Sensor**
Sensor Name	--	FSHD2017LUNA007274
Sensor Serial Number	--	FSHD2017LUNA007274
Type	--	Strain
Sensor Length	--	10.27 m
Patch Cord Length	--	--
Key	--	--
Tare	--	--
Remote Module	--	Standard
	Return Loss	**Insertion Loss**
Remote Module to Fiber Connection	-58.87 dB	1.73 dB
Patch Cord to Sensor Connection	--	--
Sensor Termination	-112.44 dB	-12.69 dB

Basic | Close

Figure 6-5: Clicking the Advanced button shows additional optical information

Remote Module: Indicates the type of remote module detected on each channel, either no remote module detected (--), Standard, or Extended.

Sensor Info: Indicates what sensor has been identified on each channel. Click on the button to add the identified sensor to the configuration of the specific channel.

6.1.4 Example: Operational Parameters

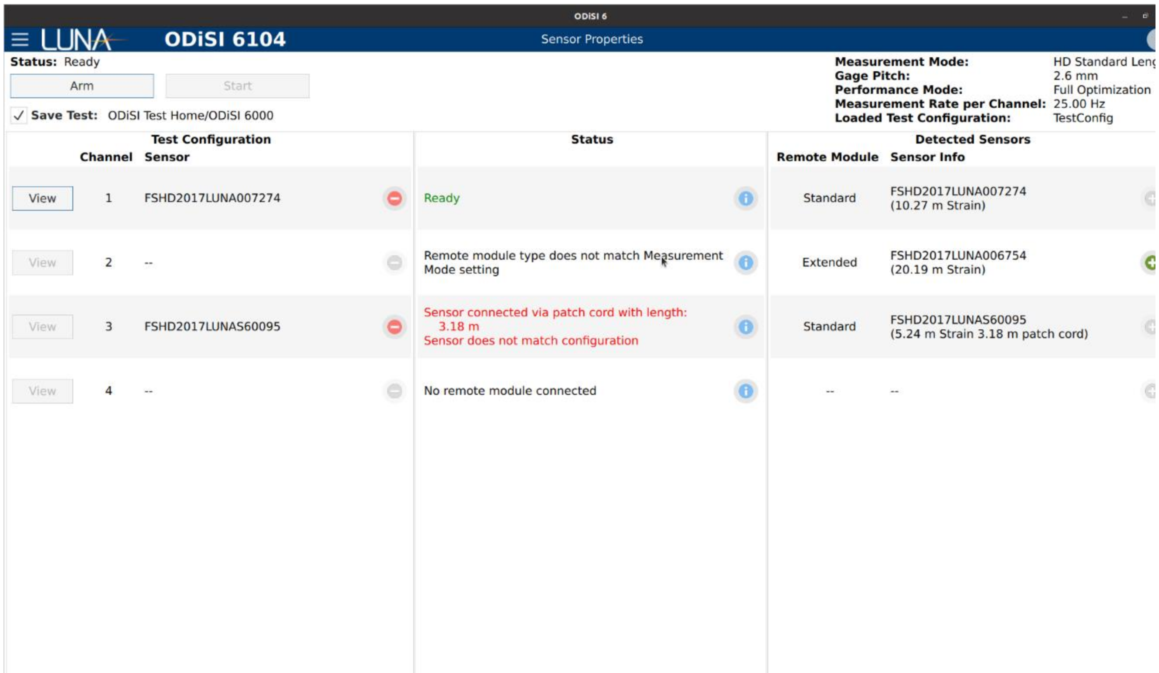


Figure 6-6: Sensor Properties screen with three connected sensors

In the above figure:

- Status: “Ready”, meaning the hardware has been set up and is ready to identify sensors and make measurements.
- Measurement Mode: HD Standard Length selected
- Gage Pitch: 2.6 mm Gage Pitch selected
- Performance Mode: Full Optimization selected
- Measurement rate per channel: Based on the sensor lengths, number of channels, Gage Pitch, and Performance Mode, the resultant measurement rate per channel is 25.00 Hz
- Channel 1: A 10.27 m strain sensor has been identified and added to the configuration of Channel 1 and this channel is ready for making measurements. The Status message is in green and the “View” button is active.
- Channel 2: A sensor has been identified but not added to the configuration of Channel 2. It is a 20.19 m strain sensor on an Extended Length remote module. This does not match the Measurement Mode selection of Standard Length. This description is displayed in the Status of Channel 2 in black.
- Channel 3: A 5.24 m strain sensor has been identified as being connected to the remote module through a 3.18 m patch cord. This does not match the original

configuration on Channel 3, which is of the same sensor (FSHD2017LUNAS60095) connected without a patch cord. The status message is in red.

Note: The system can only operate in either standard or extended length mode. Standard length and extended length remote modules cannot be used simultaneously during the same test.

6.2 Manage Sensors

The detection of the correct sensor on each channel depends on the presence of the sensor key within the instrument's Sensor Repository. Click on the "Tools → Manage Sensors" menu item to access the sensor management window.

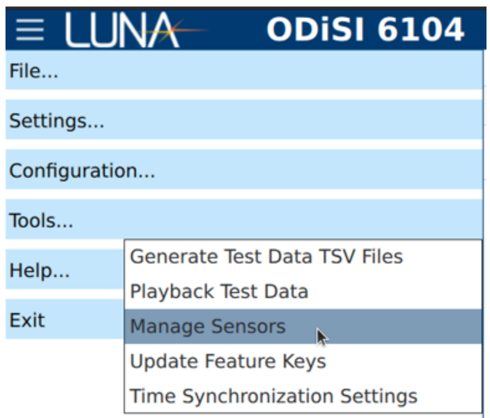


Figure 6-7: Manage Sensors menu item

The sensor management window provides the ability to install new sensor keys, delete unused sensor keys, and rename installed sensor keys.

Serial Number: Lists the serial numbers of all sensor keys installed on the controller.

Name: Lists the user-assigned names associated with all sensor keys installed on the controller.

Rename: Click to change the name associated with this sensor.

Deactivate: Click to deactivate the sensor key from the system. Deactivating sensor keys removes them from the list of keys used for sensor identification thereby also making them unavailable for making strain and temperature measurements. Deactivating sensor keys can decrease the time it takes to identify connected sensors.

Reactivate: This will reactivate the sensor key. Reactivating sensor keys makes the keys a part of the identification process again thereby also making this sensor keys available for making strain and temperature measurements.

Delete Deactivated Sensor: Click the  to delete a deactivated sensor.

Note: This will permanently remove the sensor and any associated data from the system's memory, including Tares, Rekeys, and Gages and Segments.

Rekey: Select the specific Rekey to use with the listed sensor.

Install Sensor: Click to install a sensor from a Luna-provided flash drive containing the sensor key. Install sensor will also install a package file that was exported via Export Sensor. The package file contains Tares, Rekeys, and Gages and Segments associated with this sensor..

Delete Deactivated Sensors: Click to delete all deactivated sensors.

Note: This will permanently remove the sensor and any associated data from the system's memory, including Tares, Rekeys, and Gages and Segments.

Export Sensors: Click to export the entire installed sensor folder including Tares, Rekeys, and Gages and Segments to a flash drive or CD drive.

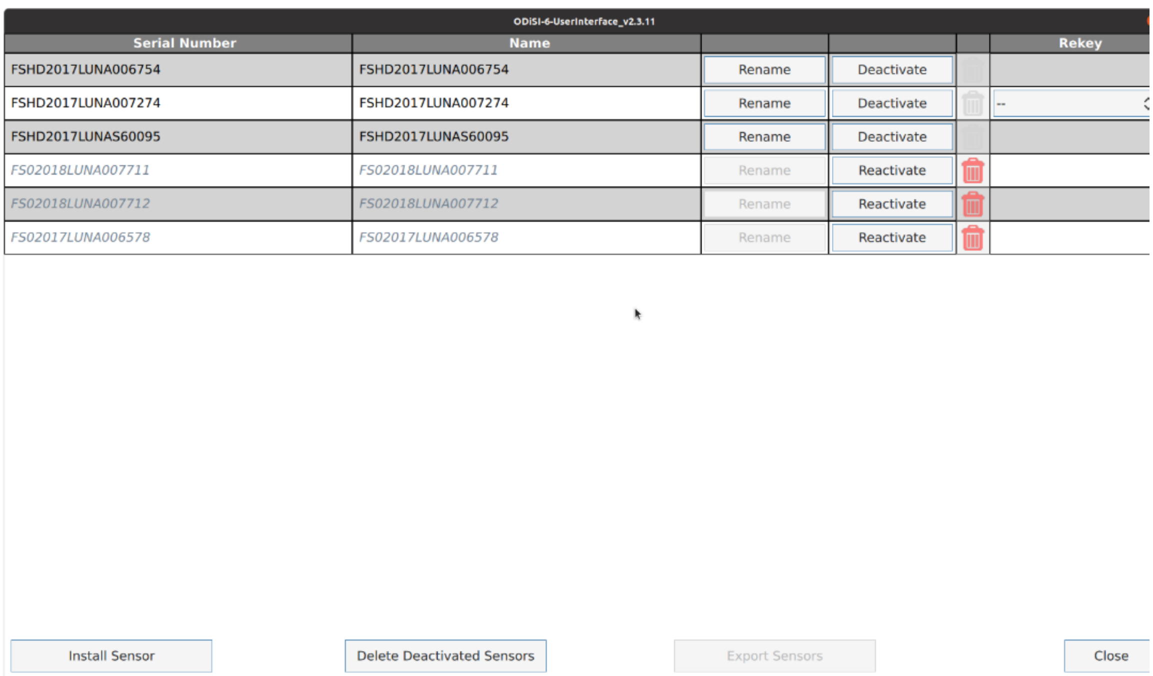


Figure 6-8: Manage Sensors dialog

6.3 View and Evaluate Sensor Status

Once a sensor is Identified and added to a particular Channel's configuration, its performance can be viewed for evaluation, and the sensor can be set up for eventual testing. Click on the "View" button for a given active channel.

Channel: 1: Drop-down menu that allows the user to preview sensors on different channels or go back to the main software interface.

Information button : Displays detailed information for the channel. Refer to the section on Channel Status for more information.

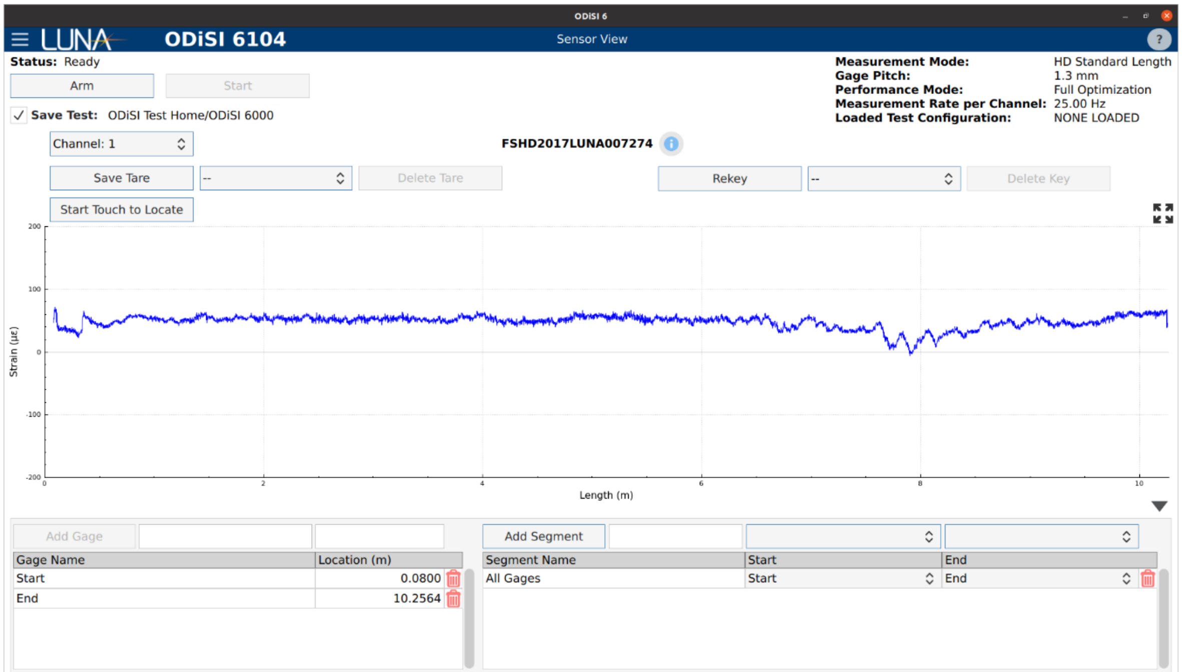


Figure 6-9: View measurements down the entire sensor length for a specific channel

6.3.1 Sensor Tare

A sensor can be zero-ed out before the start of a test. This re-zero-ing is called a Tare. Tares are specific to Gage Pitches.

Save Tare: Click this button to zero out a sensor.

Tare dropdown menu: Select from multiple saved Tares.

Delete Tare: Click to delete the selected Tare.

6.3.2 Sensor Key

Any sensor whose key has been installed in the software and is able to be identified can be rekeyed. Reasons for needing to Rekey include re-splicing a broken sensor, taking the sensor to higher strain ranges, re-centering the strain and temperature range around a new point, and permanently removing strain gradients induced in the sensor. For example, if a strain sensor is installed and is loaded to 10,000 µε prior to a test, the system will only be able to measure an additional 5,000 µε. If the sensor is rekeyed, the sensor can then be used over a larger strain range. It is important to ensure that the sensor and system are static and in a quiet environment when Rekeying a sensor.

Rekey: Click this button to capture a new Rayleigh backscatter reference for this sensor.

Key dropdown menu: Select from multiple sensor keys to be used for the sensor.

Delete Key: Click to delete the selected Rekeyed trace.

6.3.3 Define Gages

The Gage and Segment tables may be hidden to expand the plot view by clicking the down arrow ▼ located at the right side of the screen above the Segment Table. To view the Gage and Segment tables after hiding them, click the up arrow ▲ located at the bottom of the screen.

6.3.3.1 Table of Gages

Gages are a list of individual measurement points from individual sensors. These points can be used to define the start and end locations of Segments or can be viewed individually using the Gage Plot display. Gages can be created in three ways.

1. Touch to Locate

The Touch to Locate feature automatically detects the presence of a hot or cold touch to the fiber sensor. This is used to aid in the selection of Gages at specific locations along the sensor.

To use the Touch to Locate feature, click the “Start Touch to Locate” [Start Touch to Locate] button and then touch the fiber with a small hot or cold object. The software will detect this temperature change and will automatically move the red vertical cursor to the location of the hot or cold touch and update the Location field (see the below figure for an example). Click the “Add Gage” button to add this new Gage to the Gage list.

2. Cursor

To display the cursor, click once on the plot. To place the cursor at a specific location, double click on the plot. The cursor on the graph can also be moved manually by placing the mouse pointer close to the red cursor and then dragging the cursor to the desired location. Once the cursor has been moved to the desired location, click the “Add Gage” button to add this new Gage to the Gage list.

3. Manual entry

A Gage and its location can be manually entered into the Location field. Changes to the location field will automatically be reflected in the cursor location. Click the “Add Gage” button to create a Gage and change the Gage Name and Location.

For any of the above methods, if the Name field is left blank or is a duplicate of an existing gage, the software will assign the new Gage a default name (Gage 1, Gage 2, etc.). These names can be edited by clicking on them in the Gage table.

A Gage can be deleted by selecting the desired Gage and then clicking on the trash can button next to the gage location.

All sensors include default Start and End Gages, as well as a default All Gages Segment that spans from the default Start Gage to the default End Gage.

6.3.3.2 Table of Segments

Segments are continuous sections of measurement data that start and end at previously defined gages. To create a Segment, choose the start and end Gages from the dropdown menus. As with the Gages, the Segment name can be edited within the Segment table by clicking on it.

Segments can also be deleted by selecting the desired Segment in the Segment table and then clicking the trash can icon in the upper right corner of the Segment table.

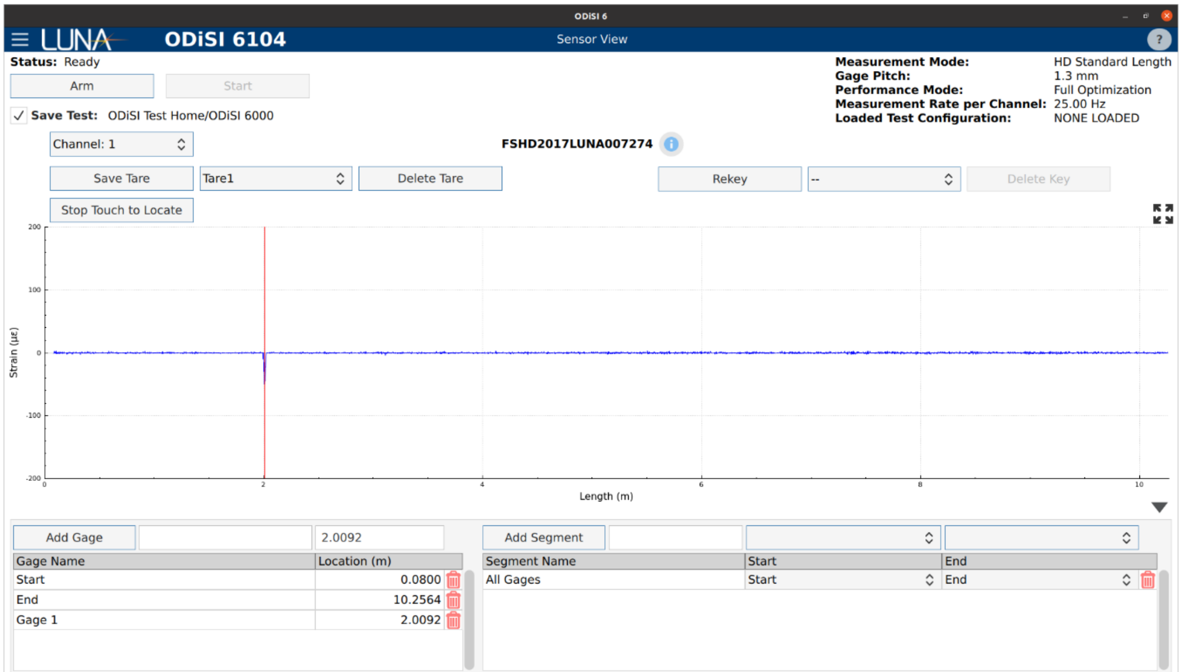


Figure 6-10: Gages and Segments

6.3.4 Plot Navigation

The ODiSI 6 software uses plots and graphs to display measurement data. The X and Y axes of these plots can be rescaled to better view features in the measurement data.

6.3.4.1 Unconstrained Zoom In/Out

To zoom in on data in both X and Y, move the mouse cursor to the region of interest and use the scroll wheel to zoom in or out. If using a laptop touch pad, use two fingers to swipe up or down to change the zoom level.

6.3.4.2 X/Y-Axis Constrained Zoom

To zoom in on only one axis, click on the desired axis (this highlights it in blue) and use the mouse wheel or two-finger scroll to zoom in or out.

6.3.4.3 Fit Plot

The Fit Plot  button automatically zooms in or out to fit all the data present in the plot.

Note: No data is being saved or streamed when viewing and evaluating the sensors.

6.4 Set Up the ODiSI for Data Logging

6.4.1 File Saving

Measurement data is stored to the instrument controller for playback or analysis when “Save Test” is checked and the system status shows “Running Test”.

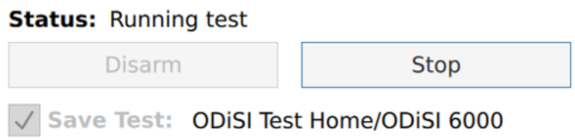


Figure 6-11: Test data file saving is enabled

Test files can be labeled with a Test Name and contain Test Notes. These names and notes are used to sort and browse for test data files along with time stamps.

Save Test: Check to log data

Click on the “File → Set Test Data File Save Options” menu item to specify the test name, notes, and destination folder.

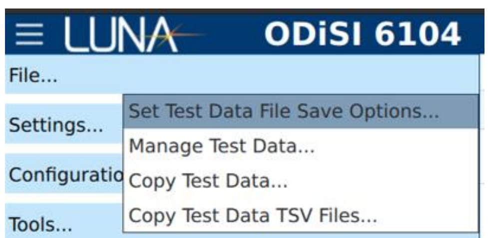


Figure 6-12: Menu item for setting specific test data file saving options

Test Name: Enter a name for the test.

Notes: Enter notes associated with the test.

Directory: Click “Browse” to change the Test Data logging directory.

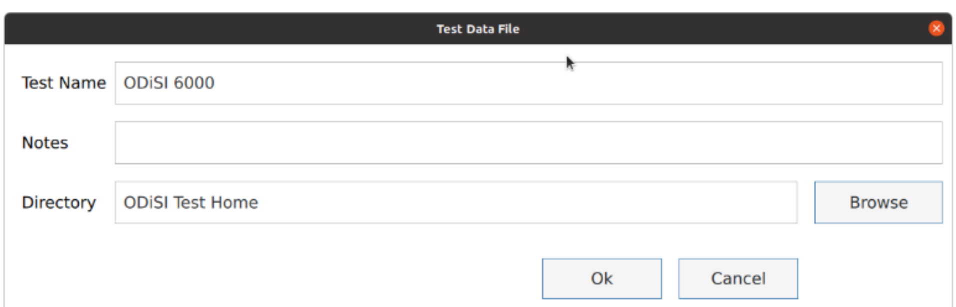
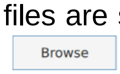


Figure 6-13: Specify test data tile saving options

Test data files are saved to the local drive under the OD6_Test Data Directory. Clicking the “Browse” 

button will display the Test Data File Dialog.

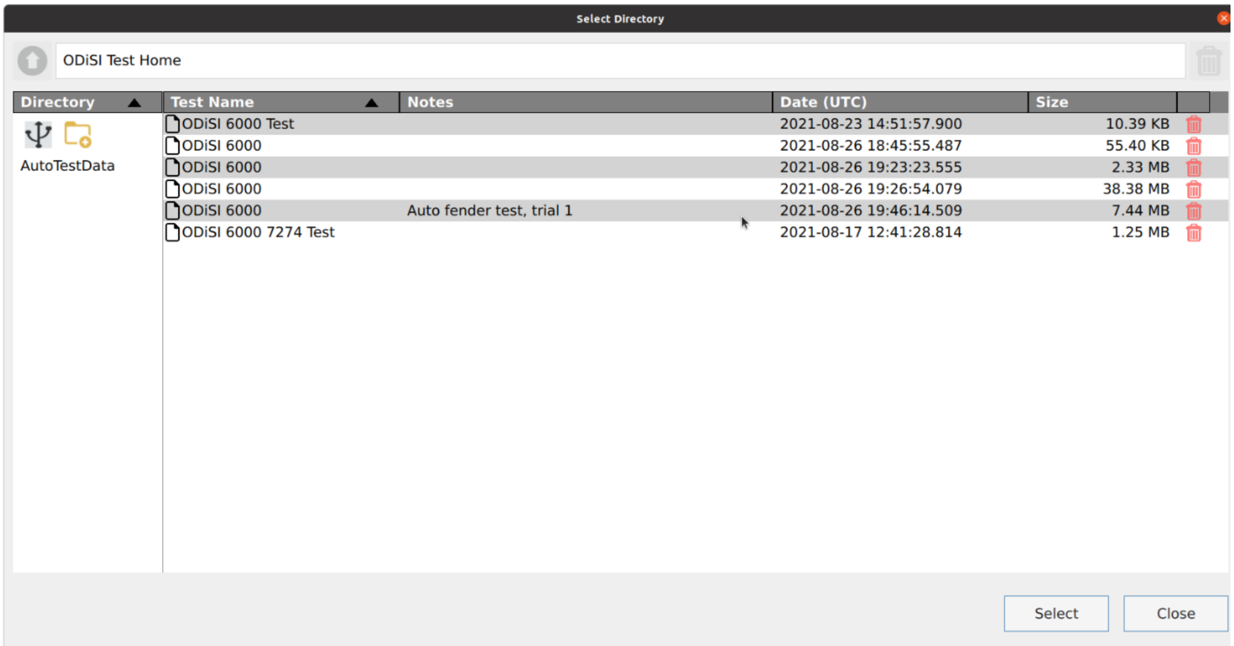


Figure 6-14: Test data file dialog accessed via the Browse button

To save a file to an external drive, click the external drive button which will navigate to an external drive connected to the controller through USB.

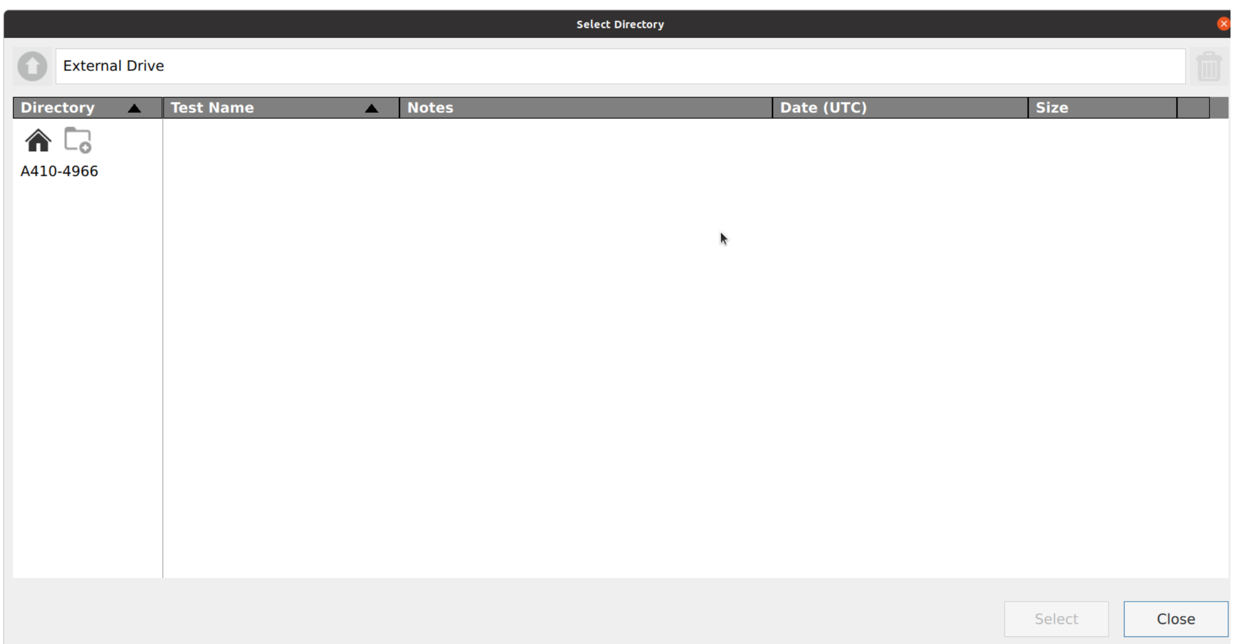


Figure 6-15: Navigate to an external drive to save test data

To navigate back to ODiSI Test Home, click the home button.

6.4.2 Managing Test Data Files

Test Data Files may be deleted or moved from one directory to another.

To manage test data files:

1. Click “File → Manage Test Data”

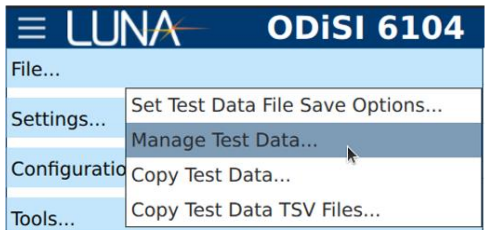


Figure 6-16: Manage Test Data menu item

2. To move test data files, select one or more test data files and/or directories in the left pane of the window. To select more than one file or directory, hold the ctrl or shift key. Click the “Move” Move button to move the selected files and/or directories.

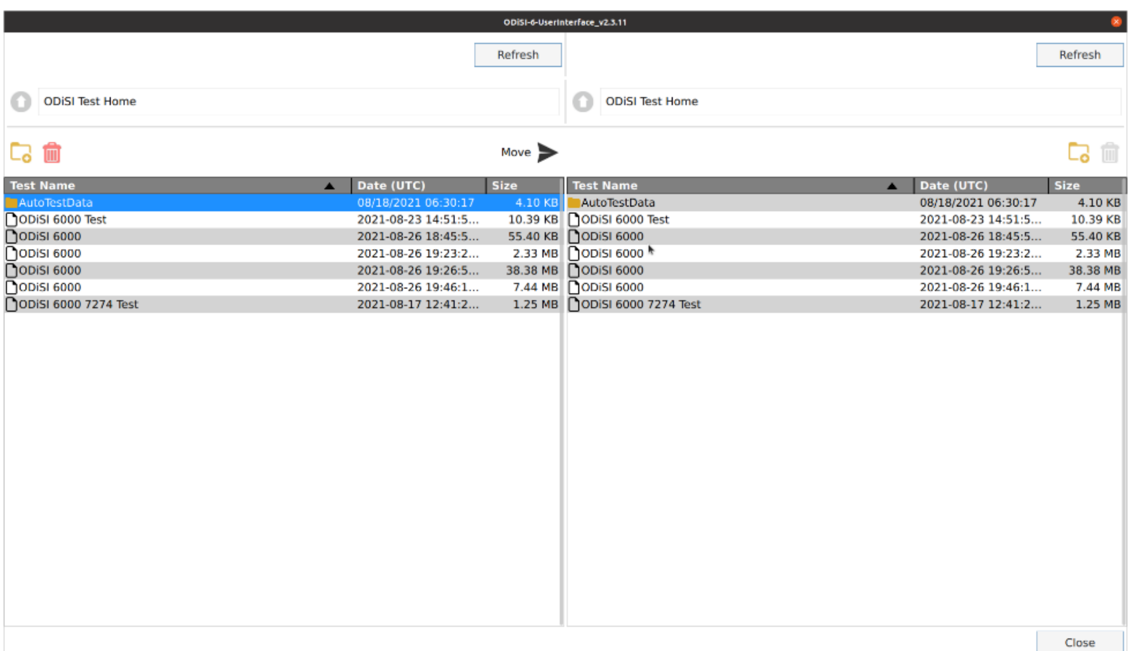


Figure 6-17: Select files and/or directories to move

3. To delete test data files or directories, select one or more test data files and/or directories and click the delete button.

6.4.3 Copy Test Data

To copy test data files to/from an external drive, click “File → Copy Test Data”.

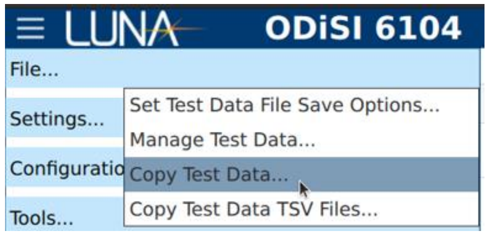


Figure 6-18: Copy Test Data menu item

1. To copy files to a USB/CDROM drive:

    a. Select the drive type on the left file browser.

    b. If using a USB drive, select the desired directory on the left file browser.

    c. Select the files and/or directories to copy on the right file browser.

    d. Click the “Receive”  button.

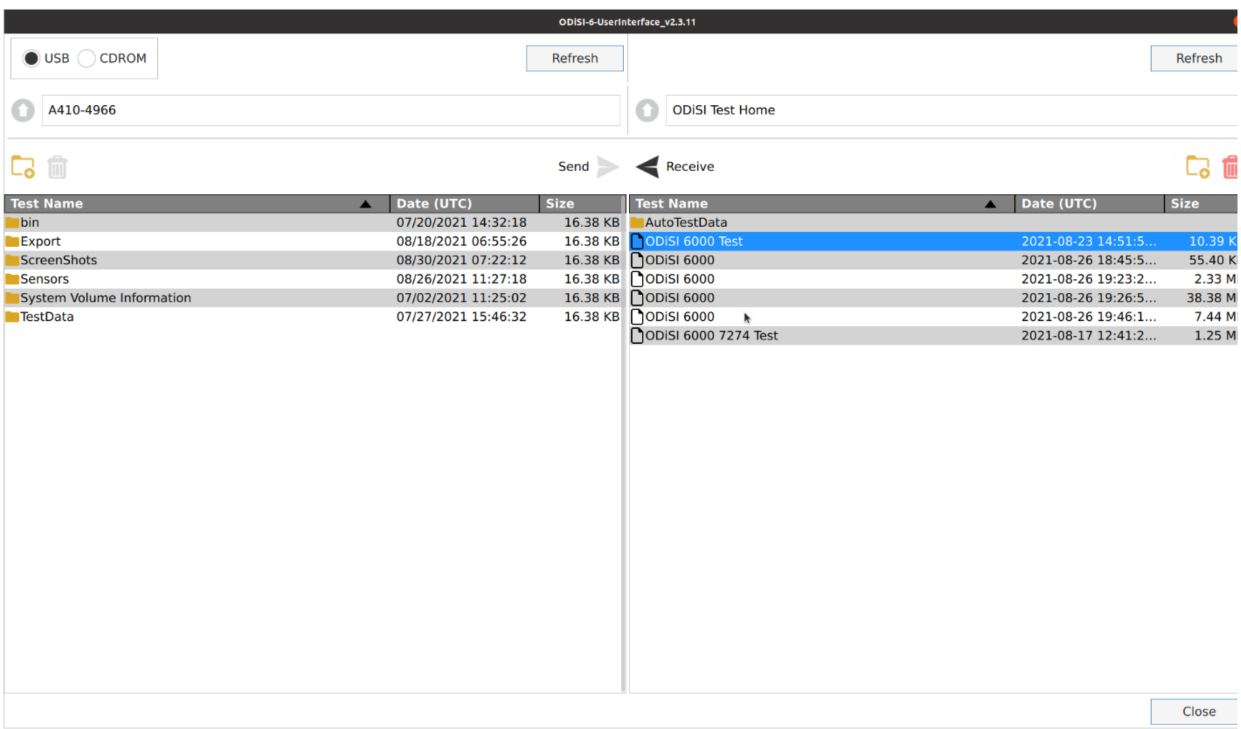
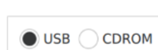


Figure 6-19: Copy test data to USB/CDROM

2. To copy files from a USB/CDROM drive:

    a. Select the drive type  on the left file browser.

b. Select the files and/or directories on the left file browser

c. Navigate to the destination directory on right file browser

d. Click the “Send” 

button.

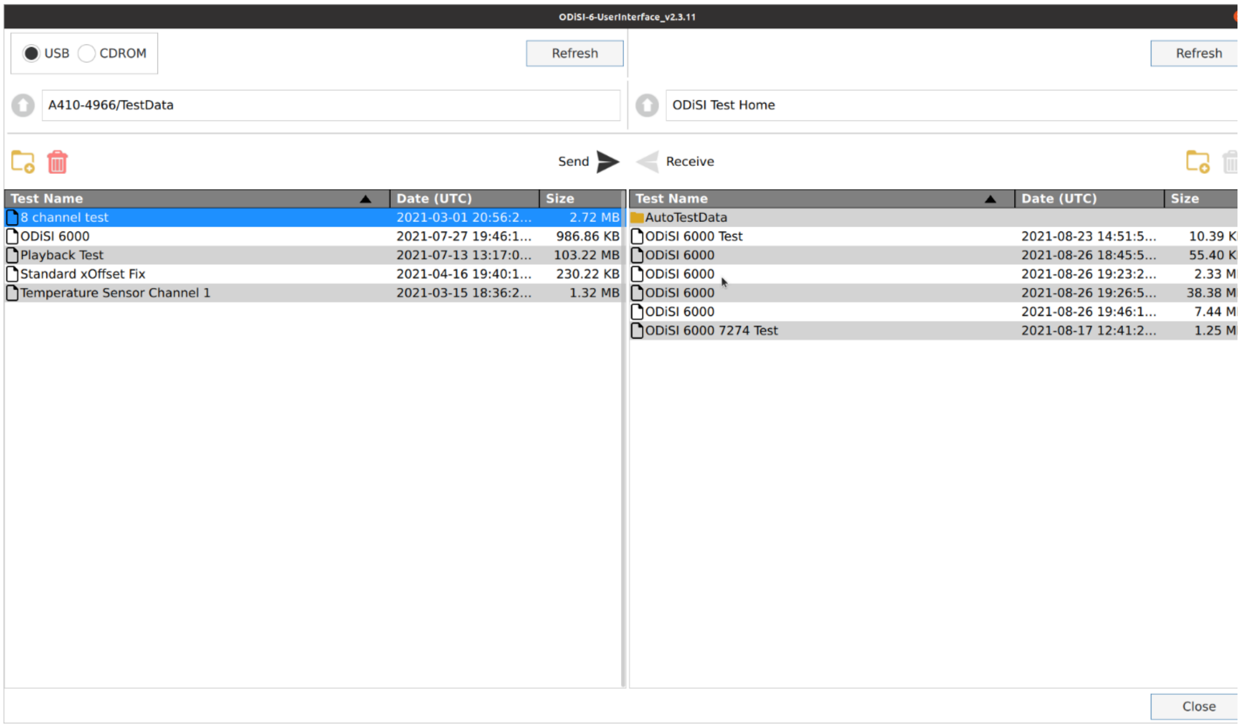


Figure 6-20: Copy test data from USB/CDROM

6.4.4 Copying Test Data TSV Files.

To copy test data .tsv files to/from an external drive, click “File → Copy Test Data TSV Files”

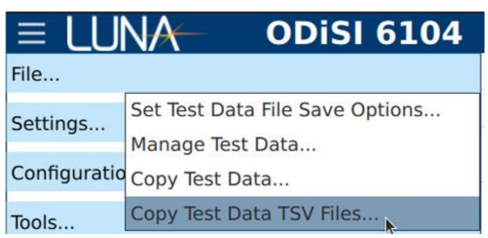


Figure 6-21: Copy Test Data TSV Files menu item

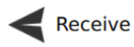
1. To copy files to a USB/CDROM drive:

   a. Select the drive type

on the left file browser.

   b. If using a USB drive, select the desired directory on the left file browser.

   c. Select the files and/or directories to copy on the right file browser.

d. Click the "Receive" 

button.

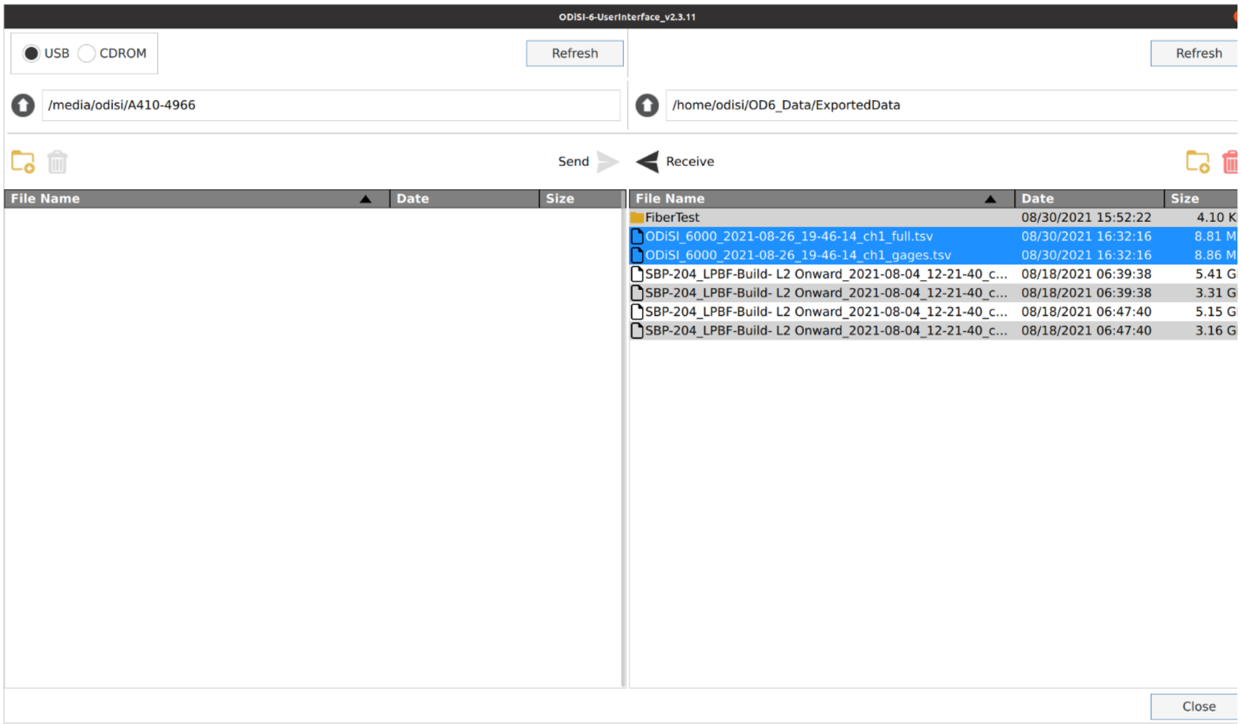


Figure 6-22: Copy .tsv files to USB/CDROM

2. To copy files from a USB/CDROM drive:

a. Select the drive type 

on the left file browser.

b. Select the files and/or directories on the left file browser

c. Navigate to the directory on right file browser

d. Click the "Send" 

button.

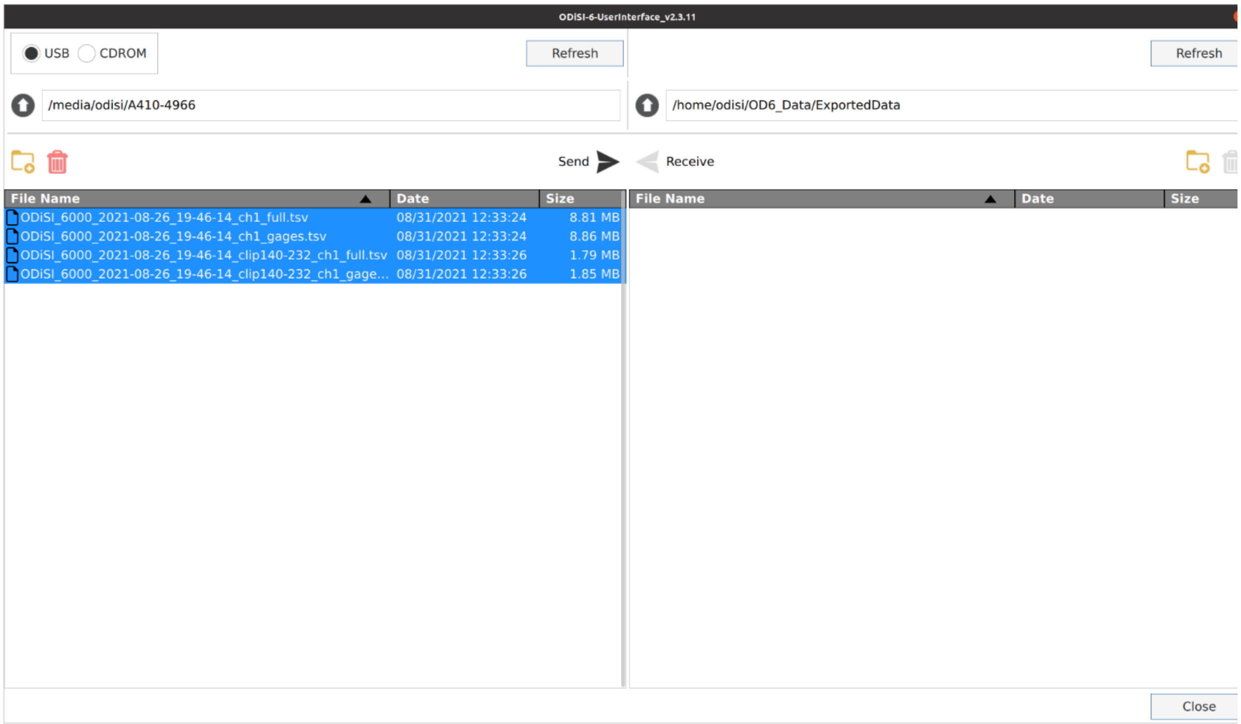


Figure 6-23: Copy .tsv files from USB/CDROM

6.4.5 Settings Menu

6.4.5.1 General

Select the General Settings menu by clicking “Settings → General”.

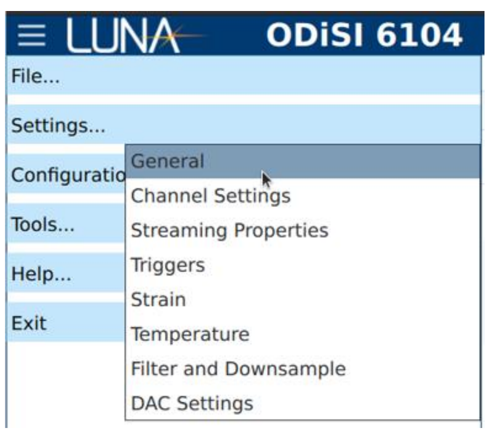


Figure 6-24: General settings menu item

Measurement Mode: Select the Measurement Mode that matches the sensor lengths and remote modules connected to each channel.

Gage Pitch: The gage pitch selection specifies the distance between the center of one gage and its nearest neighbor.

Performance Mode: The Performance Mode selection determines the processing capability of the instrument. Selecting “Maximum Rate” provides the fastest measurement rate given the Measurement Mode (i.e. remote module type), sensor lengths, and Gage Pitch selection. Selecting “Full Optimization” provides the highest quality results at half the maximum measurement rate given the Measurement Mode (i.e. remote module type), sensor lengths, and Gage Pitch selection.

X-Axis Units: Select length units from the drop-down menu.

Use Patch Cord: Check if using a patch cord (fiber jumper) between the remote module and the sensor. Required to properly identify sensors when using patch cords.

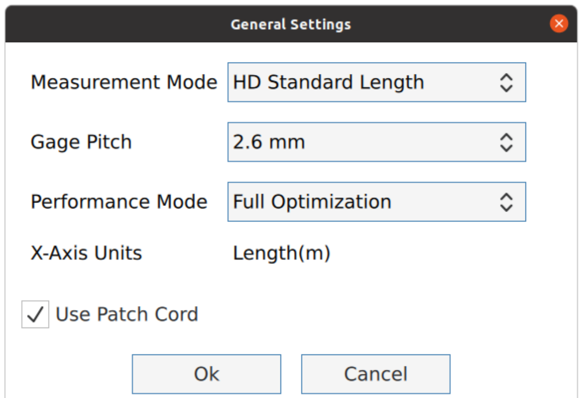


Figure 6-25: General settings dialog

6.4.5.2 Channel Settings

Select the Channel Settings menu by clicking “Settings → Channel Settings”.

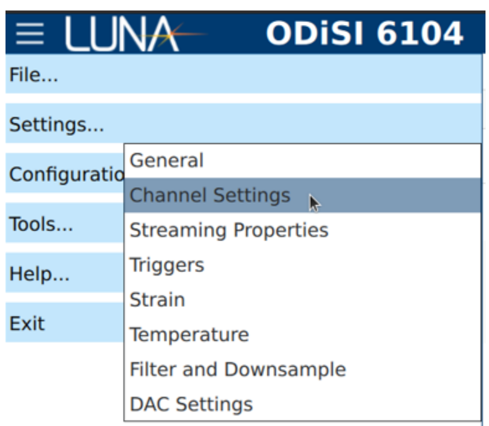


Figure 6-26: Channel Settings menu item

Standoff Length: Select standoff cable length per channel from the drop-down menus (10 m, 50 m, 100 m, 150 m, or 200 m). The longer lengths can be achieved by connecting two shorter standoff cables together using a Luna provided connector.

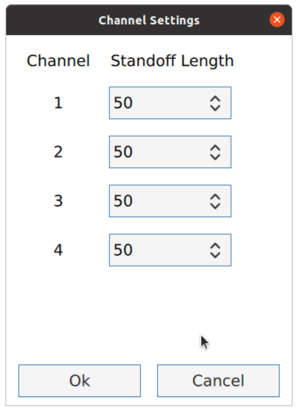


Figure 6-27: Channel Settings dialog

6.4.5.3 Streaming Properties

Select the Streaming Properties Settings menu by clicking “Settings → Streaming Properties”.

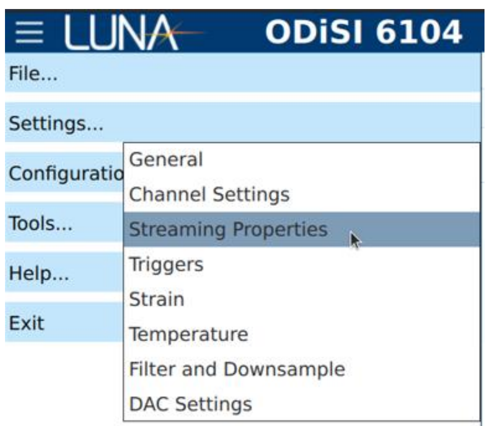


Figure 6-28: Streaming Properties menu item

ODiSI measurement data can be streamed to a separate remote PC for analysis and/or storage. The ODiSI software uses a Luna defined JSON-formatted TCP/IP protocol called ODiSI Measurement Streaming Protocol (OMSP) for data transfer. Details on this protocol can be found in section ODiSI Measurement Streaming Protocol (OMSP).

Luna also provides the ODiSI Remote application which gives the ability to Arm, Start, Stop, and Disarm the ODiSI controller software from a remote PC as well as receive and display live measurements from the ODiSI control software in real-time. The ODiSI Remote software is covered in more detail in a later section.

Controller Host Name: Displays the Controller’s Host Name.

Controller IP Address: Displays the Controller’s IP Address. The controller needs to be connected to a network prior to the ODiSI software being launched in order for the IP Address to be detected and populated.

OMSP Enabled: Check to stream measurement data.

When a test is started, the specified port is opened and the ODiSI software begins listening for a client connection. The client program can then initiate a TCP connection to the OMSP server on the specified port number. As soon as a connection is established, the ODiSI begins sending messages to the client. If the ODiSI loses the connection with the client, it resumes listening for a new client connection.

Once a new connection is established, the ODiSI resumes sending data, but does not send measurement data that was missed during the time the connection was interrupted.

The application data is one way. That is, the ODiSI sends data to the client but does not look for any responses.

When a connection is made, the Status changes to “Client connected”. The Test Name and Notes are included as Metadata to the client.

Remote Enabled: Check to enable remote control of the ODiSI control software.

The Remote Control allows the user to connect to the ODiSI controller using a TCP/IP connection and send Arm, Start, Stop, and Disarm commands to the instrument to control the starting and stopping of measurements. See the section on ODiSI Remote Operation for more information about the ODiSI Remote application and how to connect to an ODiSI controller using the ODiSI Remote.

Note on Measurement Streaming and Saving: There is an important distinction between saved measurements and streamed measurements. Saved measurements are stored on the instrument controller and are accessible for file playback. Streamed measurements are sent to a third-party PC and no record of them is maintained by the instrument controller. You can enable and utilize both of these features simultaneously.

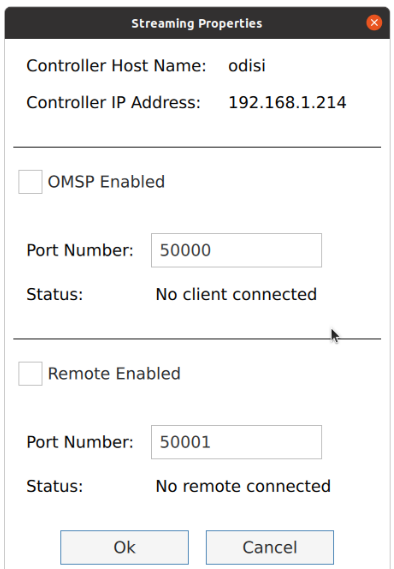


Figure 6-29: Streaming Properties dialog

6.4.5.4 Triggers

Select the Trigger Settings menu by clicking “Settings → Triggers”.

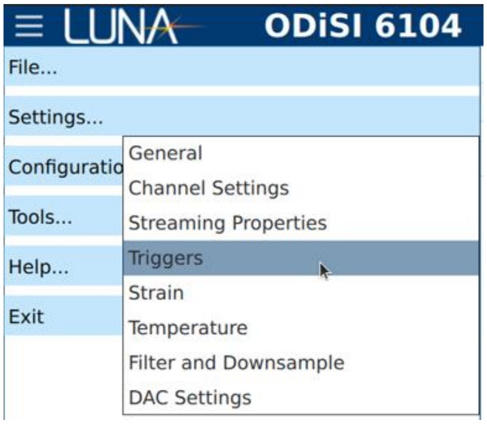


Figure 6-30: Triggers settings menu item

The “Start” button controls the software trigger to start logging data. The Stop button controls the software trigger to stop logging data.

Triggering Enabled: Check to control the starting and stopping of data logging using a repeating pattern or through external electrical triggers.

BNC port number 2 on the back of the instrument controls the hardware trigger to start logging data. BNC port number 3 controls the hardware trigger to stop logging data. Both are sensitive to a 0-5V TTL signal and trigger on the rising edge. For convenience, BNC port number 1 provides a synchronization output that is active when the ODiSI instrument is actively acquiring measurement data.

Start: Time Interval Select the time interval between subsequent automatic Starts.

Stop: Measurement Count This is the number of scans taken each time a start trigger signal is received.

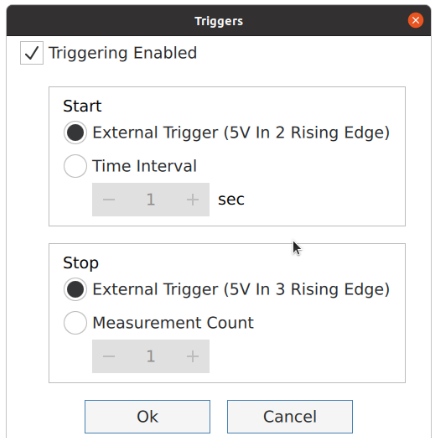


Figure 6-31: Triggers settings dialog

6.4.5.5 Strain Sensor

Select the Strain Settings menu by clicking “Settings → Strain”.

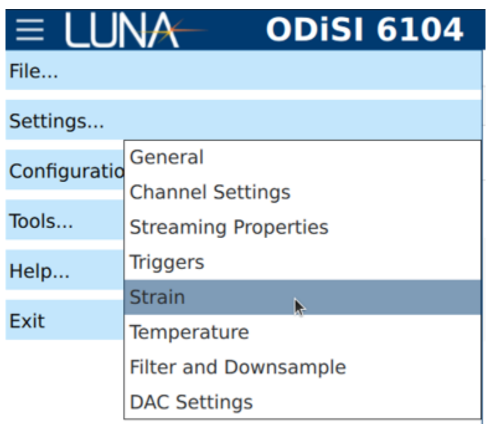


Figure 6-32: Strain settings menu item

Y-Axis Units: Displays the Y-Axis Units for Strain.

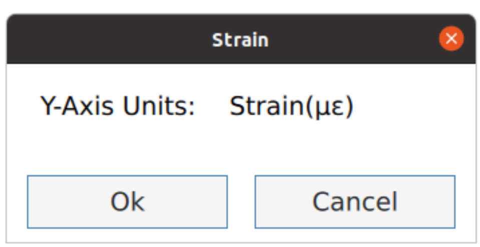


Figure 6-33: Strain settings dialog

6.4.5.6 Temperature Sensor

Select the Temperature Settings menu by clicking “Settings → Temperature”.

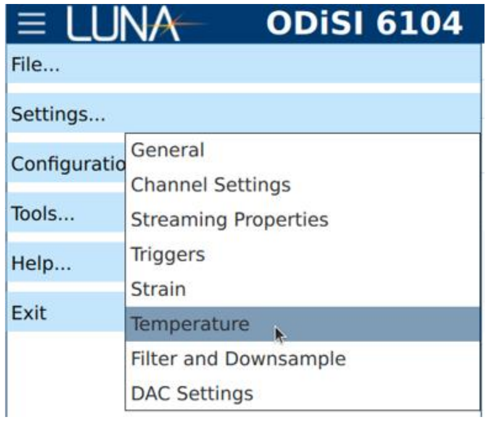


Figure 6-34: Temperature settings menu item

Y-Axis Units: Select temperature units from the drop-down menu (°C, °F, K)

Temperature Offset: When used together with a Tare for the temperature sensor, the temperature offset effectively converts the temperature change measurements into absolute temperature.

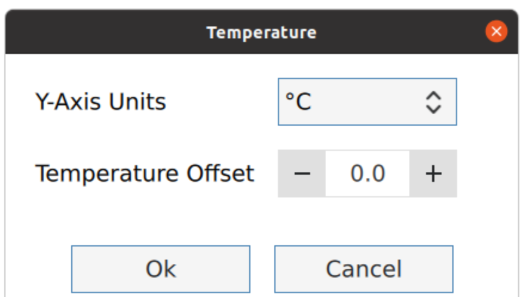


Figure 6-35: Temperature settings dialog

6.4.5.1 Filter and Downsample

Select the Filter and Downsample Settings menu by clicking “Settings → Filter and Downsample”.

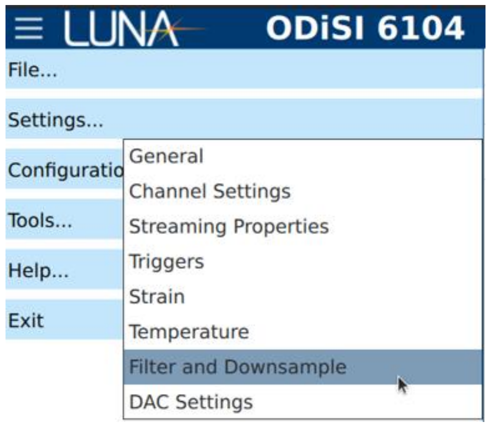


Figure 6-36: Filter and Downsample menu item

Spatial Moving Average Size: Specifies the size of the spatial moving average filter window to apply to the calculated strain/temperature results.

Spatial Downsampling Factor: Specifies the number of gage results to throw away spatially, thereby changing the “effective gage pitch.” For example, providing a value of 3 here means that for every 3 neighboring gages only 1 of those gage results will be kept.

Effective Gage Pitch: The gage pitch when taking into account any specified spatial down sampling. This represents the nominal spacing between reported gage results.

Temporal Moving Average Size: Specifies the size of the time moving average filter window to apply to the calculated strain/temperature results.

Temporal Downsampling Factor: Specifies the reduction factor in time of the reported strain/temperature results.

Measurement Rate Per Channel: Measurement rate that will be achieved on each channel. This rate depends on the sensor length, Measurement Mode, Gage Pitch, Performance Mode, number of channels, and Temporal Downsampling Factor.

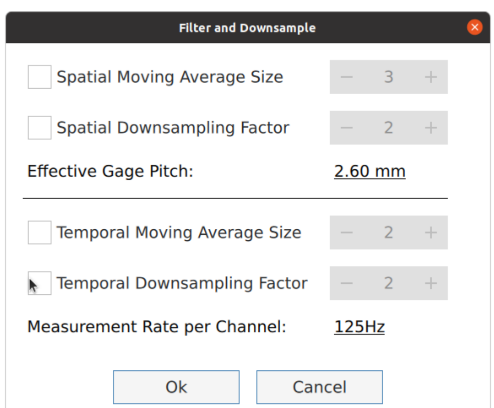


Figure 6-37: Filter and Downsample settings dialog

6.4.5.2 DAC Settings

Select the DAC Settings menu by clicking “Settings → DAC Settings”.

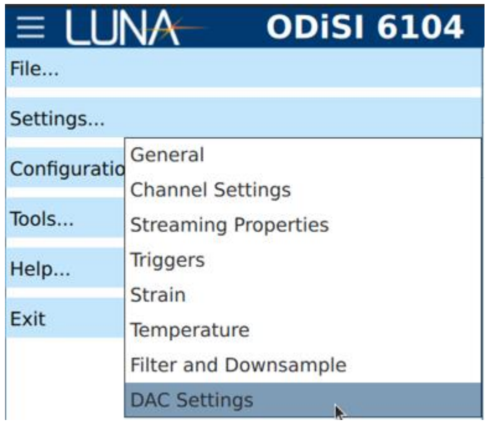


Figure 6-38: DAC Settings menu item

The DAC Settings provides an interface for enabling and configuring a connected USB-3106 Analog Output Module.

Enable DAC: Enable/Disable output to the DAC

Output Range: Select the desired output range (-10V to +10V, 0V to +10V, 0mA to 20mA).

Scale: Output scale based on the selected output range

DAC Channel: Corresponds to the 16 channels on the USB-3106.

Channel: Sensor: Select the desired channel: sensor that is currently in the test configuration.

Gage: Select the gage associated with the selected sensor. During a test run, the strain/temperature value of the selected gage will be scaled to the appropriate output value and driven out on the associated DAC channel.

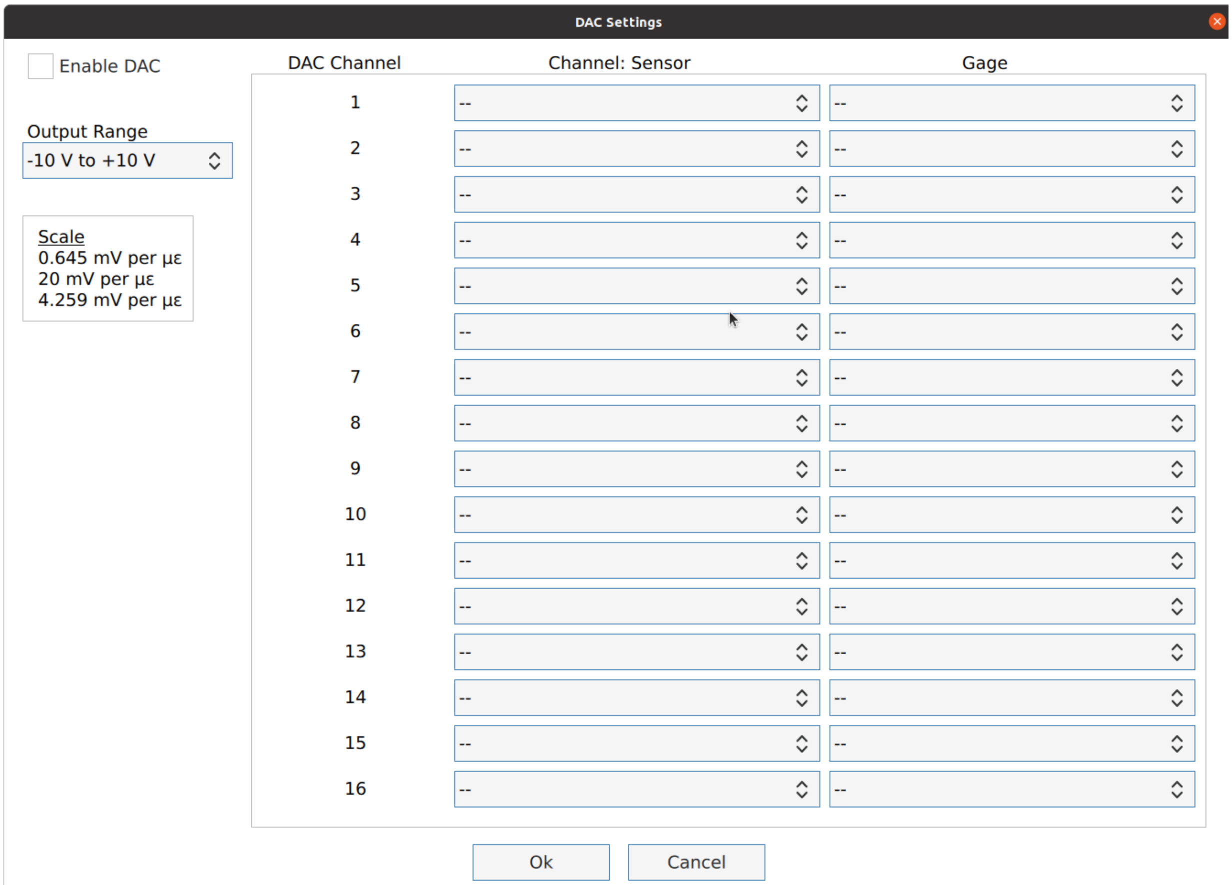


Figure 6-39: DAC settings dialog

6.5 Run a Test

Once the active sensors have been selected for a test, the system can be initialized for data logging by clicking the "Arm" button. The system will configure itself based on all the current settings, and once the instrument is ready the "Start" button will become active.

Arm / **Disarm**: Click "Arm" to initialize the system for data logging. Click "Disarm" to exit data logging mode.

Start / **Stop**: Click the "Start" button to display, save, and stream measurement data immediately. Click the "Stop" button to end these processes.

In order to change any of the various test configuration items or system settings, the system must first be Stopped and then Disarmed.

6.5.1 Sensor Plot

The Sensor Plot screen displays measurements along sensor length once a test has Started. The screen displays data for the sensors that are included in the active configuration as shown in the Sensor Properties screen. Sensors that are no longer part of the current test configuration but were used prior, are displayed as the last measurement trace on a gray background.

Use the drop-down menu to toggle between viewing each individual sensor (Multiple Plots) or viewing all sensors stacked on a single plot (Single Plot). The Single Plot view displays the strain axis on the left and the temperature axis on the right.

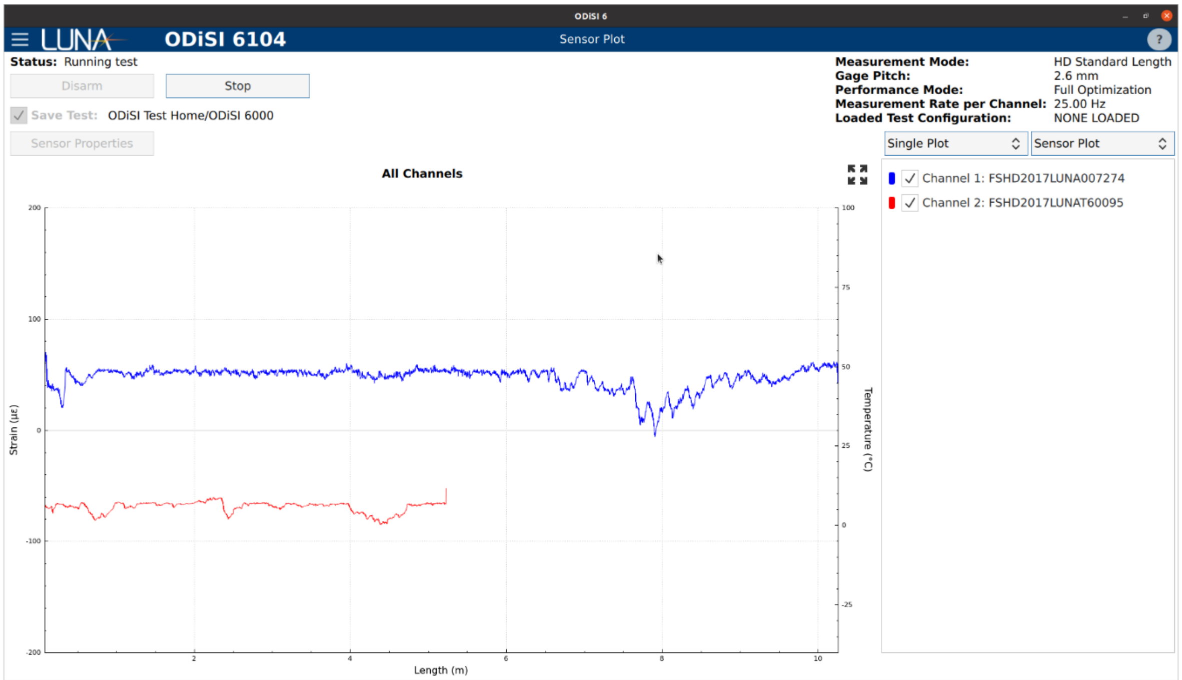


Figure 6-40: Sensor Plot screen

6.5.2 Gage Plot

The Gage Plot screen displays measurements from individual Gages as a function of time once a test has Started. Active sensors are listed on the left. Each sensor's tree menu contains branches for all Gages and Segments that have been created.

Check the associated checkbox for a given Gage to have the line graph for that Gage appear on the Gage Plot.

Click the color square to customize the color associated with a Gage. The color selection will be saved and remain the same for subsequent tests.

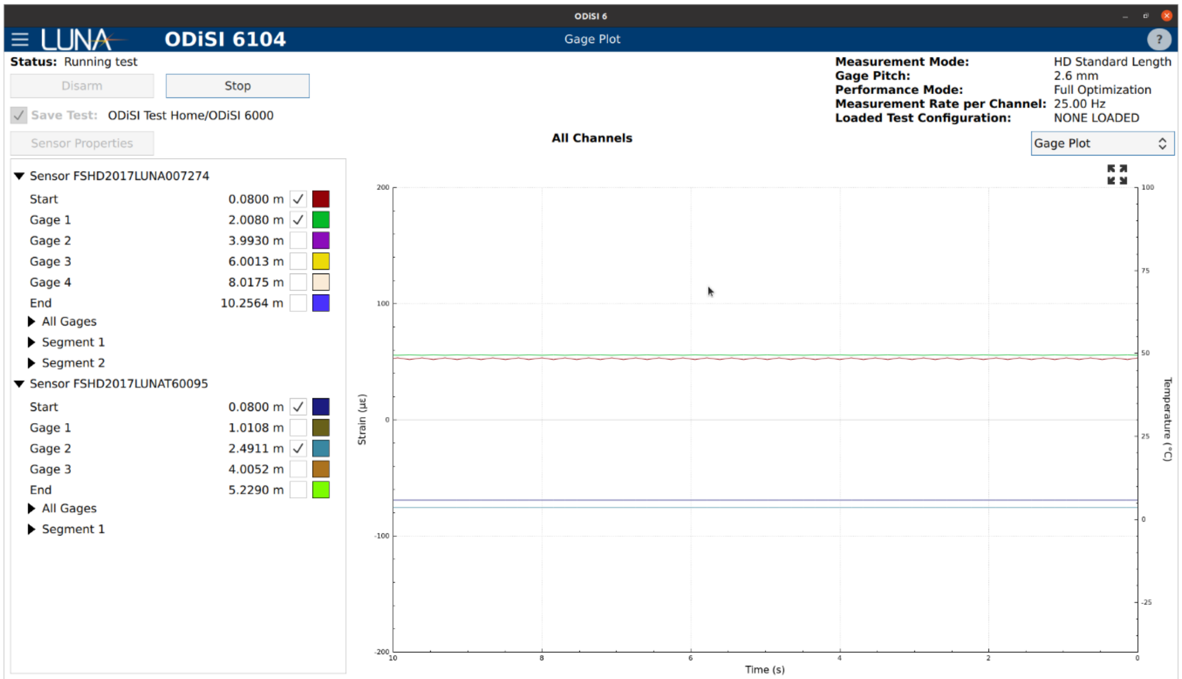


Figure 6-41: Gage Plot screen

6.6 View Test Data

6.6.1 Play Back Test Data

The test data files collected using the ODiSI software can be replayed from within the same software. When in Play Back mode, the measurement data can be viewed with the same plot visualizations as the live data. Furthermore, measurement data can be still be streamed using OMSP when in Play Back mode. Note that the sensor properties and the test file saving actions are no longer available in Play Back mode.

Browse for a test data file from the menu bar using "Tools → Play Back Test Data". Navigate to the test file and click Open.

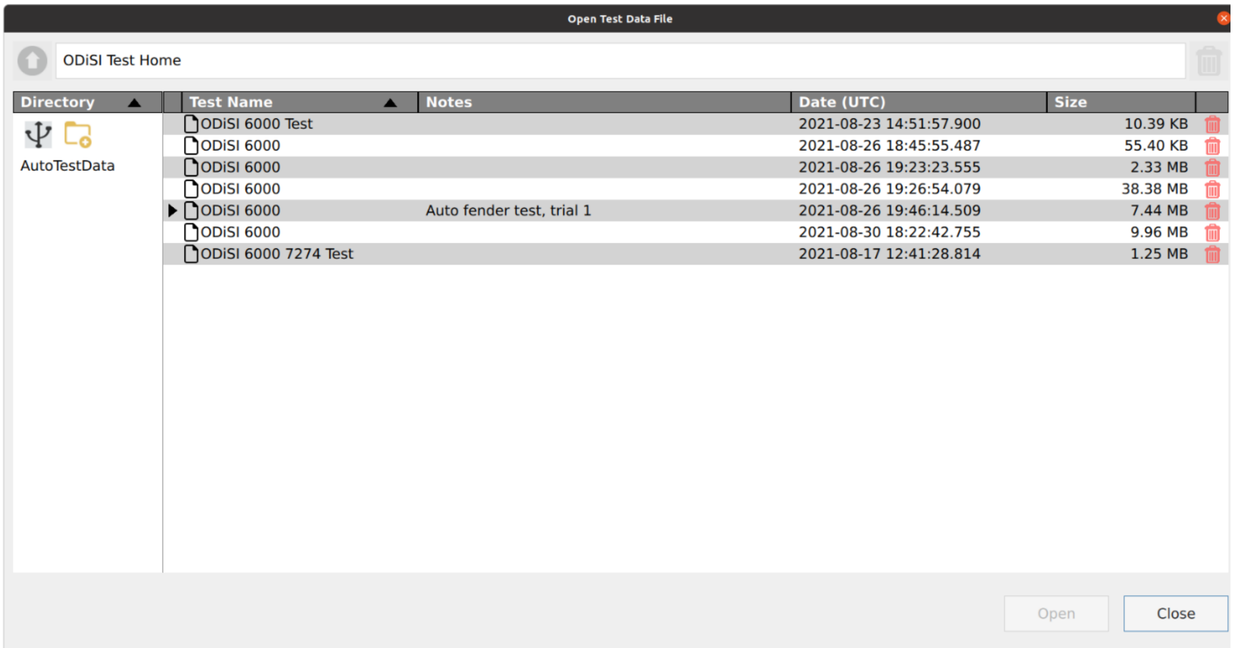
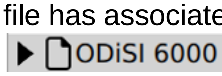


Figure 6-42: Play Back test data file open dialog

Click the external drive  button to navigate to a connected external drive.

If a play back file has associated clip files, it will have a small right arrow next to the file name (for example, 

). Clip files are previously defined smaller sections of a larger test data file. Clicking the right arrow will display the associated clip files which can be read into the player. The icon  denotes a clip file.

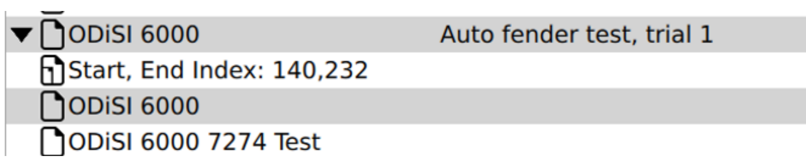


Figure 6-43: Example list of test data files

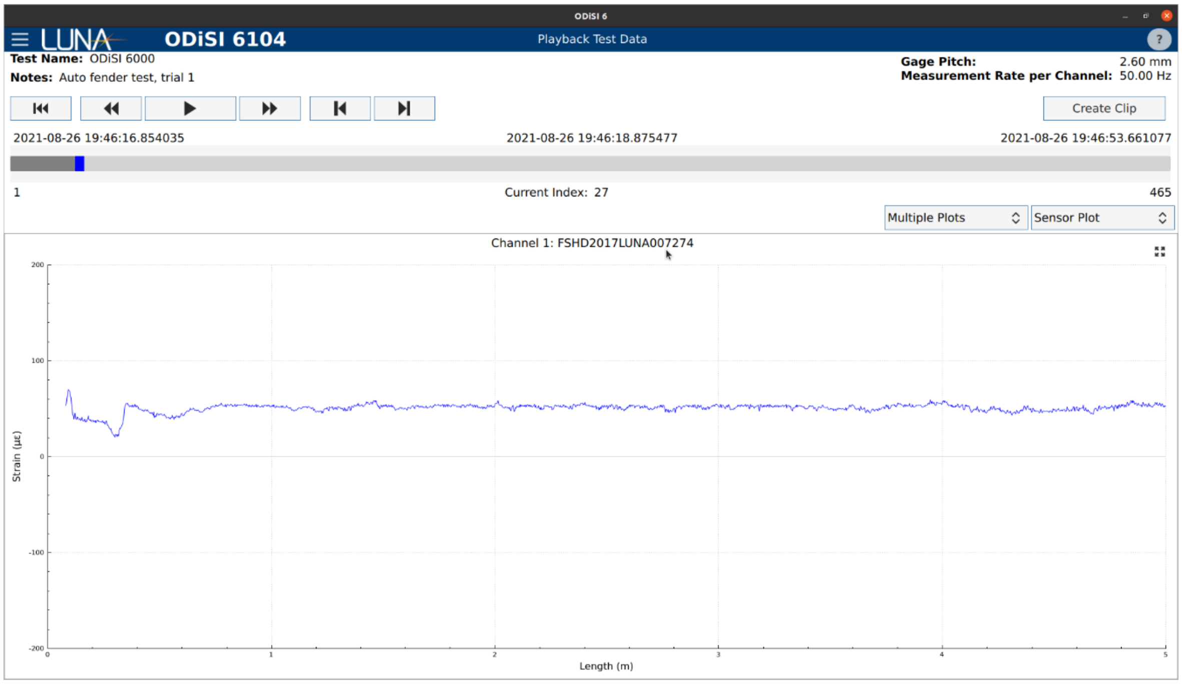


Figure 6-44: Play Back test data screen

Test Name: Displays the Test Name associated with the selected test data file.

Notes: Displays the Notes associated with the selected test data file.

Play Back Controls: There are various playback control buttons described below.

Reset button  Reset the file Play Back to the beginning of the test.

Rewind button / Fast Rewind  Plays the measurements backward. Each successive click will cause the rewind speed to double until a maximum speed is reached.

Play button Starts file play back.

Pause button:  Play button converts to pause button while data is being played. Clicking the pause button will stop the file play back.

Fast Forward:  Plays the measurements at 2x speed. Each successive click will cause the fast forward speed to double until a maximum speed.

Backward and forward buttons:  and  Step through the test file one measurement at a time.

Slider: Drag the blue slider across the top of the Sensor Plot to scroll through the data.

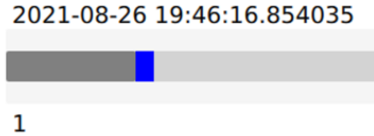
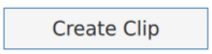


Figure 6-45: Scroll bar slider for test data file playback

Time values: The start time is displayed on the upper left, above the slider. The end time is displayed on the upper right, above the slider. The current time value as depicted by the slider is centered above the slider.

Index: The index is the current scan position of the play back file. The start index is always 1 and is displayed on the lower left, below the slider. The end index is displayed on the lower right, below the slider. The current index value as depicted by the slider is centered below the slider.

Create Clip: 

Creating a clip allows for playing back a smaller section of the test data file. Clicking this will display clip controls.

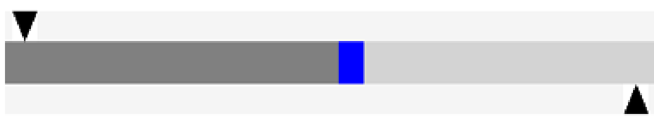
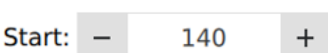


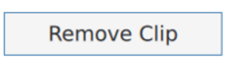
Figure 6-46: Scroll bar slider with clip definition arrows

Start and end clip sliders: Drag the arrows to define the start and end of the clip. The down arrow ▼ slider defines the start of the clip. The up arrow ▲ slider defines the end of the clip.

Start: Scan number of the first scan to be included in the new Data Clip. Used to manually enter the starting scan number or fine tune the start scan number.



End: Scan number of the last scan to be included in the new Data Clip. Used to manually enter the ending scan number or fine tune the end scan number.

Remove Clip: 

Click to remove clip and play back original full input file.

Save Clip: Save clip file by clicking "File → Save Clip"

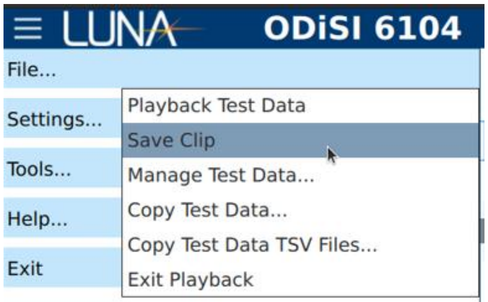


Figure 6-47: Save clip menu item

File menu:

To read in a new test data file, click “File → Playback test Data”

Figure 6-48: Playback Test Data menu item

To Generate a TSV File from the existing test data in the player, click “Tools → Generate Current Test Data TSV File.”

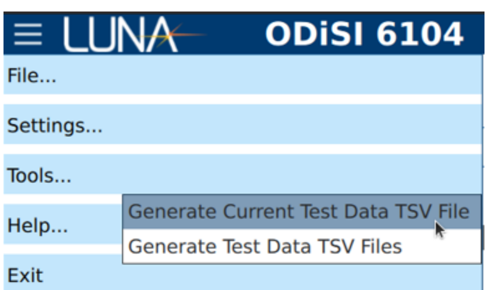


Figure 6-49: Generate Current Test Data TSV files menu item

6.6.2 Generate TSV File

The test data collected during a test is stored in a non-human readable binary format. This data can be exported to an easily readable, tab separated, text file for further analysis.

Select test data files for conversion from the menu bar using “Tools → Generate Test Data TSV Files”.

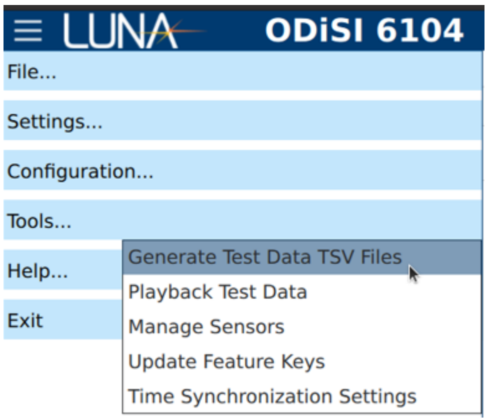


Figure 6-50: Generate Test Data TSV Files menu item

Multiple files can be selected at a time for batch conversion. Select the desired files and then click Save.

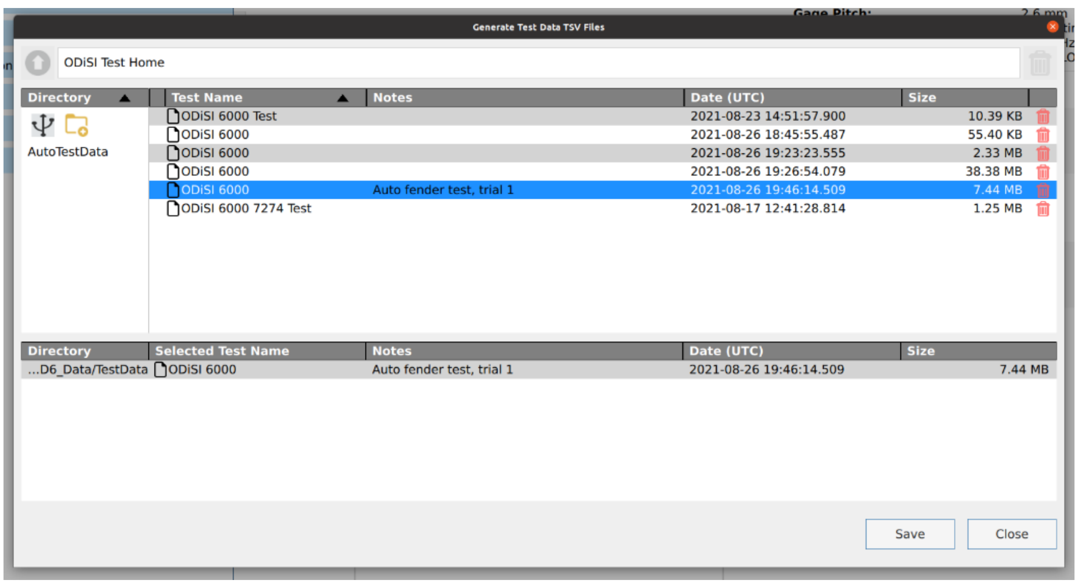


Figure 6-51: File selection window for batch conversion of data files into TSV files

After file selection, the TSV Directory window pops up.

Gages/Segments: Check to generate a TSV file containing all Gages and Segments.

Full: Check to generate a TSV file containing measurements from the entire sensor.

Select Channel(s): Select subset of Channels for which a TSV file is to be generated.

Index Range: Specify the scan index range to be written to the TSV File to limit the amount of data.

Select the directory to which TSV files are stored.

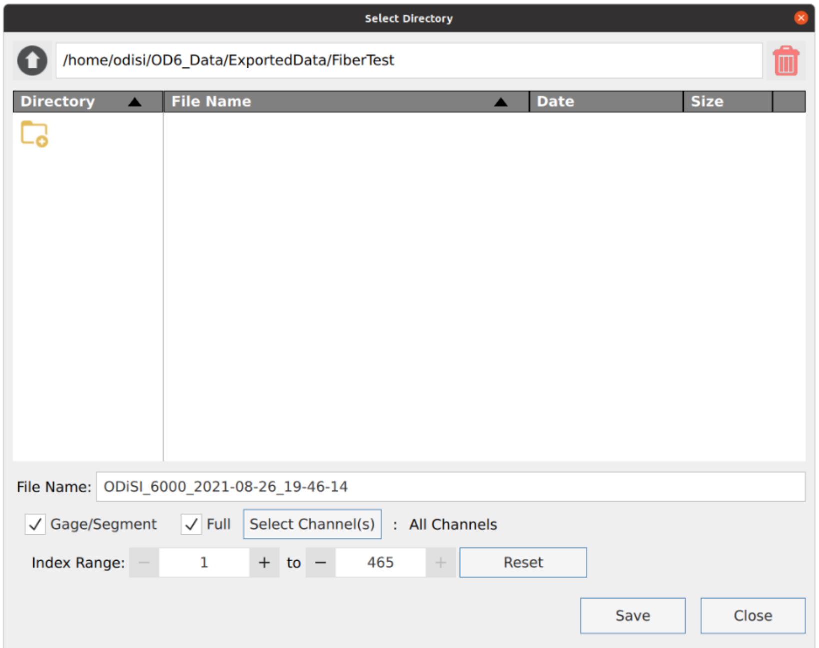


Figure 6-52: Directory selection window when generating TSV files

The converted test files use a tab separated value (TSV) format to store measurement data as well as important configuration information stored as header lines. After the header rows, each row of the data file is a measurement scan from the sensor. After the header rows, each column of the data file is a Gage location along the sensor.

The Gages and Segments converted TSV file contains 1 more header row compared to the Full converted TSV file, where the Gage Names are included above each Gage Location.

A snippet of a test data TSV file is shown below.

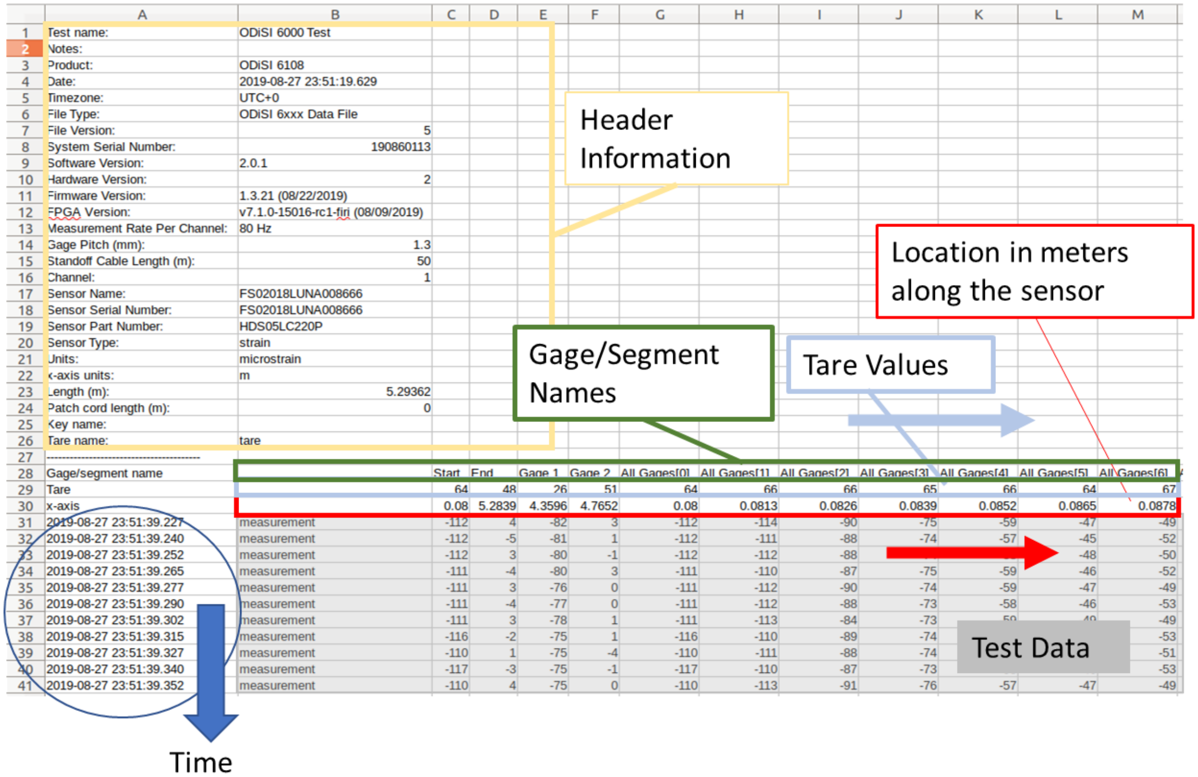


Figure 6-53: Example test data TSV file

6.7 Manage Configuration

The specific sensor combination on each channel, as well as Tare, Rekey, and all settings made through the settings menu can be saved as a Configuration for the ease of setting up the same test with the same combination of sensors.

Save Configuration: Click "Configuration → Save Configuration" to save the current settings used to configure the ODiSI. Type the configuration name in the "Save Configuration" dialog.

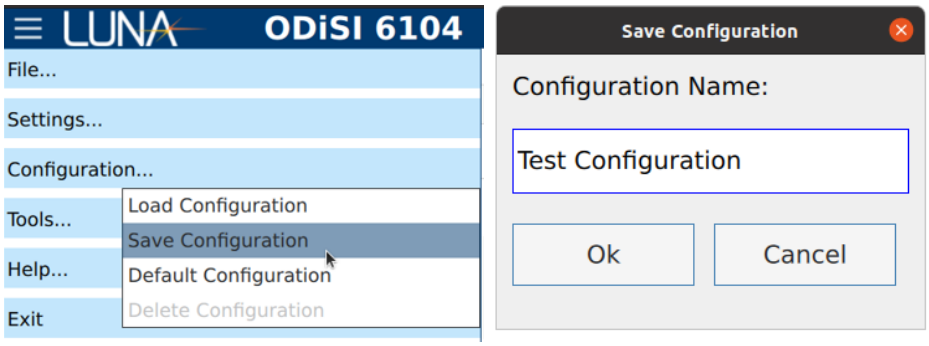


Figure 6-54: Save configuration

Load Configuration: Click "Configuration → Load Configuration" to load the previously saved settings in the named configuration.

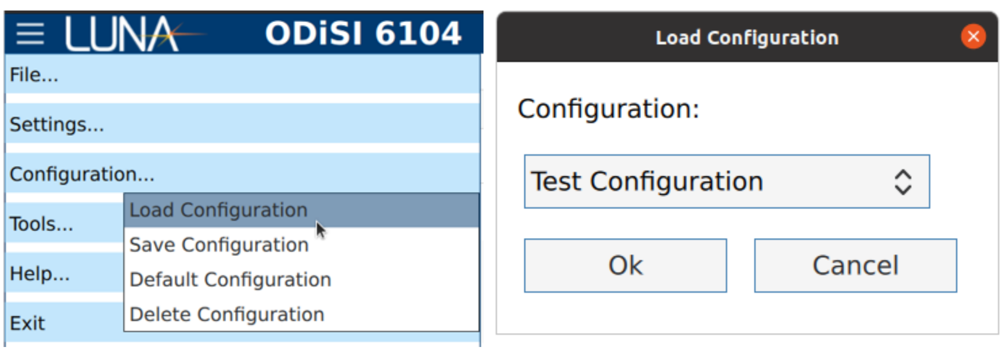


Figure 6-55: Load previously saved configuration

The loaded configuration is displayed on the top right of the User Interface.

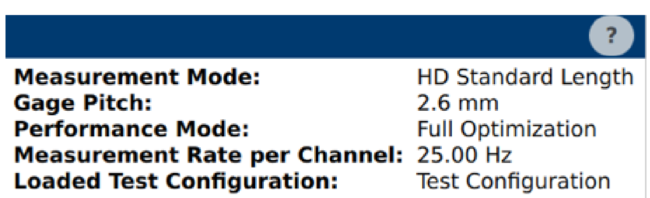


Figure 6-56: Configuration name is displayed when configuration is loaded

If the configuration is changed after a saved configuration is loaded, the configuration name will be displayed in red.

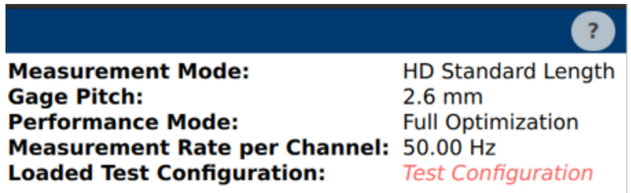


Figure 6-57: Configuration name shown in red if settings changed after load

Default Configuration: Click “Configuration → Default Configuration” to specify a saved configuration that will be used when the ODiSI software is started.

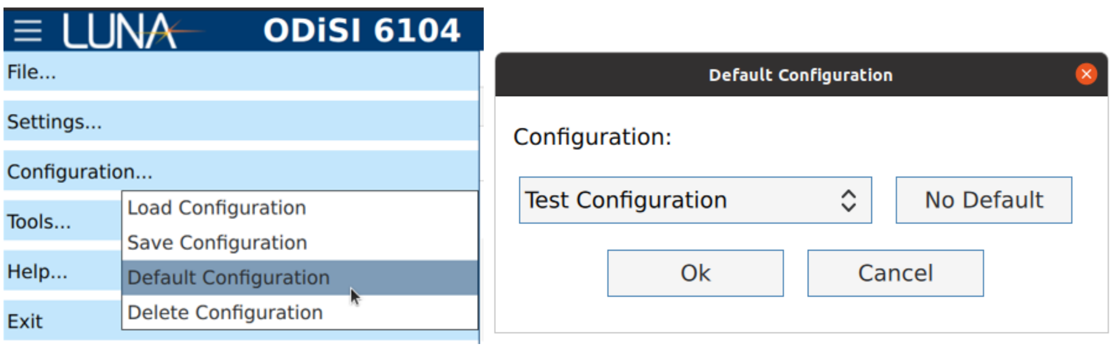
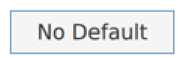


Figure 6-58: Set default configuration

To remove the default configuration, click the “No Default” 

button.

Delete Configuration: Click “Configuration → Delete Configuration” to delete the current saved configuration from the system.

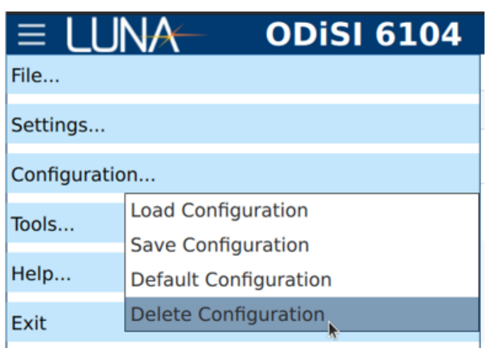


Figure 6-59: Delete the current saved configuration

6.8 Update Feature Keys

Click “Tools → Update Feature Keys” to update the software with optionally purchased features. Once the file dialog is displayed, select the Luna provided feature key update file. The ODiSI software must be restarted after updating the feature keys on the instrument.

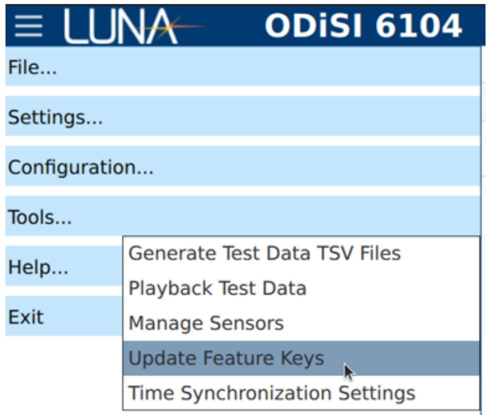


Figure 6-60: Update Feature Keys menu item

6.9 Time Synchronization Settings

Click “Tools → Time Synchronization Settings” to bring up the Time Synchronization Settings dialog.

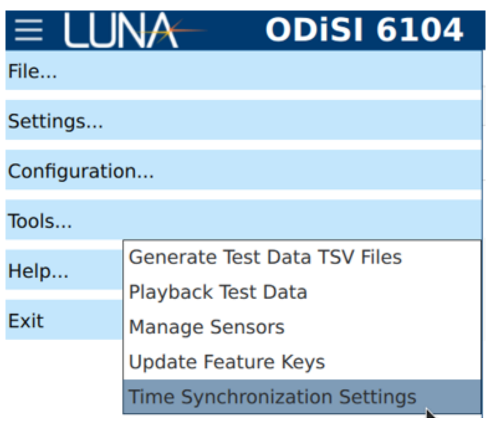
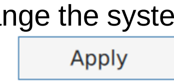
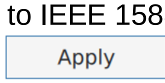


Figure 6-61: Time Synchronization Settings menu item

Synchronize ODiSI time stamps to one of these systems:

- **System**: Synchronize to the user specified time. Change the system date and time by modifying the date and time and clicking the “Apply” 

 Button.
- **PTP**: Synchronize to IEEE 1588-2008 Precision Time Protocol.

  Click the “Apply” 

 button to apply the PTP settings without starting

PTP synchronization. Click the “Start” Start button to both apply the PTP settings and start PTP synchronization. To start PTP automatically when the ODiSI software is started, check the “Start PTP Automatically” Start PTP automatically checkbox.

- **NTP**: Synchronize to RFC 5905 Network Time Protocol.

  Click the “Apply” Apply button to apply the NTP settings without starting NTP synchronization. Click the “Start” Start button to both apply the NTP settings and start NTP synchronization. To start NTP automatically when the ODiSI software is started, check the “Start NTP Automatically” Start NTP automatically checkbox.

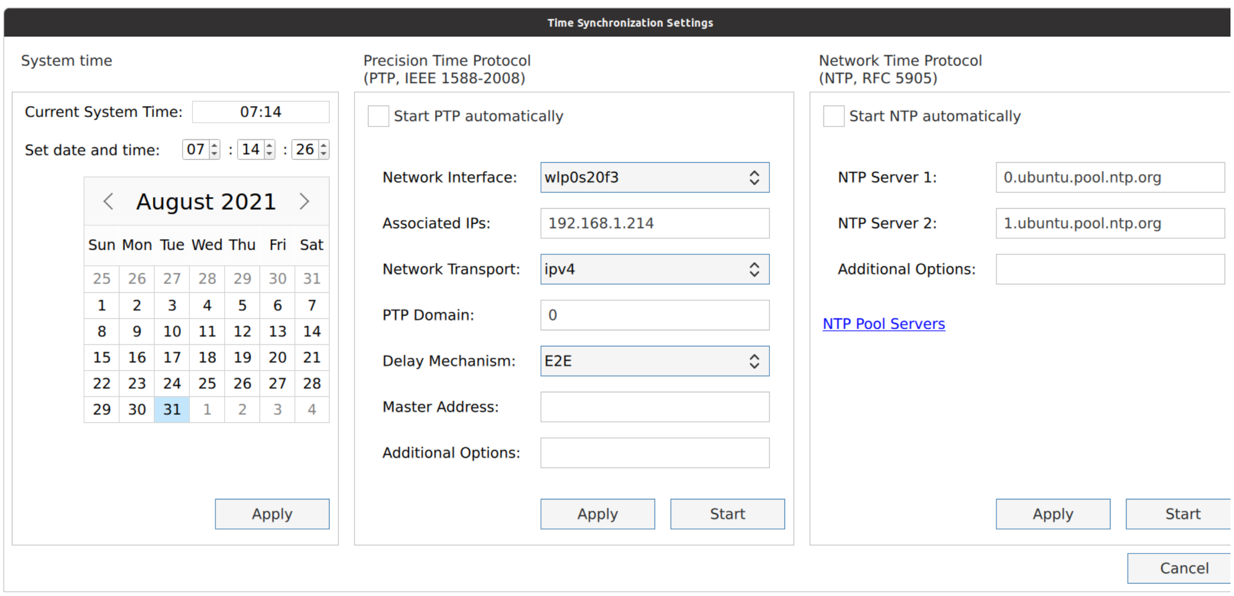


Figure 6-62: Time Synchronization Settings dialog

6.10 Help

6.10.1 Documentation

These help documents can be accessed directly from the ODiSI control software:

- **What’s New**: Displays a list of the changes made from previous versions of the software.
- **User Guide**: Matching version of the ODiSI 6 User’s Guide.
- **Setup Guide**: Instructions for how to set up the ODiSI 6.
- **Sensor Application Guide**: Comprehensive guide containing the best methods for attaching a fiber optic strain sensor to a test article.

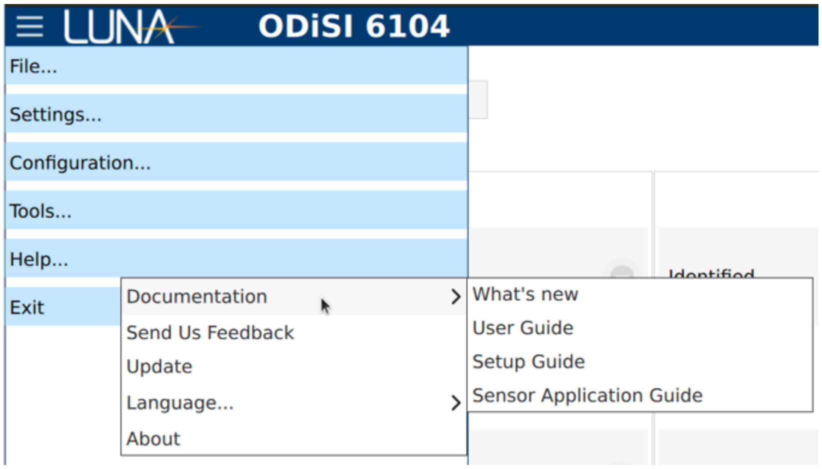


Figure 6-63: Help documentation sub-menu

6.10.2 Send us feedback

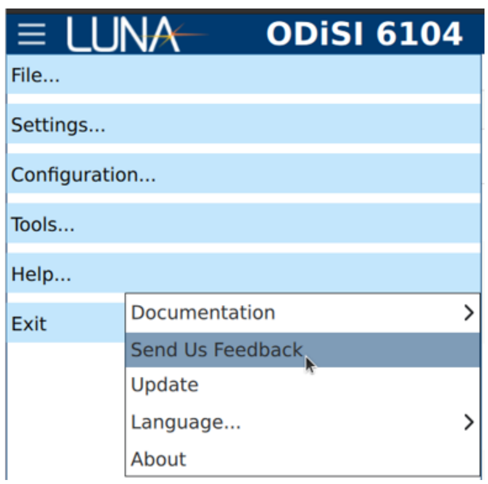


Figure 6-64: Send Us Feedback menu item

Generate a report on any issues encountered while running the ODiSI software or feature requests associated with software functionality. This report is packaged for subsequent emailing to Luna support.

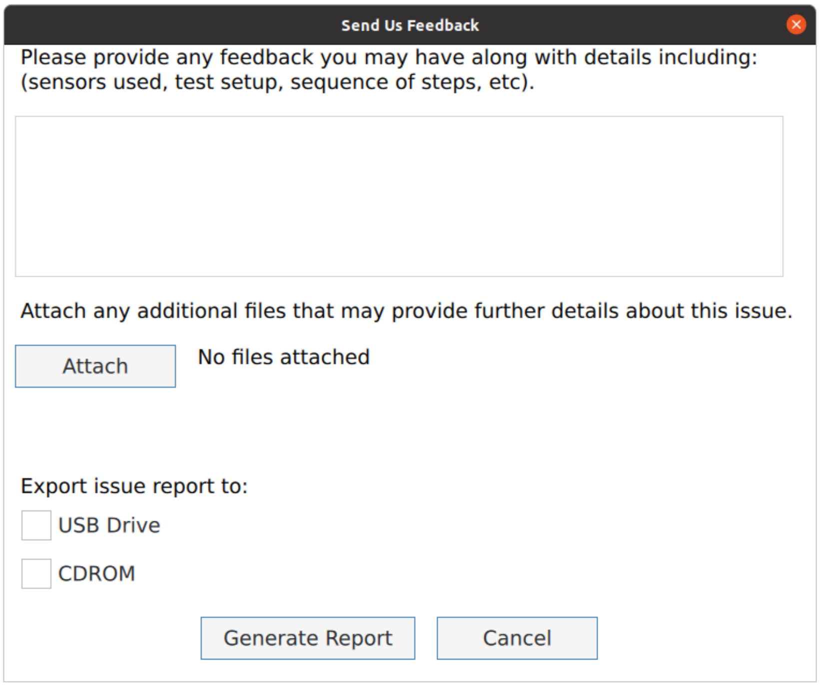


Figure 6-65: Form for providing feedback to Luna

6.10.3 Update

Figure 6-66: Software update menu item

Update the ODiSI software to the latest version, or downgrade to a previous version. The ODiSI software will automatically restart once the update is initiated.

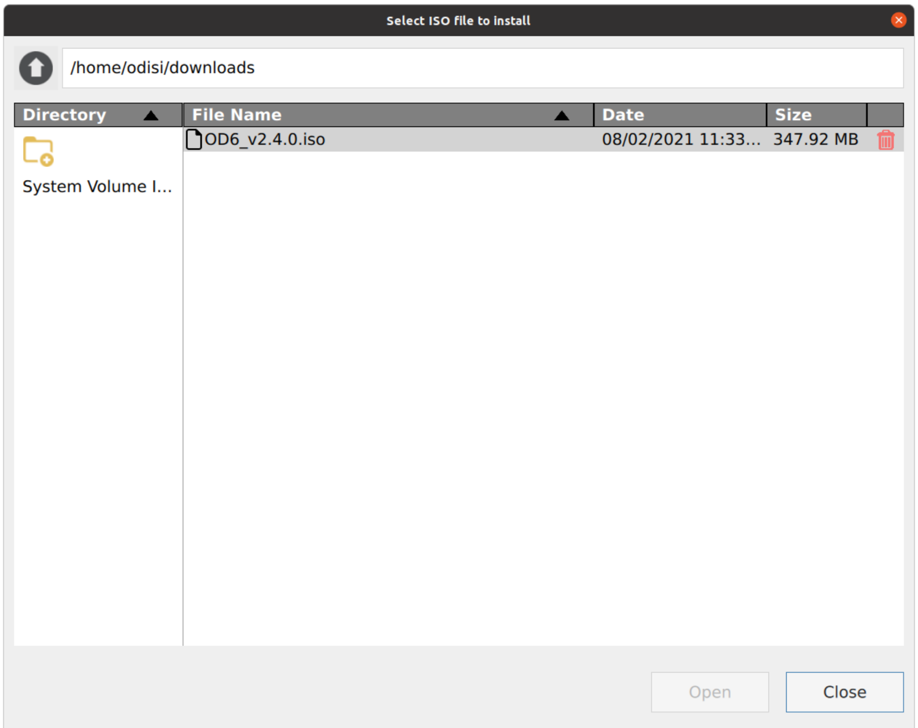


Figure 6-67: Dialog to select software update file

6.10.4 Language

Select the language to be used in the ODiSI software user interface. The ODiSI software must be restarted for the language selection to be applied.

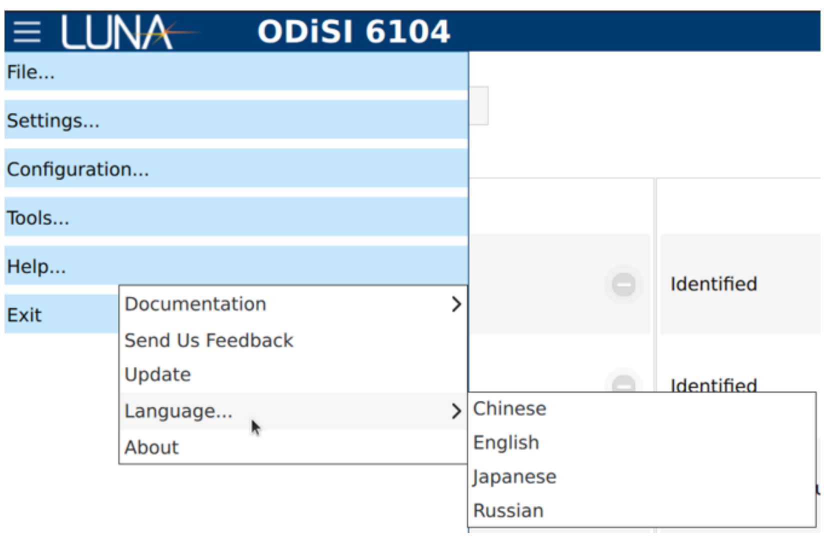


Figure 6-68: Menu to select user interface language

6.10.5 About

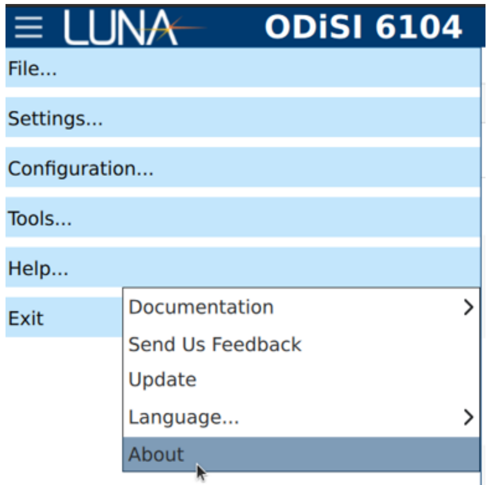


Figure 6-69: About info menu item

Displays the ODiSI software version information, connected hardware information, list of optional installed features and Luna contact information.

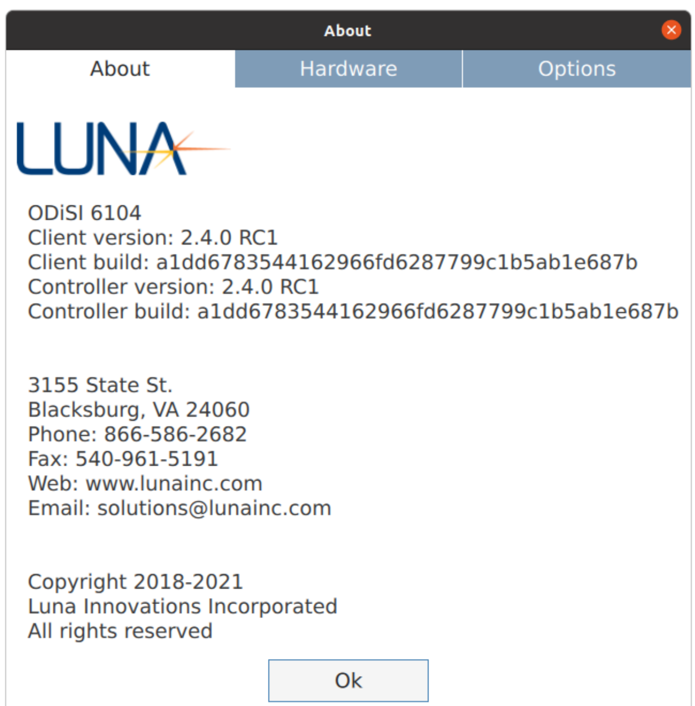


Figure 6-70: About info dialog

7 ODiSI Remote Operation

7.1 ODiSI Remote Application

The ODiSI Remote application provides the ability to Arm, Start, Stop, and Disarm the ODiSI controller software from a remote PC. When the ODiSI controller software is making measurements, the remote software will display the measurement data in real time. The ODiSI instrument and controller must be running in order for the ODiSI Remote application to connect successfully to the ODiSI controller.

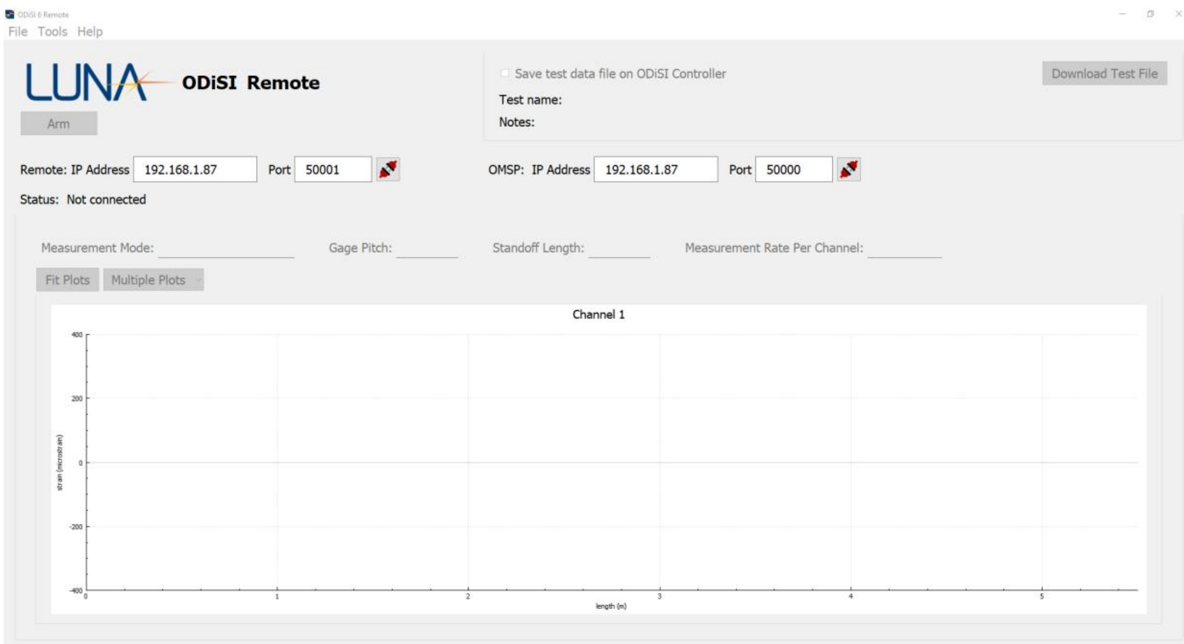


Figure 7-1: ODiSI Remote application window

7.1.1 Remotely Control an ODiSI

Configure the Remote Software with the same IP address and port displayed in the main ODiSI control software's Streaming Properties tab. Click the plug head button, which will change from red to green upon successful connection.

The ODiSI Remote application provides limited remote control functionality. The user can Arm/Disarm, Start/Stop, and enable/disable test data file logging on the ODiSI controller.

7.1.2 Stream in ODiSI Measurement Data

Configure the Remote Software with the same IP address and port displayed in the ODiSI main control software's Streaming Properties tab. Click the plug head button, which will change from red to green upon successful connection.

Measurement data as defined by Gages and Segments will be streamed into the ODiSI Remote application and can be displayed on a Sensor Plot. Within the Sensor Plot, Gages will be displayed as circle markers while Segments will be displayed as a line plot.

Figure 7-2: ODiSI Remote Sensor Plot

The ODiSI Remote also provides the ability to Play Back test data files and Generate Test Data TSV Files through the menu bar.

7.2 ODiSI Remote-control Interface

This section describes the commands (utilized internally by the ODiSI Remote application) that facilitate remote-control of the ODiSI controller application. The remote-control interface is a two-way interface in which the remote-control application sends a command and the ODiSI controller application provides a status update in response. This remote-control connection is facilitated over a TCP/IP network connection. Only one such active connection can exist at one time. The ODiSI controller application will block any attempts to establish additional simultaneous connections.

7.2.1 ODiSI Remote-control Commands

The following table describes the remote-control commands that can be sent after establishing a connection.

Table 7-1 List of remote-control commands

Command	Description
remote:arm	Arm Test
remote:disarm	Disarm Test
remote:start	Start Test

Table 7-1 List of remote-control commands

Command	Description
remote:stop	Stop Test
remote:set_filesave_on	Turn Test Data File saving on
remote:set_filesave_off	Turn Test Data File saving off
remote:getfilesave	Poll ODiSI Controller to get the file save state
remote.getfile	Download the last save test data file.
remote:add_channel=#	Add an identified sensor to the test configuration. The hashtag/number sign should be replaced by an integer value where 1 ≤ # ≤ the number of ODiSI channels
remote:remove_channel=#	Remove a channel/sensor from the test configuration. The hashtag/number sign should be replaced by an integer value where 1 ≤ # ≤ the number of ODiSI channels

7.2.2 ODiSI Controller Status

The following table describes the status messages that are sent back to the remote-control application after a connection is established. The ODiSI controller will send status messages back to the connected remote-control to indicate state changes and to give periodic updates when the ODiSI controller application is in the identify/standby state.

Table 7-2 List of remote-control status messages

Status	Description
status:ready	Instrument is ready
status:armed	Intrument is armed
status:arming	Intrument is arming
status:start	Instrument started test
status:noinstrument	No instrument is connected to the controller
status:notready	Controller is in a state where it is not ready. (Example: Incorrect configuration, no sensors connected)

status:ODiSI6	Notify connected to an ODiSI6 when a remote connection is made.
status:refused	Notify that the connection has been refused when a remote connection is made.
status:filesave_on	File saving is on
status:filesave_off	File saving is off
status:filesend_start	Sent after remote.getfile command. Test Data File download has started.
status:filesend_done	Test Data File download has completed.
field:testname=TEXT	Test Name field has changed. This notification contains the test name text after the equals sign (shown here as TEXT).
field:notes=TEXT	Test Notes field has changed. This notification contains the notes text after the equals sign (shown here as TEXT).
status:add_channel_success=#	Indicates adding the channel to the test configuration was a success. The hashtag/number sign is replaced by an integer value where 1 ≤ # ≤ the number of ODiSI channels
status:add_channel_failure=#	Indicates adding the channel to the test configuration was a failure. The hashtag/number sign is replaced by an integer value where 1 ≤ # ≤ the number of ODiSI channels
status:remove_channel_success=#	Indicates removing the sensor/channel from the test configuration was a success. The hashtag/number sign is replaced by an integer value where 1 ≤ # ≤ the number of ODiSI channels
status:remove_channel_failure=#	Indicates removing the sensor/channel from the test configuration was a failure. The hashtag/number sign is replaced by an integer value where 1 ≤ # ≤ the number of ODiSI channels
status:identified_sensors=TEXT	Periodic status message that indicates the currently identified sensors. The text after the equals sign (shown here as TEXT) is a single line of comma separated values (CSV) where each value in the CSV set is the sensor name for the corresponding channel on the ODiSI (or sensor serial number if the sensor does not have a user-

	provided name) or is blank if no sensor is identified. The number of commas in the CSV set is one less than the number of ODiSI channels
status:configured_sensors=TEXT	Periodic status message that indicates the sensors currently in the test configuration. The text after the equals sign (shown here as TEXT) is a single line of comma separated values (CSV) where each value in the CSV set is the sensor name for the corresponding channel on the ODiSI (or sensor serial number if the sensor does not have a user-provided name) or is blank if the corresponding channel is not in the test configuration. The number of commas in the CSV set is one less than the number of ODiSI channels

7.2.3 ODiSI Remote-control Workflow

The following shows an example workflow.

Table 7-3 Example remote-control workflow

ODiSI Remote Control	Command	ODiSI Controller
Remote initiates connection	Open TCP/IP Connection and Port →	
	status:refused ←	Controller refuses connection
	status:ODiSI6 ←	Controller accepts connection. The controller will also send its current status.
	status:noinstrument ←	Controller is not connected to an instrument.
	status:ready ←	Controller is connected to an Instrument and is Ready
	status:identified_sensors=TEXT ←	Controller sends list of identified sensors
Remote turns on saving test data file	remote:set_filesave_on →	
	status:filesave_on ←	Controller sets file saving on

Table 7-3 Example remote-control workflow

ODiSI Remote Control	Command	ODiSI Controller
	field:testname=TEXT field:notes=TEXT ←	Controller sends testname and notes.
Remote turns off saving test data file	remote:set_filesave_off →	
	status:filesave_off ←	Controller sets file saving off
Remote can check file save state. This is done on startup	remote:getfilesave →	
Remote adds channel	remote:add_channel=# →	
	status:add_channel_success=# ←	Add channel succeeded
	status:add_channel_failure=# ←	Add channel failed
	status:configured_sensors=TEXT ←	Controller sends list of configured sensors
Remote remove channel	remote:remove_channel=# →	
	status:remove_channel_success=# ←	Remove channel succeeded
	status:remove_channel_failure=# ←	Remove channel failed
Remote arms instrument	remote:arm →	
	status:arming ←	Instrument Arming
	status:armed ←	Instrument Armed
Remote starts test	remote:start →	
	status:start ←	Instrument started test
Remote stops test	remote:stop →	

Table 7-3 Example remote-control workflow

ODiSI Remote Control	Command	ODiSI Controller
	status:armed ←	Instrument stopped test and is back in an armed state
Remote disarms instrument	remote:disarm →	
	status:ready ←	Instrument is disarmed and is back to a ready state
	status:notready ←	Software controller has an incorrect configuration, or no sensors connected
Remote requests download of latest test file.	remote:getfile →	
	status:filesend_start ←	Controller initiates test data file download to the remote. Controller sends content of file to the Remote.
	status:filesend_done ←	Controller completes the file download to the remote

8 ODiSI Measurement Streaming Protocol (OMSP)

In the discussion of Streaming Properties above, the measurement data is streamed to and analyzed in a separate client. This is accomplished using the ODiSI Measurement Streaming Protocol (OMSP). Custom client code can be programmed to connect to the ODiSI 6 and receive measurement data for display and logging.

The protocol consists of JSON-formatted data sent over a TCP/IP connection. JSON is a lightweight data interchange format that is easy to read and parse and is supported in virtually all programming languages.

OMSP consists of four message types:

- An initial acknowledgment message when the connection is established. This message type looks like an empty metadata message.
- Metadata messages provide information about the ODiSI system, the active sensors, and the names and locations of the gages that will be streamed.
- Measurement messages contain the gage values generated from a single measurement.
- Tare messages contain the value of the tare that has been applied to the measurements. This is provided in case the client wants to store information about the tare or remove the effect of the tare on the data.

8.1 Terminology

The ODiSI measures strain or temperature at multiple points along a sensor.

8.1.1 Channel

The ODiSI acquires data from multiple channels (1 to 8 for the ODiSI 6). A different strain or temperature sensor is attached to each channel. The channel number is used in OMSP to specify which sensor is being referred to.

8.1.2 Sensor

An ODiSI sensor is used to measure either strain or temperature. Each sensor contains thousands of different gages at evenly spaced intervals, at which strain or temperature measurements are made.

All of the gages on a given sensor have the same measurement type (strain or temperature) and units.

8.1.3 Gage

The ODiSI always calculates measurements at each gage along the sensor. Users can name specific gages of interest, and use OMSP to stream those named gage values to another program.

A named gage is defined by its name and its location on the sensor.

8.1.4 Segment Vector

A segment vector is an array of multiple contiguous gage values. A segment is defined by specifying the location of the first gage and the number of gages in the vector.

All segments will use the same spacing between gages, which is defined by the properties of the ODiSI test and the properties of the sensors.

8.2 Streaming Connection

The ODiSI streams data over a TCP/IP connection. The TCP/IP port can be configured; the default port is 50000.

Upon configuration by the user, the ODiSI device opens a port and begins listening for a client connection. The client program will initiate a TCP connection to the ODiSI server on the specified port number. As soon as a connection is established, the ODiSI will begin sending messages to the client.

If at any time the ODiSI loses connection with the client, it will resume listening for a new client message and will resume sending data once a new connection has been established. The ODiSI will not send measurement data that was missed during the time the connection was down. If the user has enabled test data logging to file, the data will still be available in the saved test data file.

The application data is one way. That is, the ODiSI sends data to the client but does not look for any responses.

Each new message starts at the beginning of a new TCP packet.

8.3 Message Types

Four types of messages are transmitted over the streaming protocol: an initial acknowledgement, a Measurement Message, a Metadata Message, and a Tare.

The initial acknowledgement is returned when the client first connects. A metadata record is returned informing the client that it has connected to the ODiSI Controller.

The Measurement Message is a simple format, consisting mostly of an array of numeric data which represents the measured strain and temperature gage values. The metadata needed to fully interpret the data (gage and segment names, locations, units, etc.) require too much space to be transmitted with every measurement and are instead transmitted less frequently within the Metadata Messages. The Tare message contains the value of the tare that was applied to the measurement; it is provided for informational purposes.

All message types use JSON formatting. This data is human readable text, encoded as UTF-8. The language of the JSON fields is always English, and is not affected by the language selection made in the main software. However, all fields that hold user defined values (test name, sensor name, gage name, segment name) support the full UTF-8 character set.

User defined values will use an escape character to encode quote marks and backslash characters (if they appear in the user data). A quote mark is represented as **\”** in the JSON string. A backslash is represented as ****. These are the only characters that need to be escaped in order to not preserve JSON formatting. Most JSON libraries should automatically handle the conversion from escaped characters back to the original text.

The ODiSI will transmit a Measurement Message for every acquired measurement. A Metadata Message will be transferred once every 5 seconds. Following the Metadata Message, one Tare Message will be sent for each active channel.

When the ODiSI is stopped and not acquiring data, the Metadata Message will be sent once every 5 seconds to keep the connection alive. Measurement Messages and Tare Messages will be sent when ODiSI operation is started again.

8.4 Metadata Messages

8.4.1 Contents

The Metadata Message is formatted as human readable UTF-8 text, using JSON formatting. A carriage return plus line feed (\r\n) follows the closing curly brace of the JSON text. A CRC-16-ANSI (0x8005) checksum (encoded as 4 hexadecimal characters) follows the carriage return plus line feed. A NULL character follows the checksum and marks the end of the message.

The metadata message contains the following information, formatted as JSON name/value pairs:

Table 8-1 OMSP Metadata Message.

Description	JSON name	Value
Message type	”message type”	String “metadata”
Message format version	“message version”	Integer. Ex: 2
Product	“product”	String Ex: “ODiSI 6000”.
System serial number	“system serial number”	String
Software version	“software version”	String. Ex: “1.2.0”
Hardware version	“hardware version”	String. Ex: “1.0.0”
Test name	“test name”	String. User defined in ODiSI software.
Notes	“notes”	String. User defined in ODiSI software.
System status	“system status”	String. “stopped” or “measuring”.
Array of sensors	“sensors”	Array of JSON elements contained in [] brackets
Measurement rate per channel	“measurement rate”	Decimal number indicating measurement rate per channel.

Each sensor contains the following information, formatted as JSON name/value pairs. In a multi-channel system, any unused channels are omitted from the metadata message.

Table 8-2 OMSP Sensor Information.

Description	JSON name	Value
Channel	“channel”	Integer. 1-8 for ODiSI 6.
Sensor name	“sensor name”	String. User defined in ODiSI software.
Sensor serial number	“sensor serial number”	String
Sensor part number	“sensor part number”	String
Sensor length	“length (m)”	Decimal number indicating length in meters
Gage pitch	“gage pitch (mm)”	Decimal number indicating the spacing between individual gages along the sensor.
Sensor type	“sensor type”	String. “Strain”, “Temperature” or “SC Temperature”.
Units	“units”	String. “microstrain” or “deg C”
Array of gages	“gages”	Array of JSON elements contained in [] brackets
Array of segment vectors	“segments”	Array of JSON elements contained in [] brackets

Each gage contains the following information, formatted as JSON name/value pairs.

Table 8-3 OMSP Gage Information.

Description	JSON name	Value
Gage name	“gage name”	String. User defined in ODiSI software.
Gage location	“location (mm)”	Decimal number indicating the gage location in millimeters.

Each segment vector contains the following information, formatted as JSON name/value pairs.

Table 8-4 OMSP Segment Vector Information.

Description	JSON name	Value
Segment name	“segment name”	String. User defined in ODiSI software.
Starting location	“location (mm)”	Decimal number indicating the location in millimeters of the first gage in the segment vector.
Vector size	“size”	Integer. Number of gages contained in the segment vector.

This provides all of the information needed to parse the measurement data transmissions into specific gage values.

- The metadata message may contain a gage section, a segment vector section, or both. A segment vector will always begin at a location for which there is also a named gage.
- The “system status” field indicates whether the system is currently acquiring and producing data or is stopped. A value of “measuring” indicates that the system is producing data. A value of “stopped” indicates that the system is not producing data. When the system is stopped, the system will send Metadata Messages only. When the system is measuring, it will send both Metadata and Measurement Messages.
- No changes will be made to the sensor, gage, or segment configurations when the system is processing. When the metadata messages indicate a system status of “measuring”, the client can be guaranteed that this information will not change from one metadata message to the next.
- The client can also use the Metadata Message checksum to determine whether changes have been made to the configuration. If a Metadata Message contains the same information as the previously transmitted Metadata Message, its checksum will remain the same as well.
- When the system is in a “stopped” state, the sensor and gage configuration may be changed by the ODiSI user. The metadata messages will reflect the current configuration, but the client should be aware that this information may change.
- The JSON portion of the Metadata Message is followed by a 16 bit CRC-16-ANSI (0x8005) checksum, encoded as a 4-character hexadecimal number. The checksum is calculated over the entire length of the JSON text, beginning with the starting curly

brace and including up through the carriage return plus line feed after the closing curly brace of the JSON text.

- The checksum is followed by a single NULL character to mark the end of the Metadata Measurement transmission.

8.4.2 Example

```
{
    "message type": "metadata",
    "message version": 1,
    "product": "ODiSI 6000",
    "system serial number": "2017ODB10032",
    "software version": "6.0.0",
    "hardware version": "1.0.0",
    "test name": "My Test",
    "system status": "measuring",
    "measurement rate": 25,
    "sensors": [
        { "channel": 1,
          "sensor name": "left wing",
          "sensor serial number": "FS02017LUNA001234",
          "sensor part number" : "HDS05LC220P",
          "length (m)": 5.1,
          "spacing (mm)": 2.476302,
          "sensor type": "strain",
          "units": "microstrain",
          "gages": [
              { "gage name": "Left front", "location (mm)": 1456 },
              { "gage name": "Left mid",   "location (mm)": 2494 },
              { "gage name": "Left back",  "location (mm)": 4611 },
          ],
           "segments": [
              { "segment name": "Segment A", "location (mm)": 3007, "size": 50 }
          ]
       },
        { "channel": 2,
          "sensor name": "right wing",
          "sensor serial number": "FS02017LUNA002165",
          "sensor part number" : " HDS05LC220P",
          "length (m)": 5.1,
          "spacing (mm)": 2.476302,
          "sensor type": "strain",
          "units": "microstrain",
          "gages": [
              { "gage name": "Right front", "location (mm)": 1243 },
              { "gage name": "Right mid",   "location (mm)": 2517 },
              { "gage name": "Right back",  "location (mm)": 4487 },
          ],
           "segments": [
              { "segment name": "Segment B", "location (mm)": 1543, "size": 65 },
              { "segment name": "Segment C", "location (mm)": 3307, "size": 40 }
          ]
        }
    ]
```

```
}8F0A
```

8.5 Measurement Message

8.5.1 Contents

The Measurement Message is formatted as human readable UTF-8 text, using JSON formatting. A carriage return plus line feed (\r\n) follows the closing curly brace of the JSON text. A CRC-16-ANSI (0x8005) checksum (encoded as 4 hexadecimal characters) follows the carriage return plus line feed. A NULL character follows the checksum and marks the end of the message.

8.5.1.1 Product Name and Serial Number

The Measurement Message includes a product name and a system serial number. This allows the client program to receive data from multiple ODiSI units. Each ODiSI will transmit its own Metadata Message containing an identifying system serial number. The system serial number in the Measurement Message allows the client to determine which ODiSI unit the measurement data is from, and which Metadata Message to use to interpret the data.

8.5.1.2 Sequence Number

The Measurement Message includes a sequence number, which is incremented by the ODiSI with each measurement transmission. This number allows the client to determine if any measurements have been missed.

8.5.1.3 Timestamp

The Measurement Message includes a timestamp, which is split into separate JSON fields for year, month, day, hours, minutes, seconds, and milliseconds. There is also a field to indicate the time zone of the timestamp. The ODiSI always uses UTC timestamps, regardless of the local time zone.

8.5.1.4 Channel Number

The Measurement Message includes a channel number, which is used to map the array of data values to the gages defined for a particular sensor in the Metadata Measurement. The Measurement Message does not contain gage names or units, so it is necessary to refer to the Metadata Message to fully interpret the gage values contained in the Measurement Message.

8.5.1.5 “Data” Element

The “data” element of the Measurement Message contains an array of decimal gage values, formatted as human-readable ASCII text. The gage values are transmitted in the same order in which they are defined in the metadata message. Individual gages are defined and transmitted first, followed by segment vectors.

The measured values provided within the “data” array are provided as floating point values. The JSON value *null* will be used to indicate a NaN, or “not a number” value. (Under certain conditions, the ODiSI may not be able to calculate a strain or temperature value for a certain gage. In these events, the ODiSI reports NaN as the gage value).

8.5.1.6 Number of Gages

The element "number of gages" indicates the length of the "data" array. This value should be the same as the total number of gages defined in the "gages" and "segments" section in the Metadata Message. It is included as a sanity check.

There is no limit on the number of gages that can be contained in a single sensor. The current ODiSI product can generate a maximum of approximately 38,500 gages per sensor (50 m sensor with Gage Pitch of 1.3 mm).

The Measurement Message header contains the following information, formatted as JSON name/value pairs.

Table 8-5 OMSP Measurement Message Header.

Description	JSON name	Value
Message type	"message type"	String "measurement"
Message format version	"message version"	Integer. 2 is the current version.
Product	"product"	String Ex: "ODiSI 6000".
System serial number	"system serial number"	String
Sequence number	"sequence number"	Integer, 0 - 4,294,967,295. (Unsigned 32-bit integer.) Sequence number will wrap back to 0 after 4,294,967,295.
Timestamp	"year"	Integer, 4-digit year. Ex: 2018
	"month"	Integer, 1 – 12
	"day"	Integer, 1 – 31
	"hours"	Integer, 0 - 23 (24 hour notation)
	"minutes"	Integer, 0 - 59
	"seconds"	Integer, 0 - 59
	"milliseconds"	Integer, 0 - 9999
Time zone	"time zone"	String. Ex: "UTC-0"
Channel	"channel"	Integer. Should match one of the "channel" fields in the "sensors" array of the Metadata Message. 1 - 8 for the ODiSI 6.
Number of gages	"number of gages"	Integer

Data	"data"	Array of decimal numbers. The JSON value *null* indicates NaN.
Quality factor	"quality factor"	Array of decimal numbers

The JSON portion of the message is followed by a 16 bit CRC-16-ANSI (0x8005) checksum, encoded as a 4-character hexadecimal number. The checksum is calculated over the entire length of the JSON text, beginning with the starting curly brace and including up through the carriage return plus line feed after the closing curly brace of the JSON text.

The checksum is followed by a single NULL character to mark the end of the Measurement Message transmission.

8.5.2 Example

```
{
    "message type": "measurement",
    "message version": 1,
    "product": "ODiSI 6",
    "system serial number": "2017ODB10032",
    "sequence number": 125,
    "year": 2017,
    "month": 1,
    "day": 13,
    "hours": 13,
    "minutes": 23,
    "seconds": 14,
    "milliseconds": 56,
    "time zone": "EST UTC-5",
    "channel": 1,
    "number of gages": 4,
    "data": [ 805, -754.5, null, 901 ]
    "quality factor": [ 0.3544, 0.384, 0.367, 0.391 ]
}AF37
```

8.6 Tare Message

8.6.1 Contents

The Tare Message contains the value of the tare that was applied to the measurement. It is provided for informational purposes but is not necessary for interpreting the measurement values.

The Tare Message contains the tare value for a single sensor. One Tare Message is sent for each active channel in the test.

The Tare Message is formatted as human readable UTF-8 text, using JSON formatting. A carriage return plus line feed (\r\n) follows the closing curly brace of the JSON text. A CRC-16-ANSI (0x8005) checksum (encoded as 4 hexadecimal characters) follows the carriage return plus line feed. A NULL character follows the checksum and marks the end of the message.

8.6.1.1 Product Name and Serial Number

The Tare Message includes a product name and a system serial number, allowing the client program to receive data from multiple ODiSI units. Each ODiSI will transmit its own Metadata Message containing an identifying system serial number. The system serial number in the Tare Message allows the client to determine which ODiSI unit the measurement data is from.

8.6.1.2 "Data" Element

The "data" element of the Tare Message contains an array of decimal gage values, formatted as human-readable ASCII text. The gage values are transmitted in the same order in which they are defined in the metadata message. Individual gages are defined and transmitted first, followed by segment vectors.

The JSON value null will be used to indicate a NaN, or "not a number" value. (Under certain conditions, the ODiSI may not be able to calculate a strain or temperature value for a certain gage. In these events, the ODiSI reports NaN as the gage value.)

8.6.1.3 Number of Gages

The element "number of gages" indicates the length of the "data" array. This value should be the same as the total number of gages defined in the "gages" and "segments" section in the Metadata Message, and the same as the "number of gages" field in the Measurement Message. It is included as a sanity check.

The Measurement Message header contains the following information, formatted as JSON name/value pairs.

Table 8-6 OMSP Tare Message header

Description	JSON name	Value
Message type	"message type"	String "tare"
Message format version	"message version"	Integer. 2 is the current ODiSI version.
Product	"product"	String Ex: "ODiSI 6000".
System serial number	"system serial number"	String
Channel	"channel"	Integer. Should match one of the "channel" fields in the "sensors" array of the Metadata Message. 1 - 8 for ODiSI 6.
Number of gages	"number of gages"	Integer
Data	"data"	Array of decimal numbers. The JSON value *null* indicates NaN.

The JSON portion of the Tare Message is followed by a 16 bit CRC-16-ANSI checksum, encoded as a 4-character hexadecimal number. The checksum is calculated over the entire length of the JSON text, including the starting and final braces.

The checksum is followed by a single NULL character to mark the end of the Tare Message transmission.

8.6.2 Example

```
{
    "message type": "tare",
    "message version": 1,
    "product": "ODiSI 6",
    "system serial number": "2017ODB10032",
    "channel": 1,
    "number of gages": 4,
    "data": [ 103, -57.5, null, 91 ]
}B3F4
```

8.7 Receiving Messages Across TCP Packets

The described JSON messages may be split across multiple TCP packets, depending on the size of the message and the number of sensors and gages that have been defined.

Each message will begin in a new TCP/IP packet. The checksum and terminating NULL character will occur at the end of a packet.

A program receiving ODiSI Measurement Streaming Protocol messages can use either or both of the following methods to determine when a complete Metadata or Measurement Message has been received.

- Concatenate multiple TCP packets until a NULL character is received. The four characters preceding the NULL should be interpreted as a checksum. Everything preceding the checksum should be interpreted as a JSON-encoded Metadata or Measurement Message.
- Count pairs of curly braces (that is, the { character and the } character) as data is received. Each JSON message will begin with an opening { curly brace. Other pairs of {} curly braces will be present within the message. When a closing } curly brace matching the opening { curly brace is encountered, the receiver can conclude that the end of the message has been reached. The receiver should expect to see seven more characters – two characters for the carriage return plus line feed, four characters for the hexadecimal checksum, and a terminating NULL character.

If at any time the receiving program encounters a new packet that begins with:

```
{"message type"
```

the program should assume that this is the beginning of a new message. If the program was in the process of storing TCP packets in order to assemble a message whose end has not been received, the program should discard the previous partially-received message and begin processing a new message starting with the new packet.

9 Additional Information

9.1 Sensing Results near the Fiber Termination

One common question about sensing with the ODiSI is, "How close to the end of the sensor will I get strain/temperature results?" The answer to this question is determined by three parameters:

1. Where is the physical sensor termination inside the protective tube?
2. How does the ODiSI software locate the sensor termination?
3. How much space does the ODiSI 6000 put between where it locates the sensor termination and the end of strain or temperature sensing?

Consider the illustration of the termination end of a Luna fiber sensor:

Figure 9-1: Illustration of the termination end of a Luna fiber sensor

1. There is some variation in the position of the physical sensor termination in the protective tube. The goal is to place the physical sensor termination near the middle of the protective tube. The protective tube is ≤ 1 cm long. No strain or temperature results are possible for the length of the protective tube.
2. The structure and width of the termination will cause some variation in where exactly the termination event is located by the software. The ODiSI 6000 control software is looking for the point in the optical data at which there is the steepest drop from the sensor scatter level down to the instrument's noise floor.
3. The ODiSI 6000 control software will end its strain/temperature sensing 1 cm before the detected sensor termination event. This 1 cm is a fixed quantity in the ODiSI 6000 control software. It is necessary because the termination splice has some width and sensing is not possible where the sensing fiber is contaminated by the termination.

Typically, the sensing ends ~1.5 cm from the far end of the protective tube. The worst-case occurs when the termination is at the very beginning of the surrounding protective tube. In that case the length for the sensing dead zone at the end of the sensor is equal to the 1 cm protective tube plus 1 cm of fiber, or 2 cm total.

9.2 System Operation Guidelines

The ODiSI 6 system provides precise strain or temperature change measurements at a high spatial resolution along the length of an optical fiber sensor. It is best suited for static or low loading rate tests.

9.3 Vibration Tolerance

9.3.1 Test Setup

Like most highly sensitive testing instruments, the ODiSI 6 system is susceptible to environmental disturbances, most often vibration or motion of the sensor. Since the ODiSI 6 operates on signals reflected from the sensor, environmental disturbances, usually vibration, can corrupt the measured data. It is very important to design tests that ensure that environmental disturbances do not affect the measurements. In designing the testing, several vibration related items to keep in mind include:

- Check for vibration from other machinery on the test floor
- Monitor vibration coupling to the sensor from the load frame
- Check for shaking of unbonded sensor fiber

9.3.2 Strain Test Setup

The key to obtaining quality strain measurements is to ensure that the fiber sensor is properly attached to the test piece. The surface needs to be prepared (scuffed and cleaned with ethanol) and the fiber needs to be uniformly bonded down. Epoxy selection is also very important as it determines cure temperature, optimal temperature range for use, and the surface roughness of the test piece.

For tests at elevated temperature that require thermal compensation of strain measurements, ensure that the compensation measurement device (unbonded fiber, thermocouple, or dummy gage) is in the same thermal environment as the strain sensor.

See the **Applying Strain Sensors** document for more detailed instructions on mounting and positioning sensors, which can be accessed from the Help menu on the ODiSI 6.

9.3.3 Troubleshooting Dropouts

The ODiSI 6 relies on a correlation of reference and measurement gage data to calculate the strain along the sensing fiber. Environmental disturbances such as mechanical vibration can lead to a degradation of the measurement data. Enough disturbance weakens the correlation sufficiently to make a strain or temperature calculations unreliable. In these situations, the software drops the unreliable strain measurement and replaces it with a NaN (not a number).

If a high number of dropouts are observed along the sensing fiber, the distribution of dropouts over the sensing fiber's length can help diagnose the source of the problem.

Table 9-1 Troubleshooting Dropouts

Dropout Profile	Symptom	Resolution
Dropouts are observed at a high frequency along the entire length of the sensing fiber	The vibration correction algorithms cannot remove all vibration occurring in the remote optics module.	Investigate remote module for excessive movement or contact with vibrating machinery.
	The connector of the sensing fiber to the standoff or the connector of the standoff to the instrument has a poor optical connection.	Clean and reconnect optical connectors.
	The termination has been damaged causing a strong reflection to washout the sensor data.	Investigate termination integrity and use index matching gel to reduce reflection at the interface.
Dropouts increase in frequency along the length of the sensing fiber in a linear manner	The sensing fiber is experiencing uniform vibration over the sensing length. The effect is building along the sensing length.	Reduce test parameters of the loading structure (i.e., load amplitude and frequency). Ensure test artifact is isolated from environmental disturbances.
Dropouts vary in frequency randomly along the sensing fiber	The sensing fiber is experiencing non-uniform motion over the sensing length.	Ensure test artifact is isolated from environmental disturbances. Ensure unbonded fiber is secured and not moving
No valid data observed after a location along the sensing fiber	The optical fiber has broken at that location.	Splice the sensor and rekey it if possible. Otherwise, sensor must be replaced.
Dropout frequency is limited to areas of rapid strain transitions	The strain change across a gage length is too great for the ODiSI 6 calculation.	Attempt running the ODiSI 6 in high resolution mode to decrease the gage length, effectively reducing the amount of strain variation across a given gage length.

Dropout Profile	Symptom	Resolution
Dropout frequency is limited to areas of rapid strain transitions	The strain change across a gage length is too great for the ODiSI 6 calculation.	Rekey the sensor.
Dropouts occur at high strains, more than 12,000 microstrain	The strain experienced is beyond the limits of the ODiSI 6.	Rekey the sensor.

9.3.4 General Troubleshooting

9.3.4.1 The ODiSI 6 or Controller Does Not Power On

Table 9-2 Troubleshooting No Power

Cause(s)	Solution(s)
The ODiSI 6 and/or the controller is not plugged in or turned on (and the controller battery is dead, if applicable)	The ODiSI 6 and the controller require separate power cords. Plug in the ODiSI 6 and/or the controller, or replace dead batteries with charged ones. Instructions for the controller battery are located in the provided controller manual. Make sure to turn on the ODiSI 6 power switch on the rear of the instrument, and the controller according to its instructions.
Blown fuse	Replace the fuse. For instructions, see “Replacing Fuses” in the Maintenance and Cleaning section in the Setup Guide located, which can be accessed from the Help menu on the ODiSI 6.

9.3.4.2 Excessive Noise in Data

Table 9-3 Troubleshooting Excessive Noise

Cause(s)	Solution(s)
Mechanical vibration	Move or shut down any sources of vibration. Isolate the ODiSI 6 from those sources.
Dirty or loose fiber and/or bulkhead connections	Clean all connections and reconnect the fiber connections. For instructions, see “Cleaning Connectors” in the Maintenance and Cleaning section in the Setup Guide, which can be accessed from the Help menu on the ODiSI 6.
Subpar routing and/or orientation of standoff cable and/or remote module	Reroute and reorient the standoff cable and remote module to minimize signal degradation and to arrive at a more ideal physical configuration.
Cracks in bulkhead connector alignment sleeve	Contact Luna Technologies at 1-866- LUNAOVA or **solutions@lunainc.com** for service.

9.3.4.3 No Data After Measurement

Table 9-4 Troubleshooting No Data

Cause(s)	Solution(s)
Incorrect graph range settings	Rescale the plot axes.

9.3.4.4 Errors on Software Startup

Table 9-5 Troubleshooting Software Setup

Cause(s)	Solution(s)
The USB cable connections might be loose	Check the connections to ensure that the cable is connected properly to both the instrument and the controller.
The instrument is not turned on	Ensure that the instrument is plugged into the proper type of outlet and turn on the power switch.
The software is in an unknown state	Exit and restart the software.

The hardware is in an unusable state and is not responding to the software	Exit the software. Turn the instrument off and then back on again. Restart the controller and the control software.
The USB cable is faulty	Replace the cable
Communication Error	Turn computer off. Turn on ODiSI 6. Restart Computer.
Laser error	Power cycle the instrument and controller. Relaunch the software

10 Product Support Contact Information

Contact Luna's technical support staff with concerns or questions using one of the following methods.

Headquarters:	3155 State Street Blacksburg, VA 24060
Main Phone:	1.540.961.5190
Toll-Free Support:	1.866.586.2682
Fax:	1.540.961.5191
Email:	solutions@lunainc.com
Website:	www.lunainc.com

Specifications of products discussed in this document are subject to change without notice. For the latest product specifications, visit Luna's website at www.lunainc.com.