Torque-Link™-LXRS®

Wireless Torque Sensor

The Torque-Link™-LXRS® strain gauge node is an application-specific node assembly used for monitoring the torsional strain on a rotating shaft. Torque-Link -LXRS assemblies are designed to fit most shafts sizes and integrate with field-installed strain gauges.

To acquire sensor data, the Torque-Link -LXRS is used with a LORD MicroStrain data gateway such as the WSDA®-Base or WSDA® -1500 - LXRS®. Torque-Link -LXRS sensor nodes come with the following components and options.

Item	Description	Quantity
A	Torque-Link™-LXRS® (2 channel optional)	1
B	Lithium battery pack (installed in assembly)	1
C	Battery compartment screws - 4-40 x 5/16"	6
D	Collar screws - 8-32 x 5/8"	4 or 6
--	Strain gauge connector	1
--	Strain gauge and wiring terminal kit (optional)	1

Table 1 - Component List

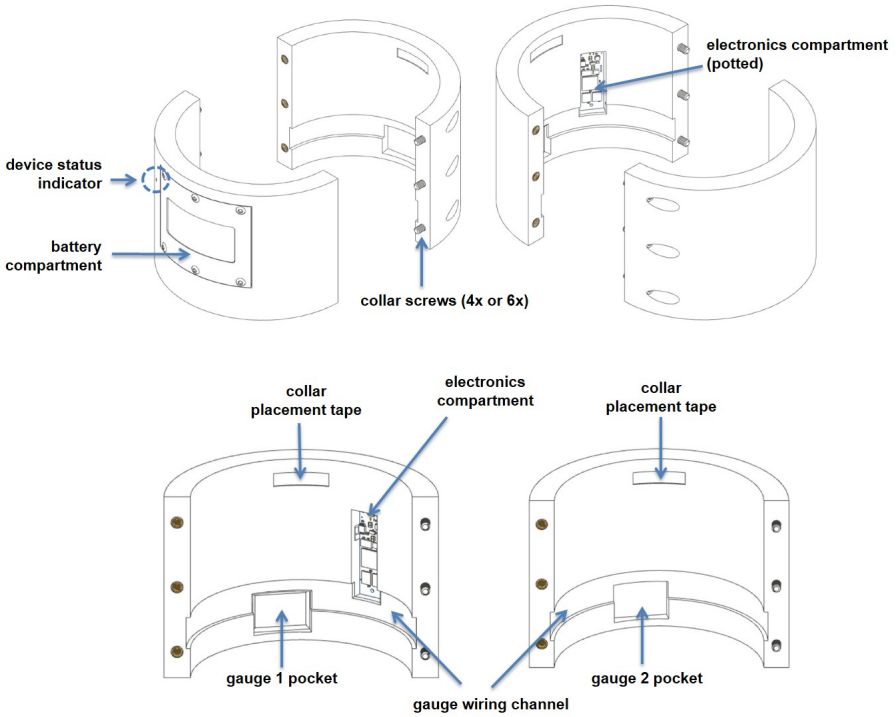


Figure 1 - Interface and Indicators

Indicator	Behavior	Node Status
Device status indicator	OFF	Node is OFF
	Rapid flashing on start-up	Node is booting up
	1 (slow) pulse per second	Node is idle and waiting for a command

Table 1 - Indicator Behaviors

LORD MicroStrain® SENSING SYSTEMS

⚠WARNING

The Torque-Link -LXRS contains an internal, non-rechargeable Lithium battery. When replacing batteries, use only the batteries specified for the node. Do not disassemble, short circuit, crush, puncture, or otherwise misuse the battery. Do not attempt to recharge the batteries. Do not expose to water. Disposal is subject to federal and local laws.

The Torque- Link -LXRS is disassembled for installation and service using a standard 9/64" hex key. The battery compartment cover is removed with a T8 Torx (star) driver.

To change the battery, remove the battery cover, unplug the depleted battery, remove it from the battery compartment, and replace with the new one in the same orientation.

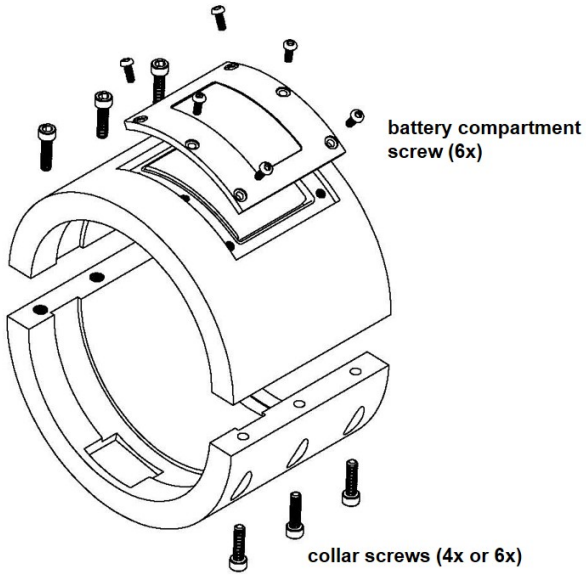


Figure 2 - Disassembly

STRAIN GAUGE AND ASSEMBLY INSTALLATION

When installing the strain gauges on the shaft, the primary considerations are the orientation of the gauges, and the position of the gauges relative to the Torque-Link -LXRS assembly and the cutouts for the gauges and wiring.

For torque measurement, the phenomenon being measured is shearing of the shaft surface. To measure this shear, the gauges should be installed at a 45° angle from the shaft center-line. Strain gauges are available in dual-element shear gauge configurations already angled at 45°, which makes this installation much easier.The gauges are installed 180° from one another to maximize bending rejection. It is recommended that a strain gauge wiring terminal be used halfway in-between the two gauges for ease of wiring and to keep the strain element wires the same length, which is a best-practice for signal integrity.

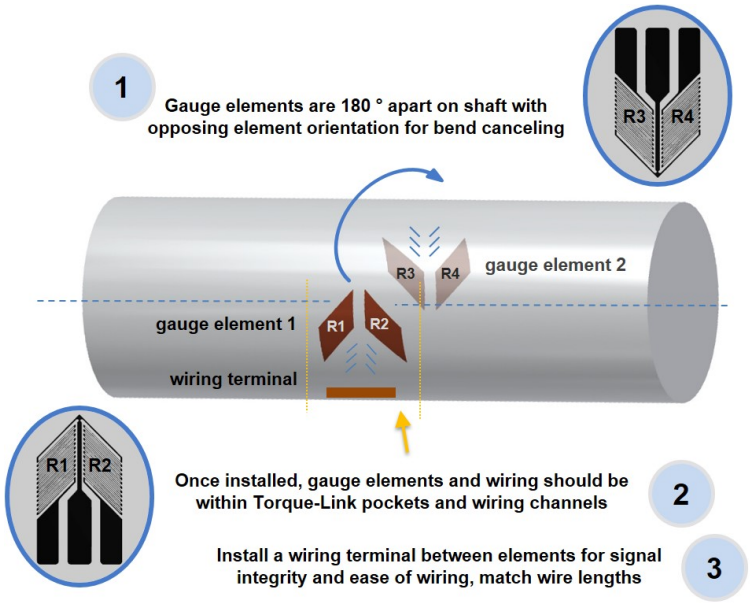
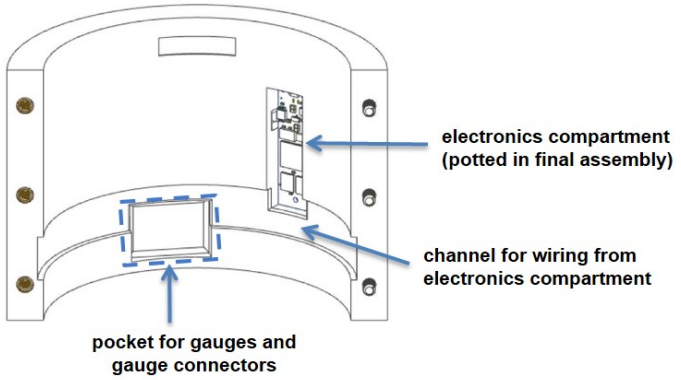


Figure 3 - Placement for Full Bridge Torque Measurements

The inner circumference of the Torque-Link -LXRS assembly has recessed channels for the gauge wiring between the electronics compartment and gauge pocket. Gauges, terminals, and wiring are installed so that they are completely contained within the cutouts when the Torque-Link -LXRS is installed. The connectors between the strain gauges and node electronics will be tucked into the strain gauge pocket during final assembly.



placement dimensions and location for gauges

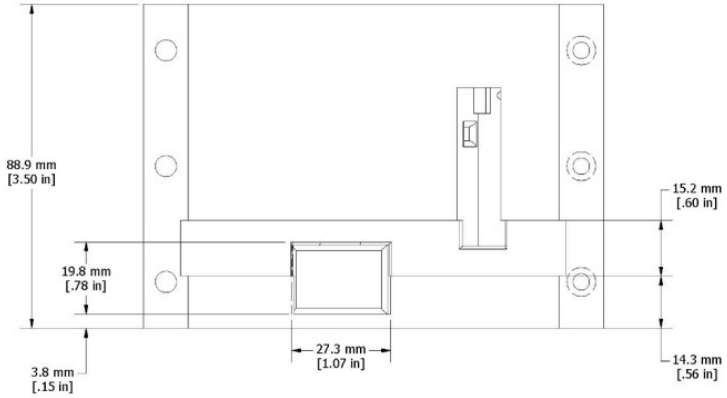
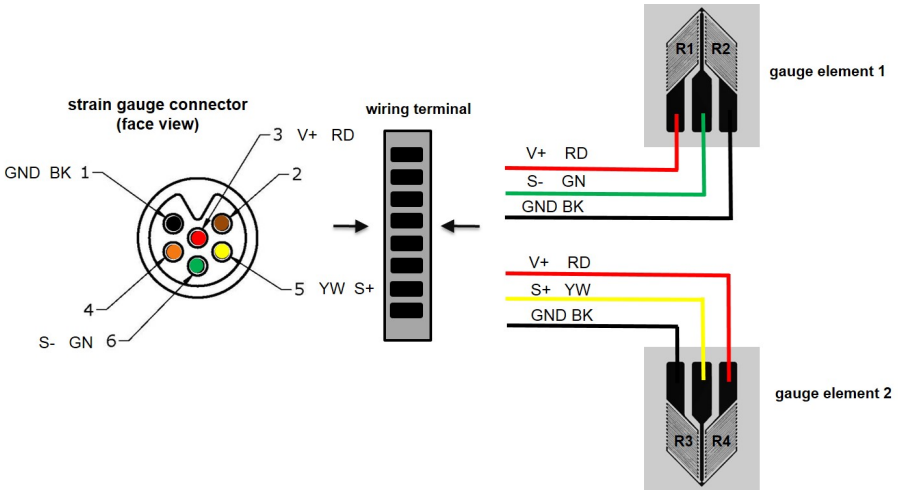


Figure 4 - Strain Gauge Placement

NOTE

For accurate torque data, strain gauge installation must be completed in compliance with strain gauge manufacturer recommendations and industry standard processes for installing strain gauges, such as *ASTM E1237-93, Standard Guide for Installing Bonded Resistance Strain Gages*. Failure to properly attach and connect the gauges will result in erroneous data.



Connector pin	Signal	Wire color	Strain element
3	V+	red	R1 & R4
5	S+	yellow	element 2 center
6	S-	green	element 1 center
1	GND	black	R2 & R3

Table 2 - Strain Gauge Wiring

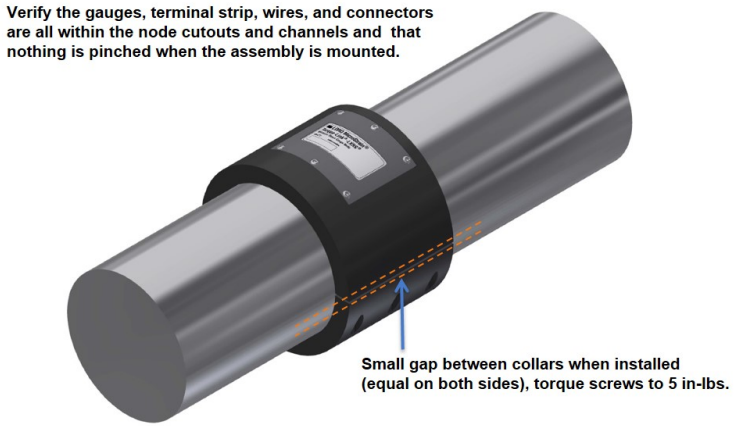


Figure 5 - Assembly Installation

1. Disassemble the collar into the two halves.
2. Peel the backing off the collar placement tape.
3. Place one half of the collar over the shaft, carefully aligning the gauge cutout over the gauge element, and wiring channels over the terminal strip and wiring. Connect the strain gauge connector to the electronic compartment connector, and tuck them into the strain gauge pocket. Train the wiring into the wiring channel.
4. Press the first half of the collar on the shaft to temporarily stick it there with the tape.
5. Align the second half of the collar over the other gauge element and wiring, and mate it to the collar screw holes on the mounted half.
6. Press the second collar half onto the shaft to stick it to the shaft with the tape.
7. Apply the thread locker on the collar screws, and fasten the two halves together, ensuring no wires are pinched. Fasten snugly with 5 inch-pounds of torque. Do not over-tighten. There should be a small gap (equal on both sides) between the collar halves.

SYSTEM OPERATION

Sensor nodes have three operational modes: *active*, *sleep*, and *idle*. When the node is sampling, it is in active mode. To stop sampling, the node is put into idle mode. Idle mode is used for configuring node settings (such as frequency and sampling rates) and is the only way to stop sampling or go between active and sleep modes. Sleep mode is an ultra low-power mode. The node will automatically go into sleep mode after a user-determined period of inactivity. The node will not go into sleep mode while sampling.

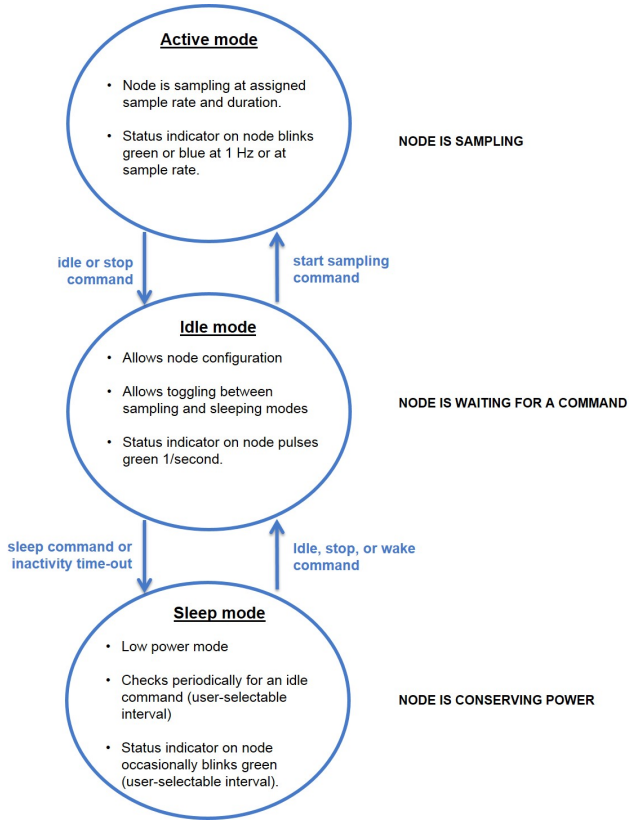


Figure 6 - Node Operational Modes

NOTE

The Torque-Link -LXRS is powered-on whenever the battery is connected. With no activity, it goes into sleep mode and must be reactivated with an idle, wake, or stop command to resume use.

1. Install Software

Install the **Node Commander® Software Suite** on the host computer before connecting any hardware. The Node Commander software is used for node configuration and data collection. The SensorCloud™ web platform is also available for data visualization and analysis, and it is accessed by logging onto the SensorCloud website (see Connect to SensorCloud™ on page 14).

The Node Commander Software Suite is included with all data gateways and is also available on the LORD MicroStrain® website for download:

http://www.microstrain.com/wireless/software

2. Make System Connections

To acquire sensor data, the Torque-Link -LXRS is used with a LORD MicroStrain data gateway such as the WSDA®-Base or WSDA® -1500 - LXRS®.

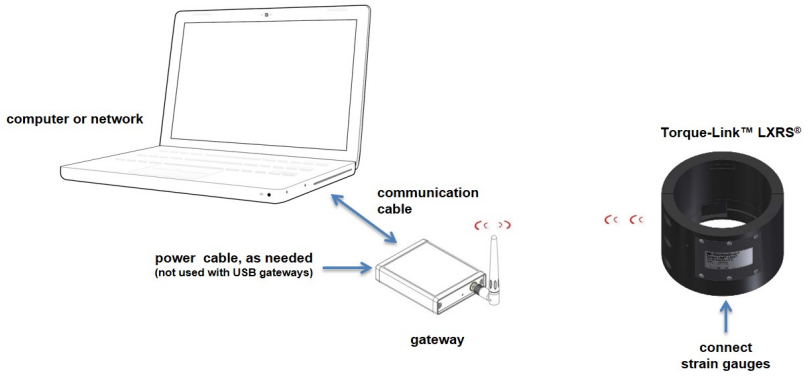


Figure 7 - System Connections

3. Establish Gateway Communication

The WSDA-Base USB gateway is used as an example in this quick start guide. For information on how to use other gateways, refer to the gateway or Node Commander® user manual.

Drivers for the USB gateways are included the Node Commander® software installation. With the software is installed, the USB gateway will be detected automatically whenever the gateway is plugged in.

1. Power is applied to the gateway through the USB connection. Verify the gateway status indicator is illuminated, showing the gateway is connected and powered on.
2. Open the Node Commander software.

3. The gateway should appear in the Controller window automatically with a communication port assignment. If it is not automatically discovered, verify the port is active on the host computer, and then remove and re-insert the USB connector.

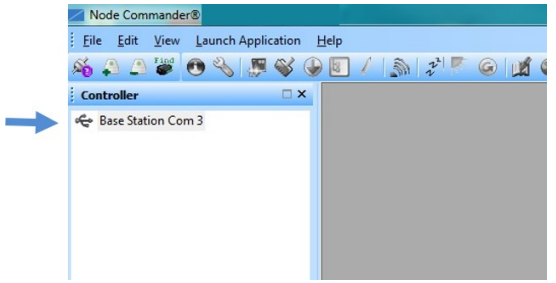


Figure 8 - USB Gateway Communication

4. Connect to Nodes

Two ways to connect the node are with the automatic node discovery feature and by manually entering the node address and then searching for it on the current gateway communication frequency.

1. To add a node by address, right-click on the gateway name in the Controller window, and select Add Node > Add Single Node.
2. The node address and frequency are indicated in the documentation included with the node. Enter the node address, and select OK. If the node is not found, a message will appear and provide the option to scan for the node on other frequencies. Alternately, the Node Discovery feature can be used.

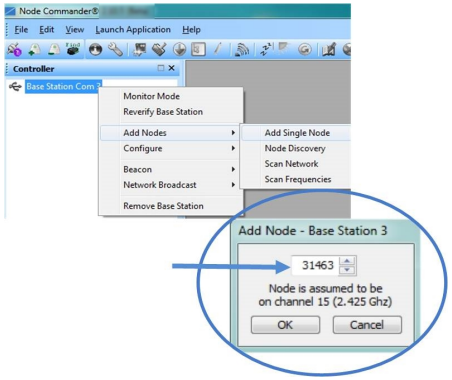


Figure 9 - Adding a Node by Address

NOTE

Nodes can be configured to boot-up in different operational modes. Automatic discovery in Node Commander® will only occur if the node is set to idle mode. To force boot-up into idle mode, cycle the node power rapidly two times, and then leave it on. The status indicator on the node will pulse once per second to indicate it is in idle mode.

The Node Discovery feature allows connection between the gateway and node to occur even if they are on different frequencies.

1. To connect to all available nodes using node discovery, begin by making sure the node power is off. Right-click on the gateway name and select Add Node > Node Discovery.
2. Turn the node power on. Within a few seconds, the node will transmit a message with its operating frequency.
3. When the device status indicator on the node ends the rapid flash sequence and begins pulsing at one-second intervals, the node has completed the normal boot-up sequence and is running in idle mode. At this point the node should be listed in the Controller window; scanning can be stopped by selecting the Stop button in the Node Discovery window.

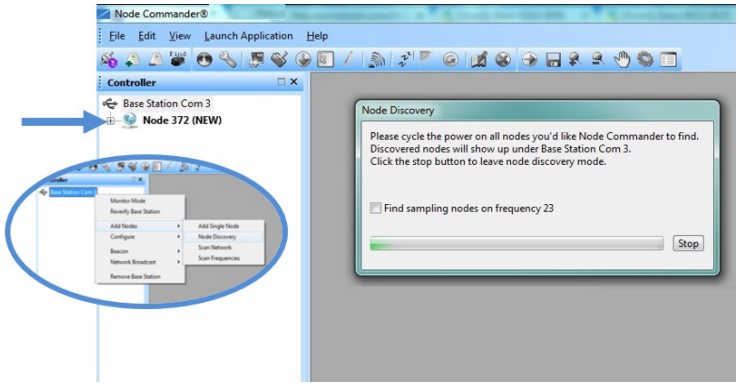


Figure 10 - Using Node Discovery

5. Configure Sensor Channels

Each sensor is assigned a channel number. The sensor settings are stored in the node memory for that channel. The configuration menus only show the channels and configuration options available for the type of node being used.

1. To enter the configuration menu, right-click on the node name, and select Configure > Configure Node. The Channels tab displays

channel options available for the node.

a. **Channel Enabled:** indicates the sensor channel number. The check box is used to enable the channel and select it for sampling. The icon next to the check box describes the channel type inherent to the node being used.

b. **Current channel configuration:** The Data Output, Units, Input Range, and Label fields describe how the channel is currently configured.

c. **Configure:** The Configure button changes the channel parameters, such as measurement units, gain and offset settings, and calibration values. The channel must be enabled first by selecting the adjacent check box.

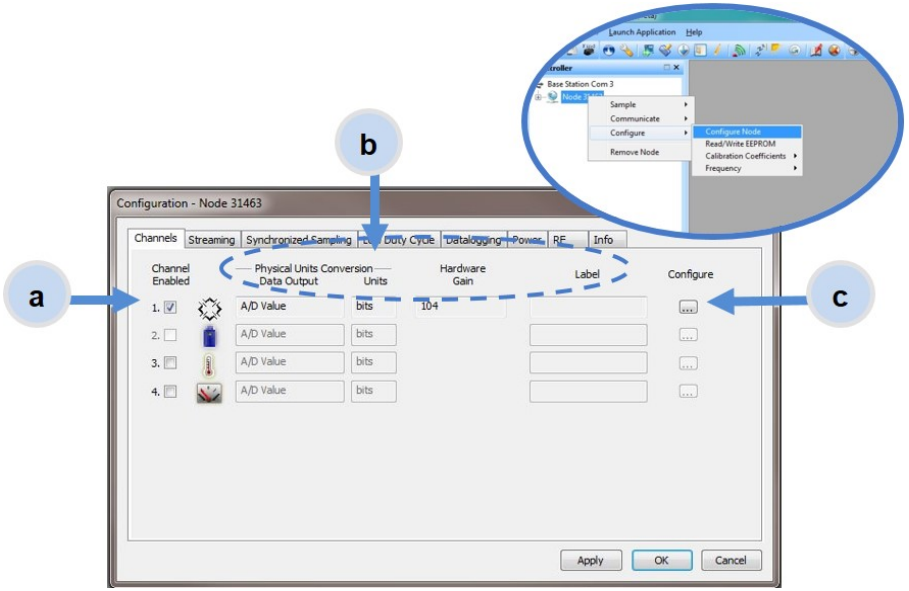


Figure 11 - Node Channels Menu

2. To enter the channel configuration menu, select the Configure button. The channel configuration menu options change depending on the sensor type selected.

   a. **Channel Label:** names the channel

   b. **Channel diagram:** shows channel electronics and data flow

   c. **Conversion Coefficients:** defines the type and units of the measurement being made

   d. **PGA Settings:** determines what gain is applied to the sensor measurement and set the position of the no-load baseline measurement for the sensor signal. It is only available for differential input channels with gain amplifiers.

   e. **Calibration values:** includes the slope, offset, scale, and formula used to convert the sensor reading to engineering units. The slope and offset can be determined from the sensor manufacturer calibration data or through a calibration process.

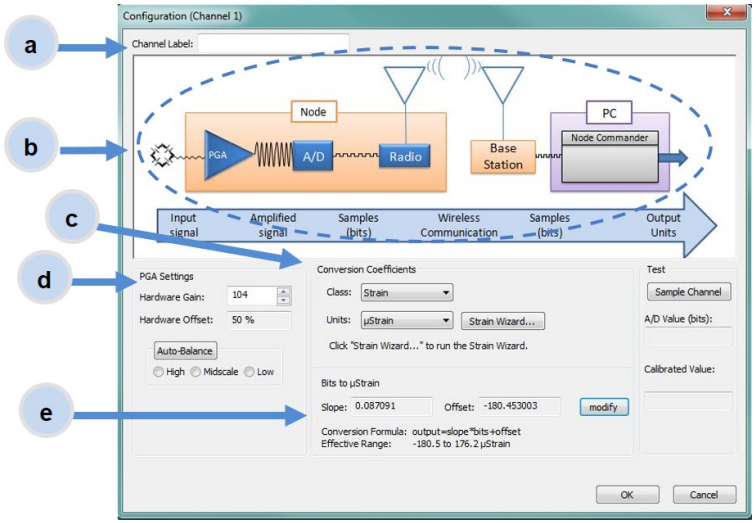


Figure 12 - Channel Setup

6. Calibrate Strain Gauges

Before the Torque-Link -LXRS can be used to acquire torque data, the strain gauges must balanced through a shunt calibration. Additionally, conversion values can be determined to scale the strain gauge output to engineering units.Performing a shunt calibration in Node Commandercompletes both steps and automatically populates the slope and offset values in the data acquisition formula used for converting the strain gauge output to strain units. If torque units are desired, a field calibration can be performed after the shunt calibration to determine those conversion values. Alternatively a theoretical torque formula can be used to convert the strain readings to torque.The procedure for a shunt calibration is described below.

1. Open Node Commander® and establish communication with the gateway and node.
2. Right-click on the node name, and select Configure > Configure Node.
3. Select the check-box for Channel 1, which is where the strain gauge is connected, and then select Configure.

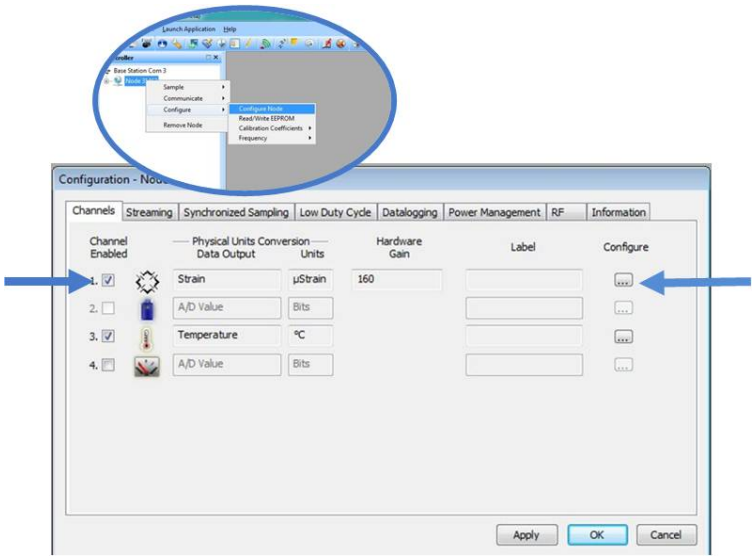


Figure 13 - Node Configuration Menu

4. Use the following settings;
   a. **Conversion Coefficients, Class:** Strain
   b. **Conversion Coefficients, Units:** µStrain
   c. **PGA Settings, Hardware Gain:** 20
   d. **PGA Setting:** Midscale (for positive and negative going signals)
5. Select the Auto Balance button to tare the no-load value of the strain gauge. Observe the value returned for the Auto Balance value.

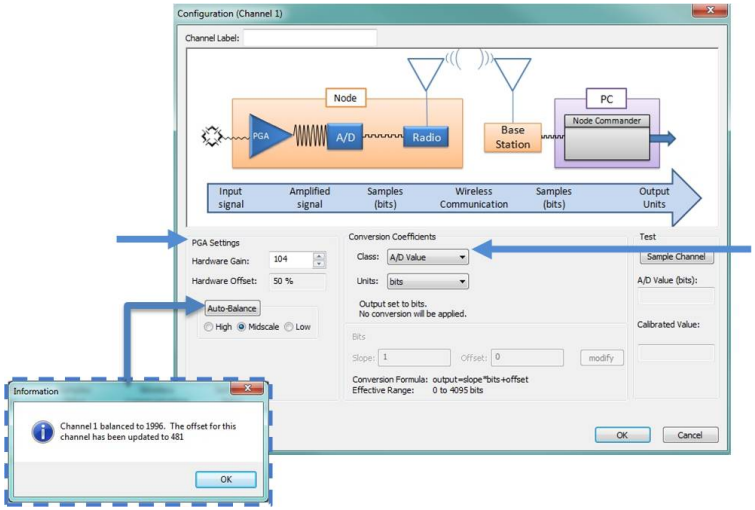


Figure 14 - Channel Settings

6. Select the Strain Wizard.
7. Select Internal or External calibration. An internal calibration uses a shunt resistor inside the Torque-Link -LXRS to apply a fixed load on the strain input. An external calibration uses a user-installed shunt resistor attached to the input.
8. Select the appropriate Bridge Type, and click Next.
9. Select Use the Strain Measurement Wizard and click Next.
10. Set the following parameters:
    a. **Number of Active Gauges:** number of strain elements connected (for example: 4 for a full-bridge, and 2 for a half-bridge)
    b. **Gauge Factor:** ratio of mechanical strain to electrical output (a gauge specification).
    c. **Gauge Resistance:** the strain gauge ohm value (a gauge specification).
    d. **Shunt Resistance:** 499000 ohms (if using the internal shunt resistor)

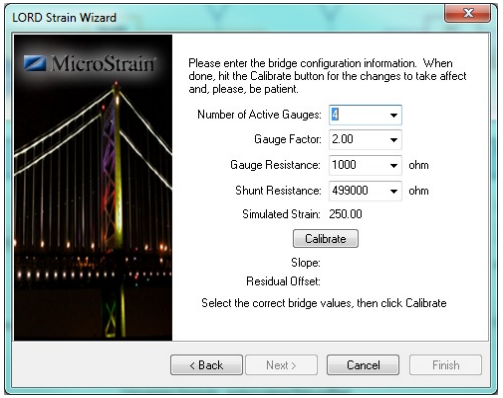


Figure 15 - Strain Wizard Settings

11. Select Calibrate.
12. Verify the calibration looks as shown in Figure 16 - Strain Gauge Calibration. The green line represents the output of the strain gauge. With no load applied it should sit near the Auto Balance baseline value, represented by the red dashed line. During calibration, a shunt resistance (selected on the Parameters page) is applied across the strain bridge, shown by the square pulse on the output. The Offset value, shown with the dashed blue line, is the average output value of the pulse and should sit across the top of the pulse. If the gauge has not had to time to equilibrate before sampling, or if varying environmental factors exist, spikes in the gauge output may occur and affect the Baseline and Offset values. If this occurs, the Baseline and Offset values can be adjusted to clip the spikes in the output values. Adjust them as needed, and select Accept when completed.

Figure 16 - Strain Gauge Calibration

13. Select Finish to end the Strain Wizard. Note that the slope and offset values have been calculated automatically.

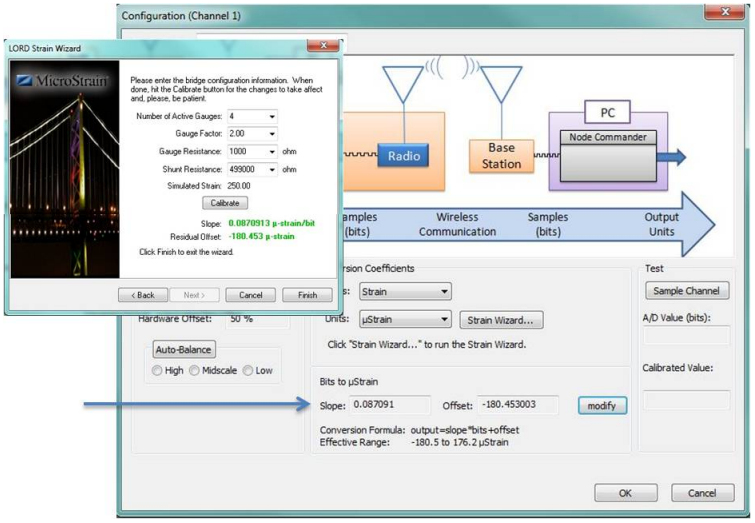


Figure 17 - Completed Strain Wizard

14. Select OK to exit the Channel Configuration window.
15. In the Node Configuration window, select Apply to write the configuration and calibration values to the node.
16. Select OK to exit.

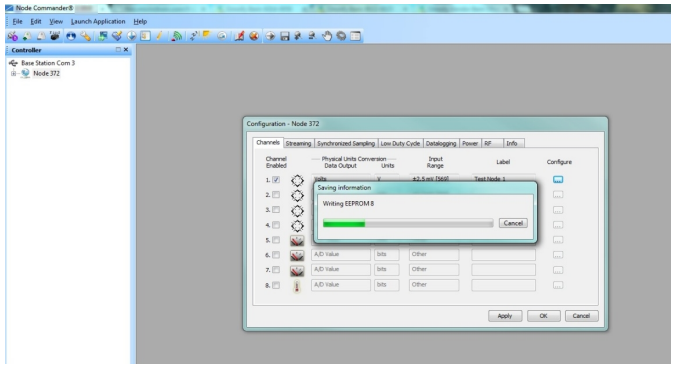


Figure 18 - Apply Node Settings

7. Configure Sampling Settings

Sampling settings are accessed through the Configure Node menu. The Torque-Link -LXRS has four primary sampling modes: Synchronized Sampling, Low Duty Cycle Sampling, Streaming, and Datalogging. Some modes have user-configurable settings for sample rate, sample duration, and datalogging. Other settings are automatic, depending on number of active channels and other variables. For more information on sampling modes, refer to the Node Commander user manual.

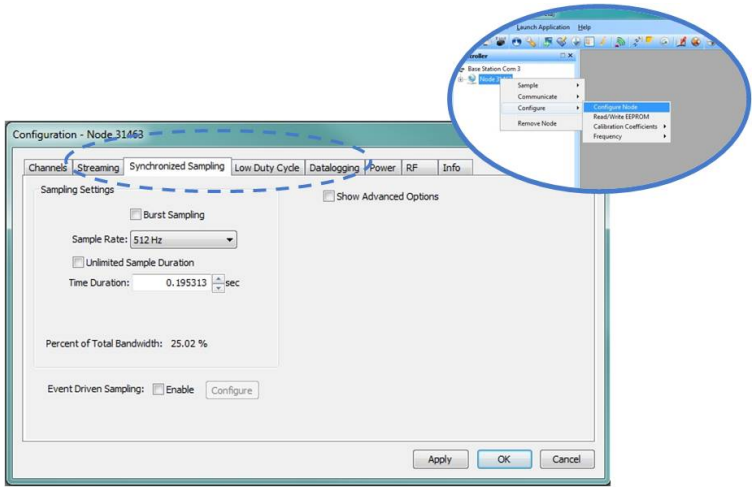


Figure 19 - Sample Settings Menu

In general, when determining what sample mode and rate is most suitable for the application, refer to the following guidelines;

- Use a sample rate at least twice the value of the target measurement frequency. This is the minimum sample rate required to produce an accurate digital representation of the measured signal. The higher the sample rate, the more accurate the digital representation.
- Using the minimum required sample rate will increase battery life and minimize the allocated network bandwidth.

- Using periodic burst sampling in place of continuous sampling will increase battery life. The longer the sample interval, the more power and network bandwidth will be saved.

For synchronized sampling, use the online calculator to evaluate network bandwidth at different sampling settings :

http://www.microstrain.com/configure-your-system

8. Start Data Acquisition

When data acquisition is started, each of the sampling modes has different menu options and views. The following is an example using Synchronized Sampling. For more information about other sampling modes, refer to the Node Commander user manual.

To start a sampling session, nodes can be selected individually or as a group. When selected as a group, they will all be set to the same sampling mode. Right-click on the nodes, and select Sample > Synchronized Sampling.

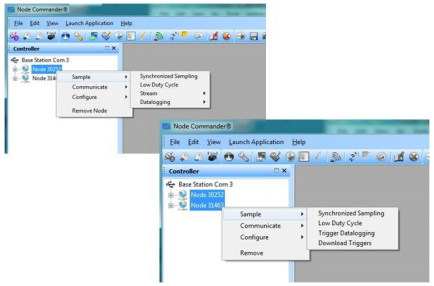


Figure 20 - Starting a Sampling Session

When a synchronized sampling session is started, the sampling menu appears and includes settings to enable optional sampling features, configure nodes, and to specify where the data will be saved. The built-in bandwidth calculator displays the total bandwidth used by the nodes selected for synchronized sampling (Figure 21 - Synchronized Sampling Menu).

a. **Save Location:** indicates where the data file will be saved on the host computer. Use the Browse button to select a location.

b. **Node configuration:** includes the node serial number, sampling settings, bandwidth calculation, and current status. Highlight any node or group of nodes, and the Remove, Configure, and Refresh buttons become active.

c. **Lossless:** enables the lossless data protocol. The protocol enables buffering and retransmission of data in order to provide 100% data collection success. Using this feature may increase data display latency.

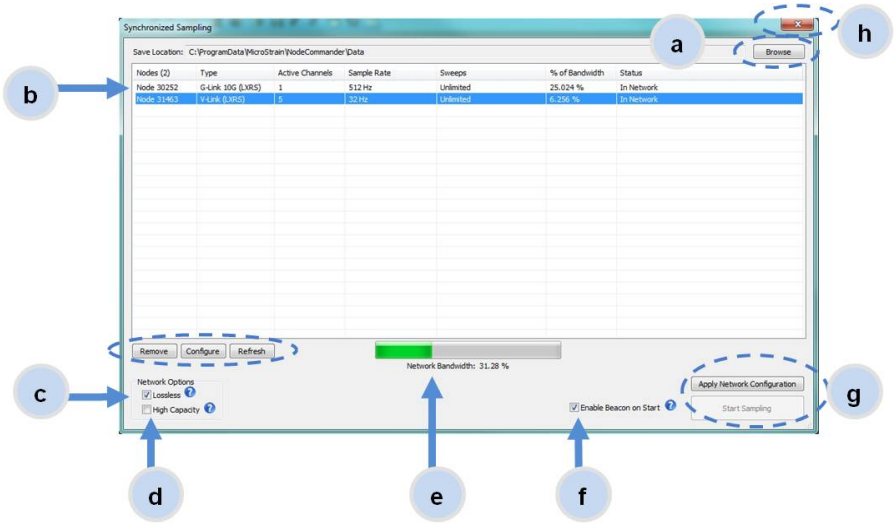


Figure 21 - Synchronized Sampling Menu

d. **High Capacity:** optimizes bandwidth and power use for nodes with slower sample rates by reducing the transmit rates. It may increase data latency.

e. **Network Bandwidth:** is the total calculated bandwidth used by all the nodes. The bandwidth changes as nodes are added, removed, and as the settings are changed.

f. **Enable Beacon on Start:** When synchronized sampling is started the nodes wait for the first beacon transmission to initiate sampling. When this option is selected (default), the gateway

beacon is enabled and will begin transmitting at a fixed interval when sampling is started. Refer to the Node Commander® User Manual for more information.

g. **Apply settings and start sampling:** Before acquisition can begin, use the Apply Network Settings to save the session settings to the node. When completed, select Start Sampling to begin.

h. **Close sampling window** (with the red "X") to exit sampling or, once the sampling has started, to view the data window behind it.

NOTE

Once sampling has started it will continue as configured without the need to leave Node Commander open. However, if the node is powered off and is not configured to sample on boot-up, data acquisition will end and must be restarted.

Synchronized sampling features two data views: Grid view and Graph view. Once sampling has started, the grid view is the default view (Figure 22 - Synchronized Sampling Data View). The data display will begin automatically but may take several seconds to appear if sampling is set to slower sample rates.

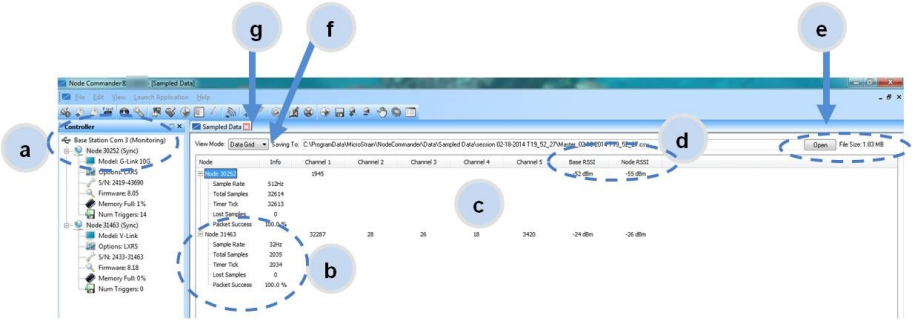


Figure 22 - Synchronized Sampling Data View

a. **Device status:** Node sampling mode and gateway status are displayed in parentheses next to the device name.

b. **Node information:** includes node serial number and sampling statistics. Right-click on the node name for more menu options such as Stop Nodes.

c. **Data:** is a display of the sampled data with each channel in its own column.

d. **Radio strength:** indicates the strength of the communication between the gateway and node.

e. **Data file:** is the location and size of the data file, as data is added. View the data in .CSV format with the Open File button.

f. **View menu:** Allows user to toggle between Data Grid and Graph views.

g. **End sampling:** The red "X" is used to exit the sampling window and/or end sampling.

Use the view menu to select the Graph view of the data (see Synchronized Sampling Graph View on page 13). Click on the node name to view the graph for that node. Click again to hide it.

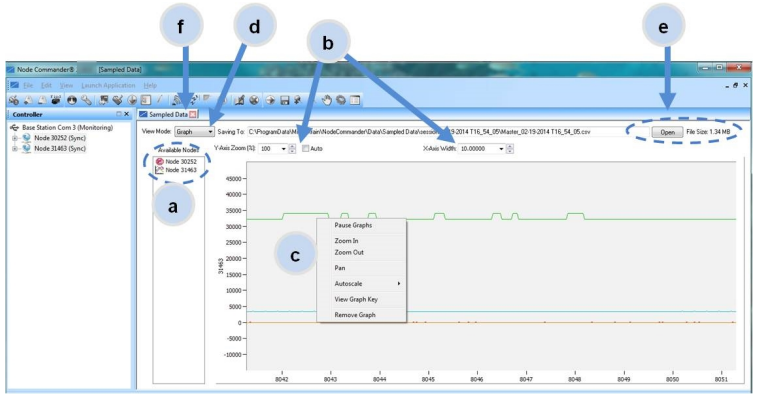


Figure 23 - Synchronized Sampling Graph View

a. **Available Nodes:** Click on the node to display the graph for that node. Click again to hide it. Right-click on the node name for more menu options such as Stop Nodes and Save Stream.

b. **Axis range:** Select the *x*-axis width and *y*-axis zoom percentage, or use the Auto check box for automatic scaling.

c. **Graph:** The node graph shows the sampled data. Each active channel is displayed in a different color. The *x*-axis is time in seconds and the *y*-axis is the A/D value (bits). Right-click on the graph for additional menu options such as View Graph Key, Pan, Zoom, Pause, and Remove Graph.

d. **View menu:** Allows user to toggle between Data Grid and Graph views.

e. **Data file:** The location and size of the data file as data is added. View the data in .CSV format with the Open File button.

f. **End sampling:** The red "X" is used to exit the sampling window and/or end sampling.

9. Access Data Files

Data acquired in Node Commander is stored in .CSV format and can be opened with Microsoft Excel, Quattro Pro, Open Office, or another CSV editor/spreadsheet program. Data in this format is easily uploaded to SensorCloud™ using the CSV Uploader. The data files can be found on the host computer in the default directory or the location specified . The files are organized in separate folders by mode and then further categorized by date, session, and/or node serial number.

The default directory is:
C:\ProgramData\Microstrain\NodeCommander\Data

Synchronized sampling and low duty cycle files are found in the Sampled Data folder, and **streaming data** is stored in the Streaming folder. **Datalogging files** need to be downloaded from the node to be available for viewing. They are accessed through datalogging menus as well as the File menu, and are saved in the Downloaded Triggers folder.

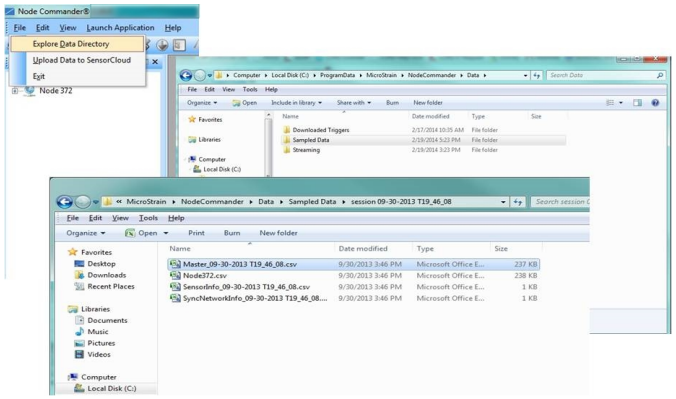


Figure 24 - Exploring Data

10. Connect to SensorCloud™

For global data aggregation, visualization, and analysis, data is uploaded to the SensorCloud web platform. Basic SensorCloud services are available to all users free of charge. Ethernet gateways, such as the WSDA® -1500 - LXRS®, can be enabled to upload data automatically to SensorCloud once the node sampling has been activated. Refer to the gateway user manual for more information.

To connect to SensorCloud go to the SensorCloud website log-in page, and enter the log-in credentials. Register as a new user if needed.

http://sensorcloud.com/log-in/

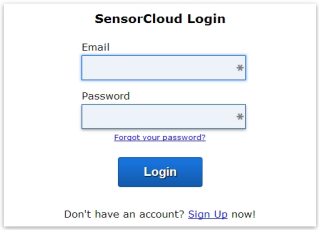


Figure 25 - SensorCloud™ Log-in or Register

The SensorCloud interface has **six main views**. When logging in as a registered user, the Device view is the default. Navigate to other views by clicking the view name at the top of the page (Figure 26 - SensorCloud™ Menu Views). The Data and Settings views are only available once a device is selected from the device list.

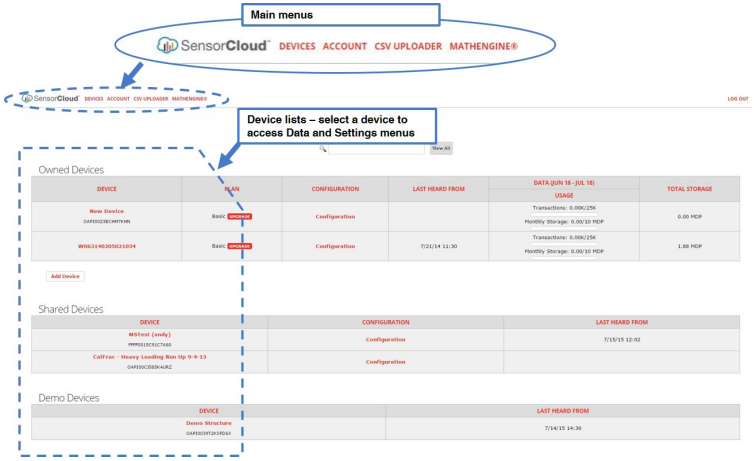


Figure 26 - SensorCloud™ Menu Views

Device - The device list shows every Ethernet gateway and API device associated with the SensorCloud account, including owned, shared, and demo devices. This view provides links to each device's SensorCloud subscription plan, configuration options, and a summary of last communications and data transactions.

Account - The account view is for logistic management of the SensorCloud account, such as changing the log-in password, accessing user email, and reviewing billing information.

CSV Uploader - The data upload feature enables data from any source (such as non-Ethernet LORD MicroStrain gateways, or third-party sensor) to be uploaded to the SensorCloud platform. The data must be in the LORD MicroStrain CSV format.

Data- This view is only available after a device is selected. It displays data that is collected from sensor nodes or uploaded from files. Data selections are listed by node channel or a user-defined label and can be enabled for display in the graph window. The interactive graph enables navigational features such as panning, zooming, and accessing data points and ranges with a single click. There are also features for use and management such as viewing the meta-data and downloading, embedding, and tagging data graphs.

Figure 27 - SensorCloud™ Data View

Settings - The settings view provides options for adding meta-data, configuring the data displays for each channel, creating alerts based on data thresholds, setting the data timezone, and more.

MathEngine® - is used to analyze sensor data. Functions include the ability to filter out frequencies, smooth out noisy data, perform math operations such as Fast Fourier Transforms (FFTs), and more. MathEngine® interfaces with the SensorCloud graphing view for faster processing. Users can write their own algorithms for custom applications. Refer to the MathEngine® website for more information.

http://sensorcloud.com/mathengine

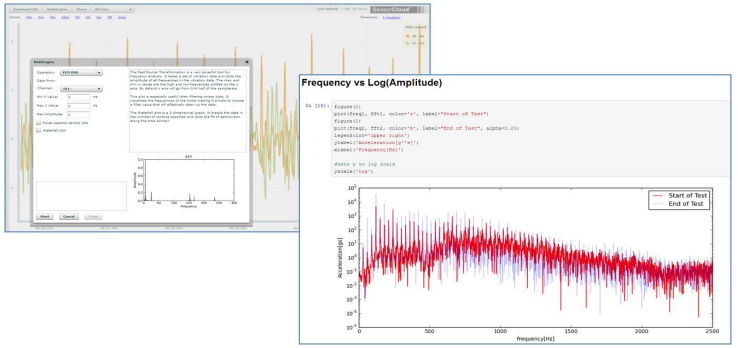


Figure 28 - MathEngine® View

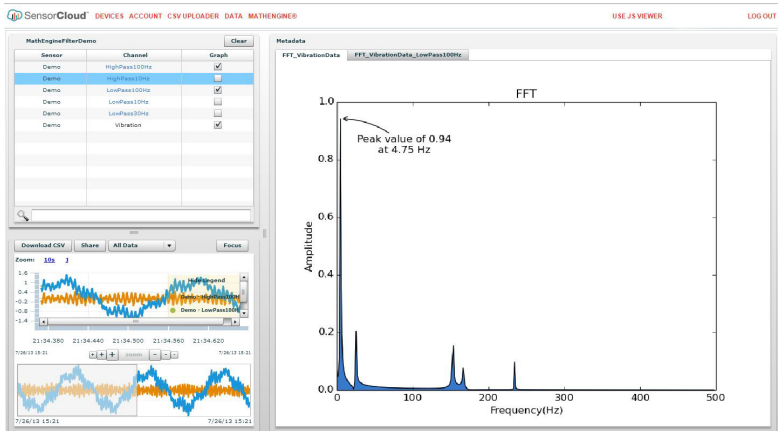


Figure 29 - FFT Graph in SensorCloud™

For more information about SensorCloud features and navigation, refer to the SensorCloud website or contact LORD MicroStrain Technical Support.

http://sensorcloud.com

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