LORD USER MANUAL

Torque-Link®-200

Wireless Torque Sensor

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1. Wireless Sensor Network Overview

The LORD Sensing Wireless Sensor Network is a high-speed, scalable, sensor data acquisition and sensor networking system. Each system consists of wireless sensor interface nodes, a data collection gateway, and full-featured user software platforms based on the LORD Sensing Lossless Extended Range Synchronized (LXRS) data communications protocol. Bi-directional wireless communication between the node and gateway enables sensor data collection and configuration. Gateways can be connected locally to a host computer or remotely via local and mobile networks. Some gateways also feature analog outputs for porting sensor data directly to stand-alone data acquisition equipment.

The selection of available nodes interface with many types of sensors, including accelerometers, strain gauges, pressure transducers, load cells, torque and vibration sensors, magnetometers, 4 to 20 mA sensors, thermocouples, RTD sensors, soil moisture and humidity sensors, inclinometers, and orientation and displacement sensors. Some nodes come with integrated sensing devices such as accelerometers. System sampling capabilities include lossless synchronized sampling, continuous and periodic burst sampling, and data logging. A single gateway can coordinate many nodes of any type, and multiple gateways can be managed from one computer with the SensorConnect™ and SensorCloud™ software platforms. Integration to customer systems can be accomplished using OEM versions of the sensor nodes and leveraging the LORD Sensing data communications protocol.

Common wireless applications of LORD Sensing Systems are strain sensor measurement, accelerometer platforms, vibration monitoring, energy monitoring, environmental monitoring, and temperature monitoring.

2. Node Overview

The Torque-Link-200 strain gauge node is an application-specific node assembly used for monitoring the torsional strain on a rotating shaft. Torque-Link-200 assemblies are designed to fit most shafts sizes and integrate with field-installed strain gauges.

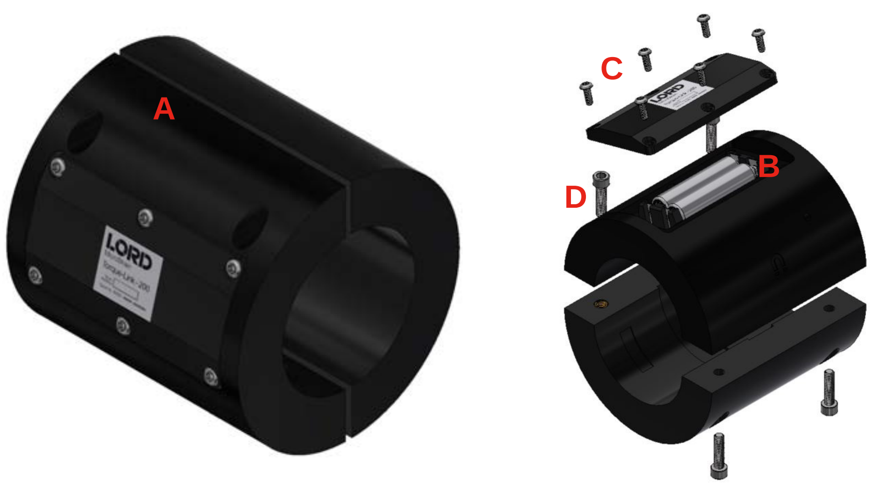
The Torque-Link-200 utilizes the SG-Link®-OEM wireless sensor technology to acquire and distribute the strain gauge data. The Torque-Link-200 has 16-bit resolution, can log data to internal memory, transmit in real-time, and support event-driven triggers with both pre-event and post-event buffers.

To acquire sensor data, the Torque-Link-200 is used with any LORD Sensing LXRS® data gateway such as the WSDA-101 and WSDA-1500, and SensorCloud™ software interface.

Figure 1. Torque-Link-200 Collar

2.1 Component List

The Torque-Link-200 includes the components shown in **Table 1. Component List**. The standard assembly has one sensor channel which accommodates monitoring a full-bridge strain element array. A two-channel assembly is also available for redundant or additional monitoring.



Item	Description	Quantity
A	Torque-Link-200 (1 channel standard [shown], 2 channel optional)	1
B	AAA Lithium batteries	2
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. Torque-Link-200 Component List

2.2 Interface and Indicators

The Torque-Link-200 consists of two half collars. One half includes compartments for the node electronics and battery pack, and cutouts for a strain gauge and wiring. The electronics compartment is potted at the factory to make it suitable for harsh environments. The other half has the cutouts for the strain gauge and wiring. In the optional two-channel version of the Torque-Link-200, both halves contain an electronics and battery compartment.

From the electronics compartment there are two connectors. One goes directly into the battery compartment for connecting power, and the other is trained through the wiring channel to connect to the strain gauges.

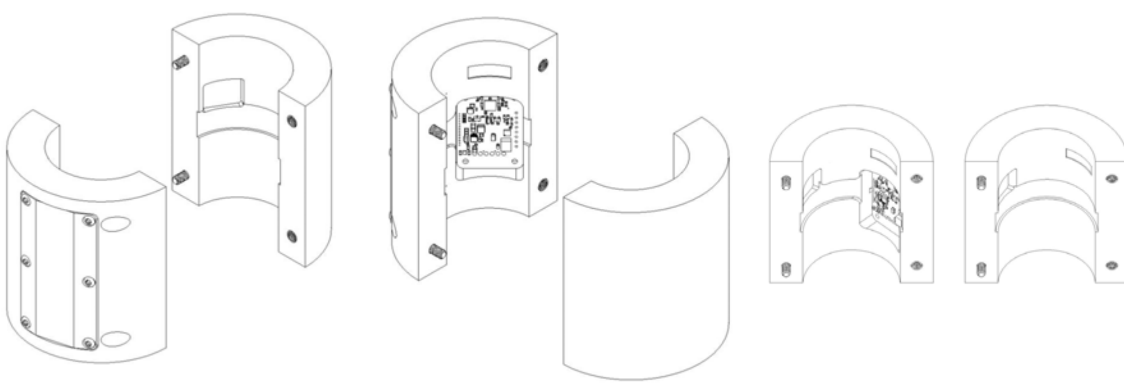


Figure 2. Torque-Link-200 Views

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 2. Indicator Behaviors

2.3 Assembly and Disassembly

⚠WARNING

The Torque-Link-200 uses internal, non-rechargeable lithium batteries. The Torque-Link-200 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.

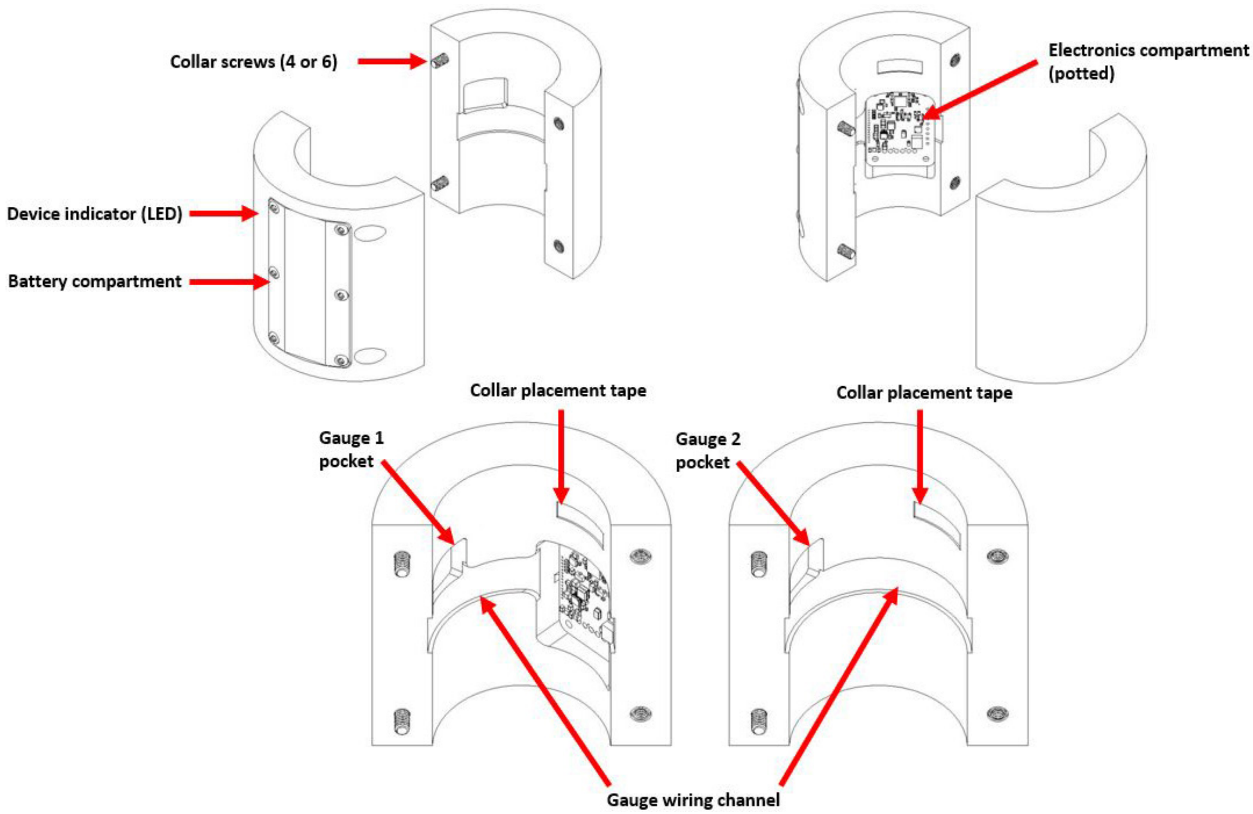


Figure 3. Disassembled Torque-Link-200 Collar

2.4 Node Operational Modes

Sensor nodes have three operational modes: active, sleep, and idle. When the node is sampling, it is in active mode. When sampling stops, the node is switched into idle mode, which is used for configuring node settings, and allows toggling between sampling and sleeping modes. The node will automatically go into the ultra low-power sleep mode after a user-determined period of inactivity. The node will not go into sleep mode while sampling.

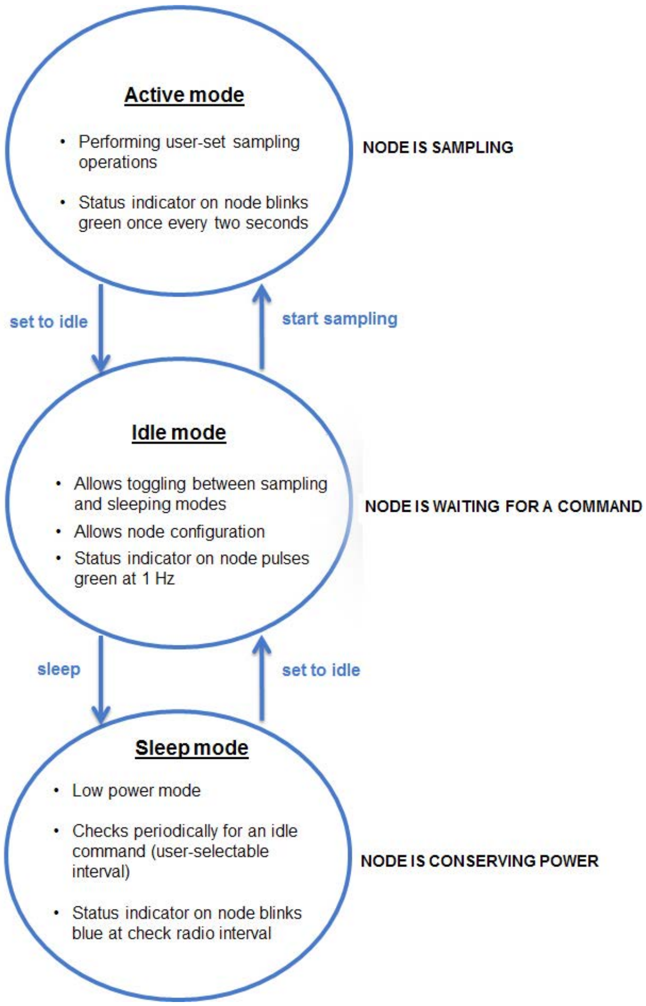


Figure 4. Node Operational Modes

NOTE: The Torque-Link-200 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.

2.5 On-board Temperature Sensor

- The Torque-Link-200 has an on-board, solid state temperature sensor mounted on the surface of the circuit board.
- The temperature sensor output is connected to the diagnostic channel under "internal temperature" of the Torque-Link-200.
- Refer to the node specification table for the temperature sensor operating parameters.
- The temperature sensor has a measurement range of - 40˚C to +85˚C range with an accuracy of ± 2˚C @ 25˚C.
- The sensor is made by Texas Instruments (part number LM60). Specifications may be found on the manufacturer's website.

2.6 On-board RPM Measurement

- The Torque-Link-200 has an on-board, solid state, ultra-sensitive Hall-effect sensor mounted on the circuit board.
- A magnetic target of sufficient strength and proximity is needed in the line of sight of the magnet symbol on the Torque-Link-200 collar. This indicates the position of the Hall-effect sensor.
- During operation, the Torque-Link-200 rotates with the shaft and causes the Hall-effect sensor to switch on after passing over the magnetic target. The output from the Hall-effect sensor is connected to channels 5 and 6 of the Torque-Link-200. Channel 5 outputs the pulse frequency and Channel 6 outputs total pulses. These outputs can be used to calculate revolutions per minute (RPM).
- Pass the magnetic target over the Torque-Link-200 collar at different heights to determine the appropriate gap needed for a reliable signal before installation.
- The sensor is made by Allegro (part number A3213LUA-T). Specifications may be found on the manufacturer's website.

3. Connect to Gateway and Nodes

3.1 Software Installation

Install the SensorConnect software on the host computer before connecting any hardware. Access the free software download on the LORD Sensing website at:

http://www.microstrain.com/software

SensorCloud is an optional data collection, visualization, analysis, and remote management tool based on cloud computing technology. It is accessed directly from an Internet connection. For more information:

http://www.sensorcloud.com/

3.2 Connect to Gateway

Drivers for the USB gateways are included the SensorConnect software installation. With the software installed, the USB gateway is automatically detected 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 SensorConnect™ software.
3. The gateway should appear in the Controller window automatically with a communication port assignment. If the gateway is not automatically discovered, verify the port is active on the host computer, and then remove and re-insert the USB connector.

Figure 5. USB Gateway Communication

3.3 Connect to Nodes

SensorConnect establishes communication using the following: automatic node discovery on the same frequency, automatic node discovery on a different frequency, and add node manually.

3.3.1 Automatic Node Discovery on Same Frequency

If the base and node are on the same operating frequency, the node will populate below the Base Station listing when powering on the Torque-Link-200.

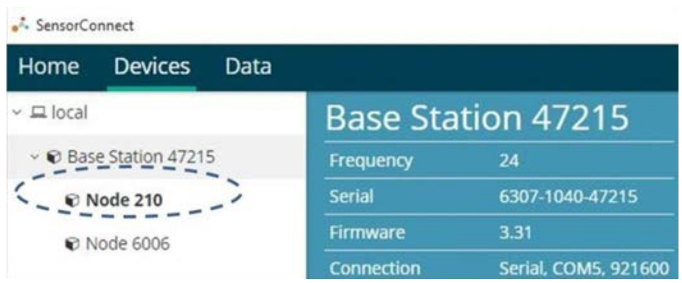


Figure 6. Node Discovered On Same Frequency

3.3.2 Automatic Node Discovery on Different Frequency

If a red circle with a number appears next to the Base Station, the node may be operating on a separate radio channel. Select the Base Station and then select the Nodes on Other Frequencies tile.

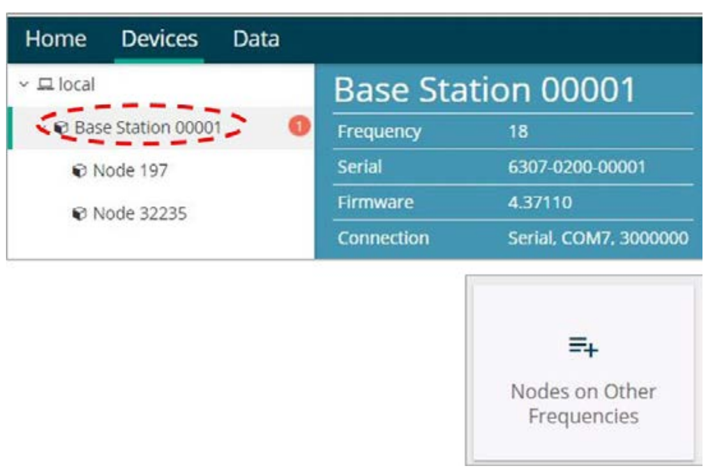


Figure 7. Node On Other Frequency

Highlight the new node being added and select Move Node to Frequency (#).

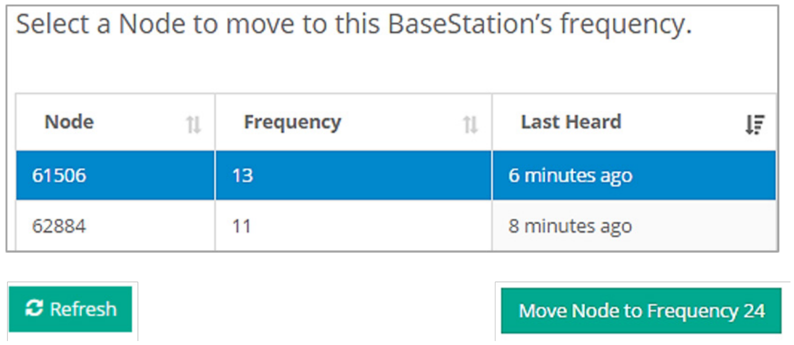


Figure 8. Move Node

3.3.3 Manually Add Node

Adding a node manually requires entering the node address and its current frequency setting.

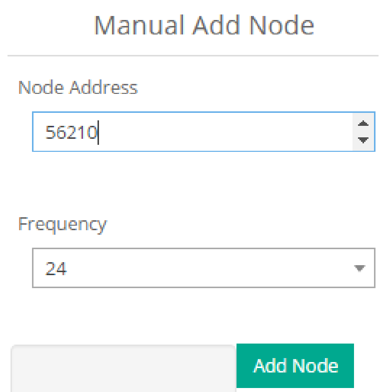


Figure 9. Add Node By Address

If the node was successfully added, two confirmation messages appear and it is listed under the Base Station.

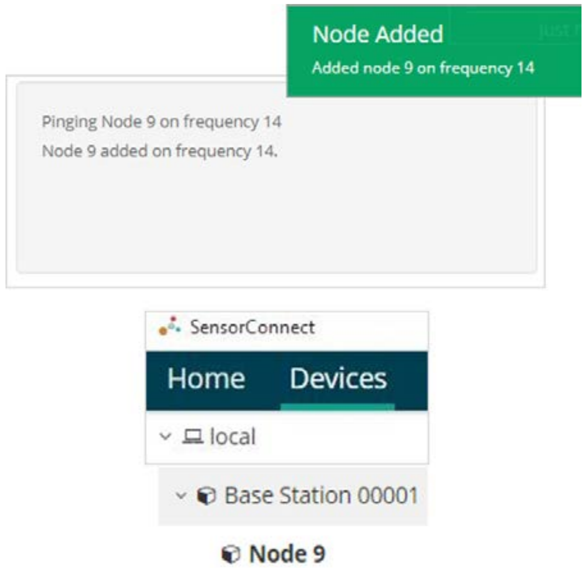


Figure 10. Add Node Confirmation

If the node fails to add, a failure dialogue box opens. The node did not respond to the base station which could indicate the node is not in idle mode, or may be on another frequency. If "Add Node Anyway" is selected, it associates that node with the channel entered but will likely cause a communication error. If the node was not in idle, move the base station to the frequency of the node and issue a "Set to Idle" command.

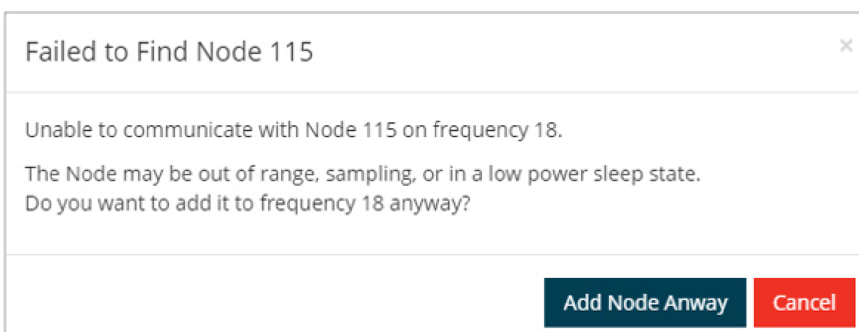


Figure 11. Failure to Add Node

4. Wireless Sensor Configuration

4.1 Hardware Configuration

Node settings are stored to non-volatile memory and may be configured using SensorConnect. This chapter describes the user-configurable settings.

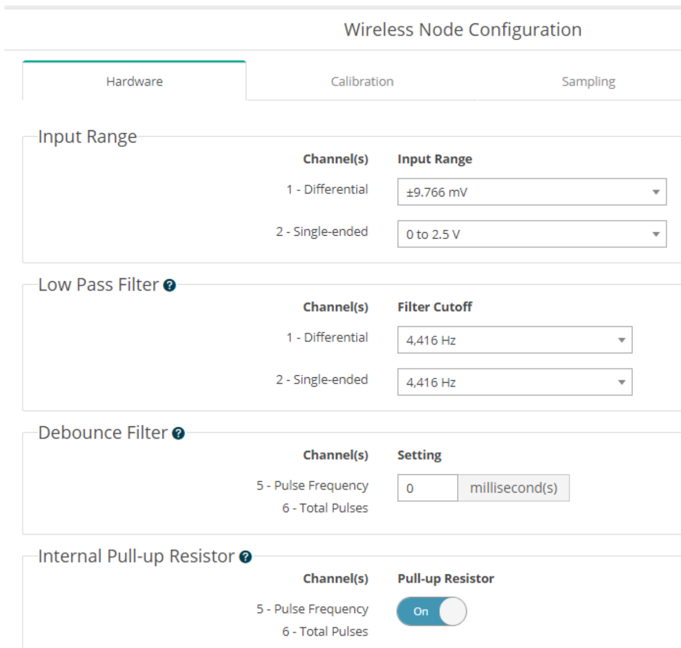


Figure 12. Hardware Configuration Menu

- **Excitation Voltage -** Set the voltage of the “Sensor Power” output. Use the highest voltage for best resolution. Use the lowest voltage for longer battery life and to reduce self-heating of 120-Ohm strain gauges.
- **Input Range -** Set the programmable gain amplifier (PGA) to limit the sensor input range. Increasing gain will increase signal resolution, while decreasing gain will allow a larger input range.
- **Low Pass Filter -** A SINC4 digital low pass filter is used to reduce noise. Set the filter to a high frequency for a fast settling time and longest battery life. Set the filter to a lower frequency for reduced noise at the cost of a longer settling time. Slower filter settings may not be available at the fastest sampling rates.
- **Debounce Filter -** Sets the minimum amount of time a switching signal must be stable before it triggers a pulse count. This is used to remove unwanted pulse counts due to bouncing inputs such as from a mechanical switch.
- **Internal Pull-up Resistor -** Enable this when connecting open-drain or open-collector output types.

4.2 Calibration Configuration

Analog channels may be independently calibrated with linear calibration coefficients. Use the “Cal Tools” wizard for easy calibration for strain gauges or mV/V sensors, or output raw units such as volts and ADC counts.

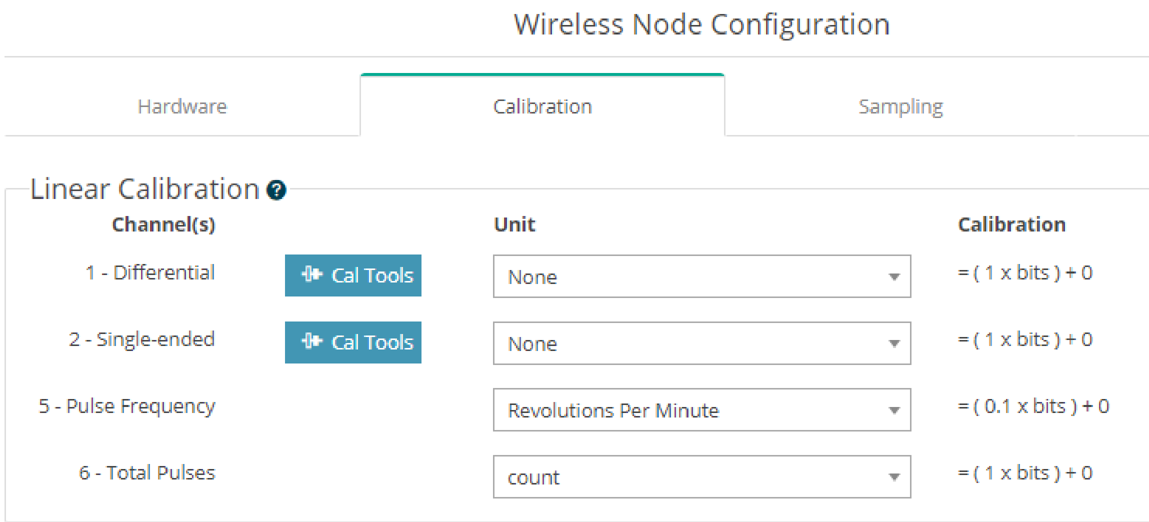


Figure 13. Wireless Sensor Calibration Menu

4.3 Sampling Configuration

There are four user-set sampling options for the Torque-Link-200, including Lost Beacon Timeout, Diagnostic Info Interval, Storage Limit Mode, and Sensor Warmup Delay in the Wireless Node Configuration > Sampling menu.

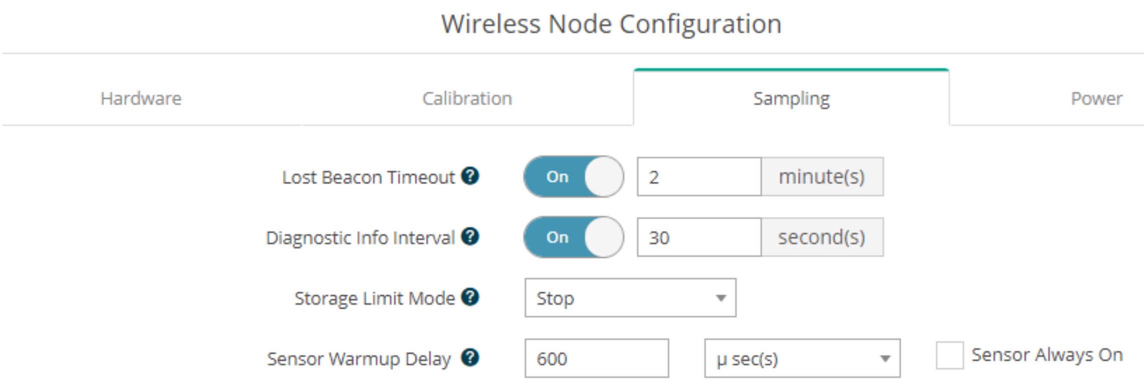


Figure 14. Sampling Configuration Menu

- **Lost Beacon Timeout -** When the node is running in a synchronized network, it periodically synchronizes its time clock to a beacon broadcast from the WSDA gateway. The Lost Beacon Timeout feature means the node will stop sampling and transmitting data after the beacon has been lost for the configured amount of time. The node will save power in this state without user intervention until the beacon returns. Within two minutes of the beacon returning, the node automatically samples and transmits data again.
- **Diagnostic Info Interval -** At the defined transmit interval, the wireless sensor will report diagnostic information. The node will continue to transmit this diagnostic information in all operating modes, including Idle, Sleep, and Run modes.
- **Storage Limit Mode -** The Storage Limit Mode applies when the node is datalogging to internal flash. The two available options are: 1) Stop - when the node fills up its flash memory, it will stop logging data. It is important to erase old data before starting new data logging sessions, and 2) Overwrite - when the node fills up its flash memory, new data will overwrite old data in a first-in, first-out method.
- **Sensor Warmup Delay-** Leave the sensor excitation on continuously or duty-cycle power to the sensor in order to save power. When duty cycling power to the sensors, assure the sensor signal can settle within the configured sensor warmup time. For periodic burst sampling, the node will warmup the sensor for a minimum of 1 second before the sampling burst, regardless of the configured warmup time.

The contents of the diagnostic packet may be viewed in the Data tab within SensorConnect.

Description	Data Values	Data Type	Unit
Current State	0 = Idle 1 = Deep sleep 2 = Active run 3 = Inactive run	unit8	--
Run Time	Idle	unit32	seconds
	Deep sleep	unit32	seconds
	Active run	unit32	seconds
	Inactive run	unit32	seconds
Reset Counter	--	unit16	counts
Built in Test Result	0 = no errors	unit32	--
Internal Temperature	Valid range: -40 to 125°C	sint8	Celsius
Low Battery Indicator	0 = good 1 = low 2 = critical (sensor will stop sampling)	unit8	--
External Power	0 = not connected 1 = external power connected	unit8	--
Sample Info	Sweep index	unit32	counts
	Bad sweep count	unit32	counts
Transmission Info	Total transmissions	unit32	counts
	Total retransmissions	unit32	counts
	Total dropped packets	unit32	counts
Synchronization Info	Synchronization attempts	unit32	counts
	Synchronization failures	unit32	counts
	Seconds since last synchronization	unit32	counts
Event Trigger Index	--	unit16	counts

Table 3. Diagnostic Packet

4.4 Power

There are multiple power options for the Torque-Link-200, including Default Operation Mode, User Inactivity Timeout, Check Radio Interval, and Transmit Power, in the Wireless Node Configuration > Power menu.

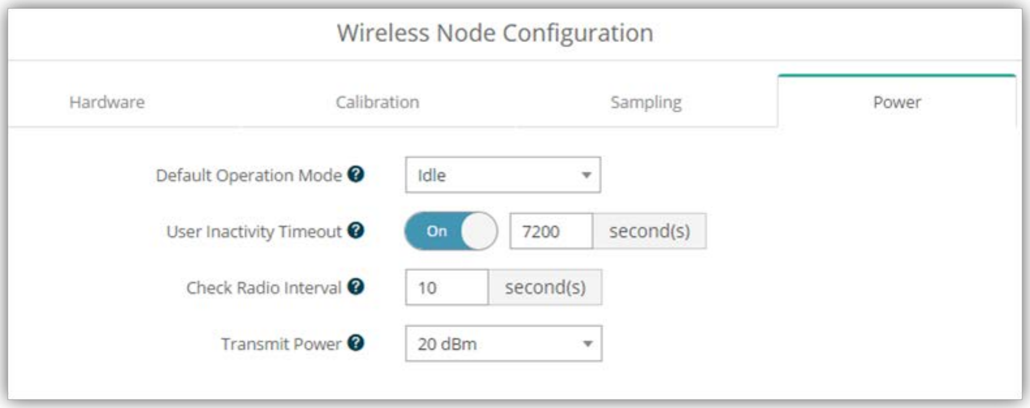


Figure 15. Node Configuration Power Menu

- **Default Operation Mode -** When power is applied, the node enters Default Operation Mode.
- **User Inactivity Timeout -** While in Idle mode, the node automatically enters Sleep mode if it does not receive any commands for the selected amount of time. If Sample is selected under Default Operation Mode, the node automatically re-enters the sample mode it performed last with all current settings. Disable User Inactivity Timeout to avoid the node automatically changing states.
- **Check Radio Interval -** While in Sleep and Sample modes, the Check Radio Interval sets the frequency the node checks the radio channel for a “Set to Idle” command. Decreasing the Check Radio Interval will shorten the amount of time it takes to wake the node into Idle mode with the cost of decreasing battery life. Increasing the Check Radio Interval could increase battery life at the cost of increasing the amount of time it takes to wake the node into its Idle mode.
- **Transmit Power -** Set the output power of the radio to a value between 0dBm to +20dBm. The output power will effect communication range and also battery life.

5. Wireless Sensor Sampling Configuration

5.1 Start Collecting Data

There are several ways to collect data from the Torque-Link-200, including from a single node, a network of nodes, or restarting the last used sampling mode

- **Single node -** From Devices, select Node address > Sample > Apply and Start Network to begin collecting data from a single wireless sensor.

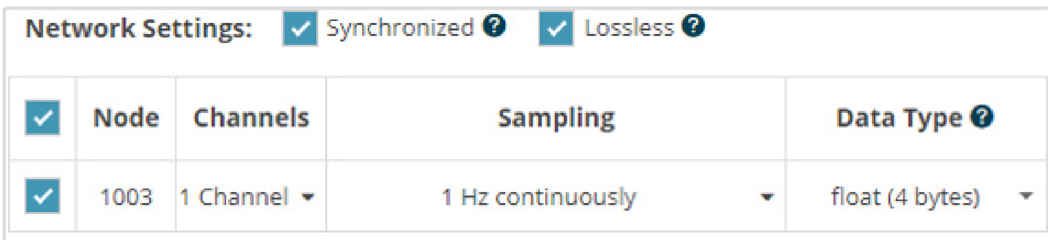


Figure 16. Single Node Sampling

- **Network of Nodes -** From Devices, select > Base Station > Sampling Network > Nodes to be sampled > Apply and Start Network to start collecting data from a network of wireless sensors.

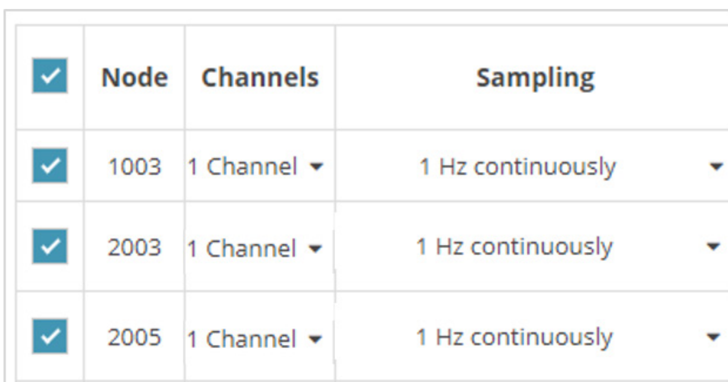


Figure 17. Network of Nodes Sampling

5.2 Network Options

Synchronized and Lossless are available for the Torque-Link-200.

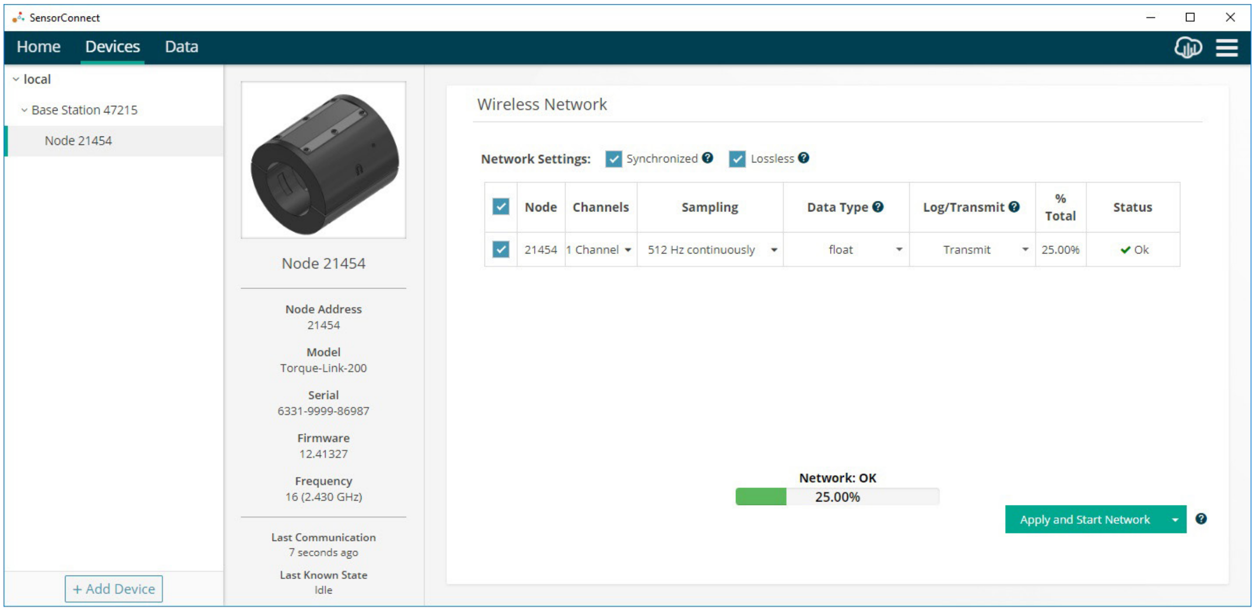


Figure 18. Network Settings Menu

- **Synchronized -** All nodes in the network periodically synchronize their time clocks to a beacon that is broadcast by the WSDA gateway. Each beacon contains a UTC timestamp, allowing nodes to timestamp their collected data within an accuracy of +/- 50 us. Each node also buffers data and transmits in time-slots allocated prior to sampling. Using time-slots assures the transmissions will not “collide”, or corrupt each other. It also provides a means for efficiently scaling the size of the network to allow as much data throughput as possible.

Deselect Synchronized if low latency, or the lowest power at slow sample rates is required.

- **Lossless -** Near lossless data collection is available in most environments through the use of data buffering, radio acknowledgments, and retransmissions. Each node buffers collected data and timestamps to an internal 2 Mbit FIFO buffer. For each transmission, data is pulled from this buffer. The node retransmits data until this acknowledgment is received. Inherent overhead in the transmission scheduling protocol assures the node time to recover from periods of poor radio communication. This feature allows lossless performance in environments where the node achieves as low as 50% packet error rate. It also allows for operation in situations where the gateway and node move in and out of range of each other.

The Lossless feature is only available when Synchronized is enabled. Disable Lossless if the application requires consistent latency or can tolerate lost data.

5.3 Derived Output Channels

There are three derived data channels available for the Torque-Link-200. Using these data channels for trend monitoring allows the ability to extend battery life while reducing data. Each operation is performed on a window of data from the specified sensor channel, where the window size is equal to the output period of derived channel. The timestamp associated with each sweep is that of the last data point collected within that window. The derived data output rate must be at least 32 times slower than the sample rate.

- **Mean:** averages all measurements taken within the window.
- **RMS:** squares the mean of all window measurements and finding the square root.
- **Peak to Peak:** subtracts the smallest window value from the largest value.

5.4 Sampling Operations Options

Sampling options for the Torque-Link-200 are Continuously, Limited or Event Triggered.

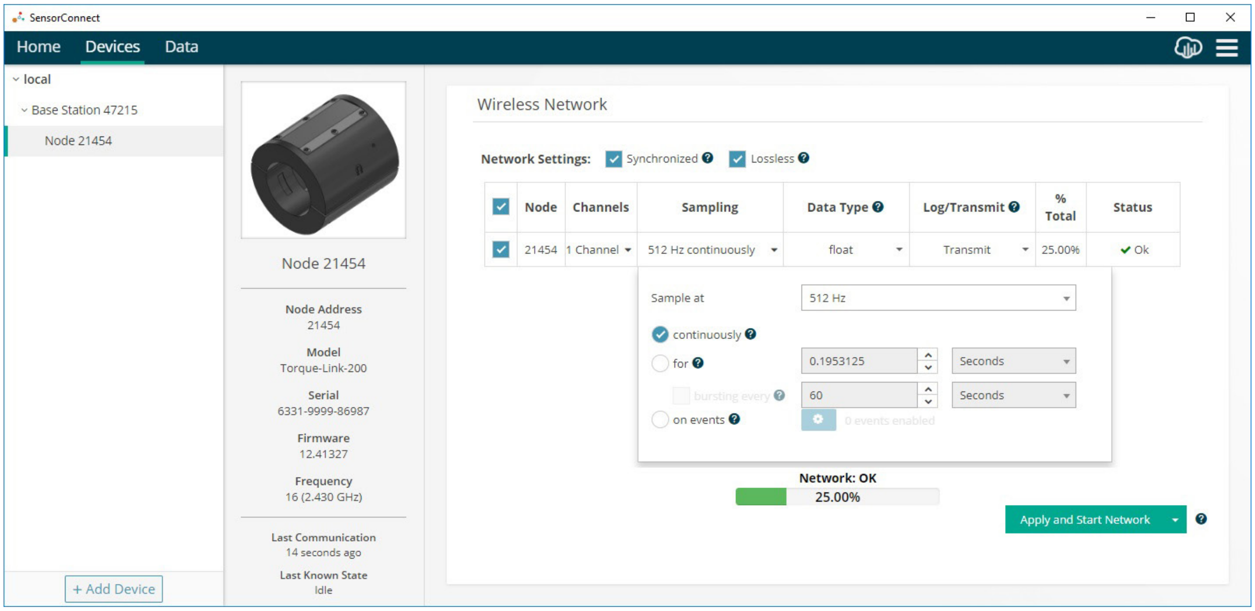


Figure 19. Sampling Operations Menu

- **Continuous** - Collect data continuously at the configured sample rate. All data is transmitted and/or logged to flash memory until a Set to Idle command is received.
- **Limited** - Automatically stop sampling and return to Idle mode after the configured time duration is met.
- **Event Triggered** - The node will collect data continuously, but only transmit/log the data if one of the configured threshold conditions has been met. When the condition is met, all active sensor channels will transmit/log both pre- and post-event data. This option allows for longer battery life, reduced data sets, and increased network size.

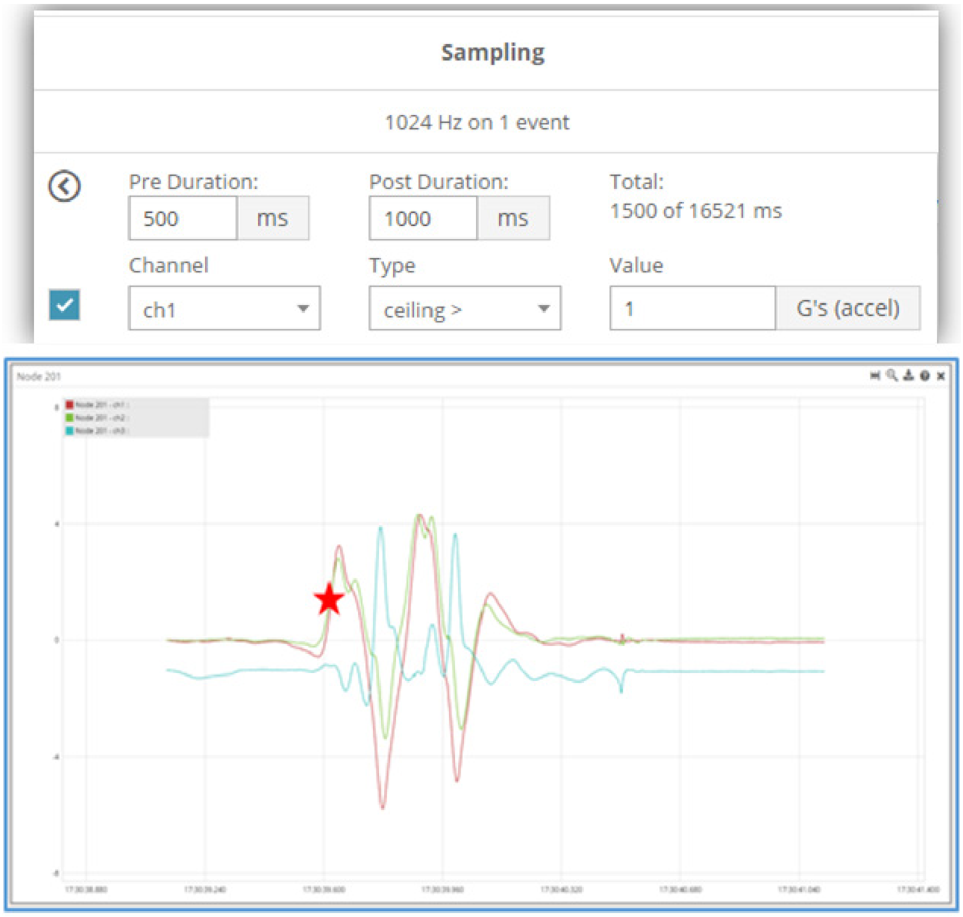


Figure 20. Event Triggered Sampling

5.5 Output Operation

Options for managing data: transmit data, log to flash memory, or both.

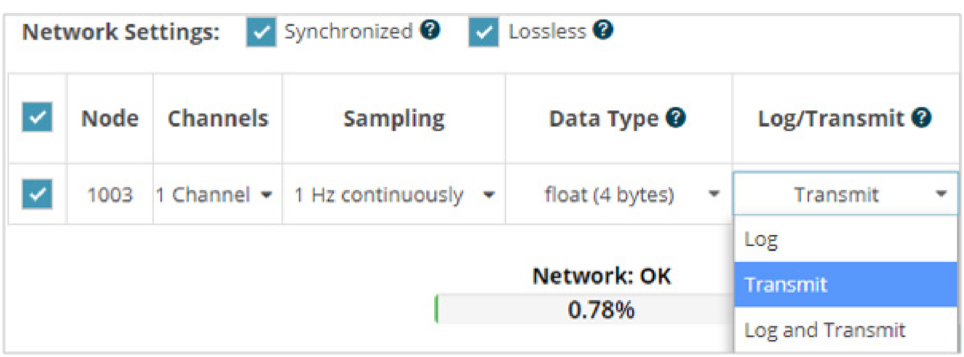


Figure 21. Data Outputs

6. Data Handling

Data acquired through SensorConnect is automatically saved on the host computer and can be uploaded to SensorCloud. Ethernet gateways provide the option to automatically port the data to SensorCloud during data acquisition for near real-time display and aggregation. Ethernet gateways can also be configured to save data locally to internal memory for future upload to the host computer or SensorCloud.

SensorCloud is based on cloud computing technology and is designed for long term collecting and preservation of data. Features include time series and visualization graphing, automated alerts, and data interpretation tools such as data filtering, statistical analysis, and advanced algorithm development with the integrated MathEngine® interface. Leveraging the open source API, SensorCloud can also be used to collect data from other LORD Sensing sensor products or third-party systems. Basic SensorCloud services are available to all users free of charge at: http://www.sensorcloud.com/.

6.1 SensorCloud

6.1.1 Connect to SensorCloud

Go to the SensorCloud website and select sign-in to enter the log-in credentials, or register as a new user if needed: http://www.sensorcloud.com/

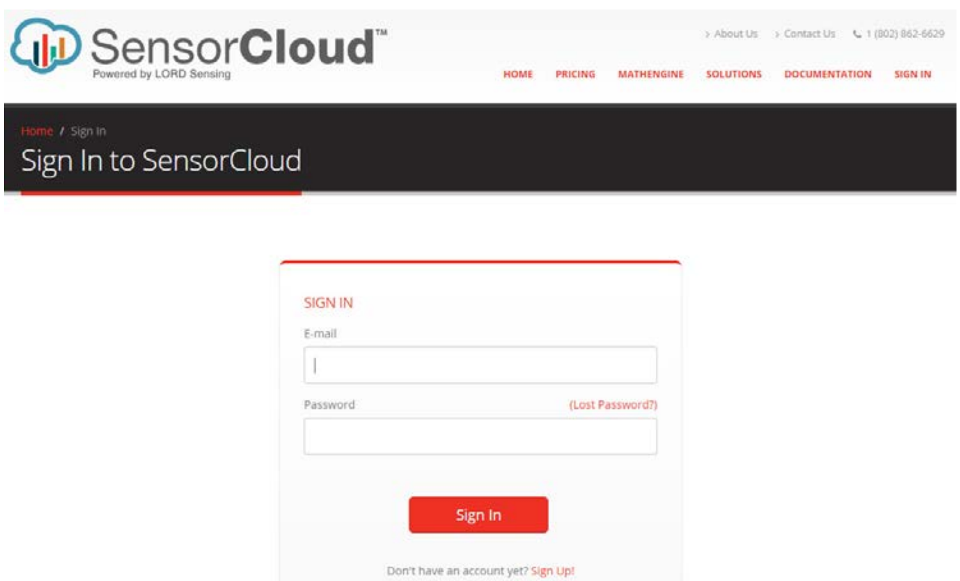


Figure 22. SensorCloud Log-in or Register

6.1.2 Navigating Menus

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. The Data and Settings views are only available after a device is selected from the device list.

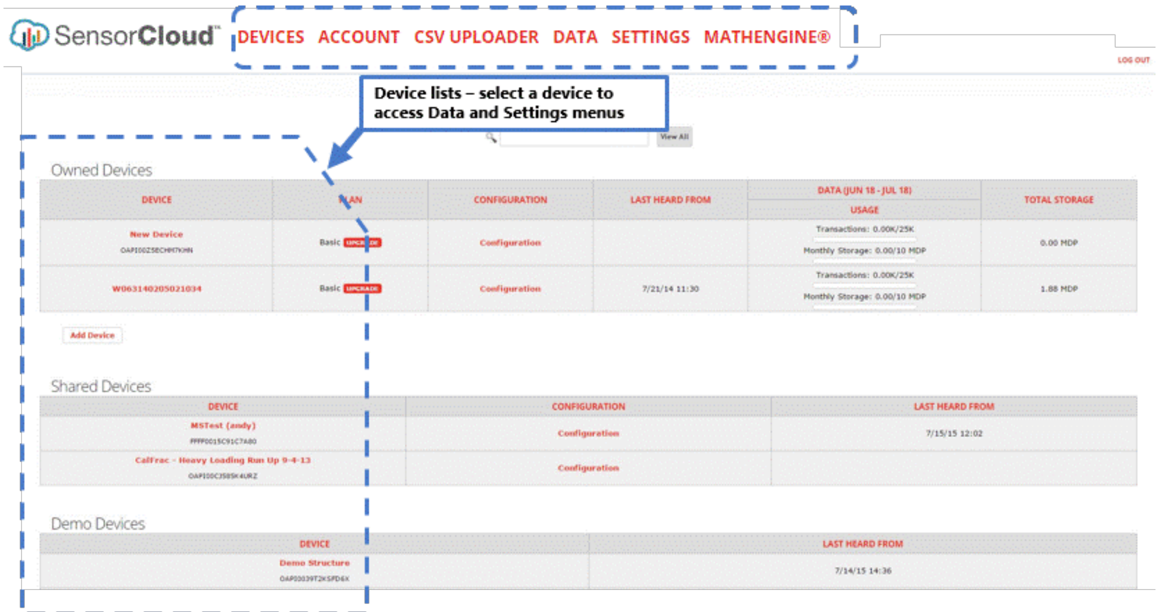


Figure 23. SensorCloud Menu Views

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 Sensing gateways, or third-party sensor) to be uploaded to the SensorCloud platform. The data must be in the LORD Sensing 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 has navigational features such as panning, zooming, and an overview graph for single-click access to data points or ranges. There are also use and management features such as viewing the meta-data and downloading, embedding, and tagging data graphs.

Figure 24. SensorCloud Data View

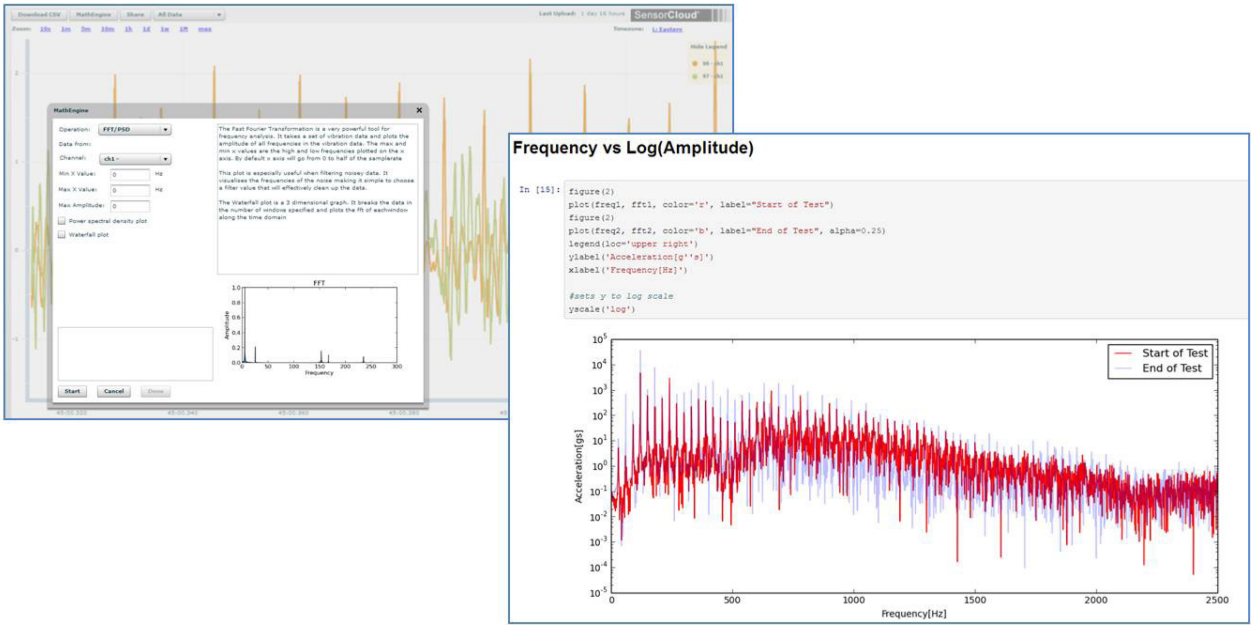


Figure 25. SensorCloud MathEngine® View

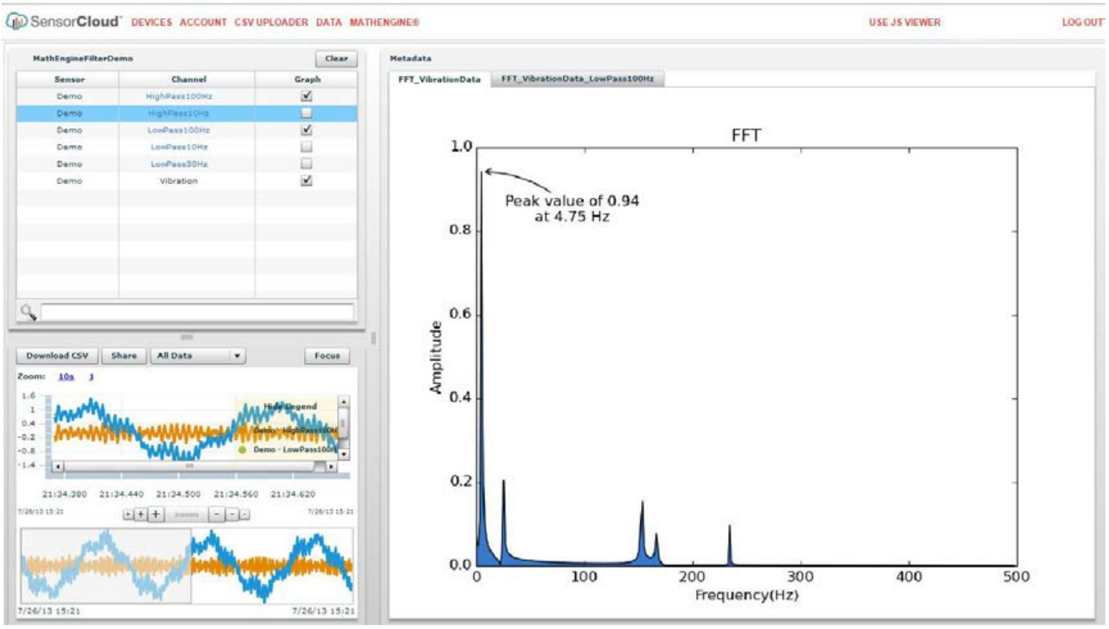


Figure 26. SensorCloud FFT Graph

6.2 SensorConnect

6.2.1 Using Dashboards and Widgets

Collected data is viewed on the Data page through the creation of dashboards and widgets. Think of dashboards as individual pages and widgets as an illustration on the page. Create multiple data widgets on each dashboard to display sampled data as a time-series graph, text chart, or a simple gauge that only displays the most current reading. This format provides an easy way to organize many sensors and networks, and it allows the information to be displayed in the most appropriate layout.

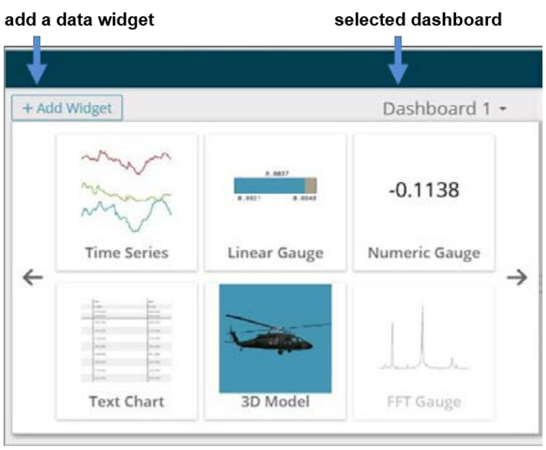


Figure 27. Viewing Data

6.2.2 Navigating Graphs

Use the mouse, Shift, and Control keys inside the graph window to adjust the data view.

Control	Action
Mouse wheel	Zoom in/out on x-axis
Shift + mouse wheel	Zoom in/out on y-axis
Mouse double-click	Zoom to extends
Shift + mouse left-click, drag left/right	Zoom window left/right
Shift + mouse left-click, drag up/down	Zoom window up/down
Ctrl + mouse left-click, drag	Zoom box

Table 4. Graph View Controls

6.2.3 Widgets Options

The widget configuration menu is different for each type of widget but typically includes sensor or channel selections and widget settings such as titles and legends.

After adding a widget, left click to select and configure it in the Channels and Settings left sidebar menu. Under Channels, the channel(s) for the widget can be enabled and disabled.

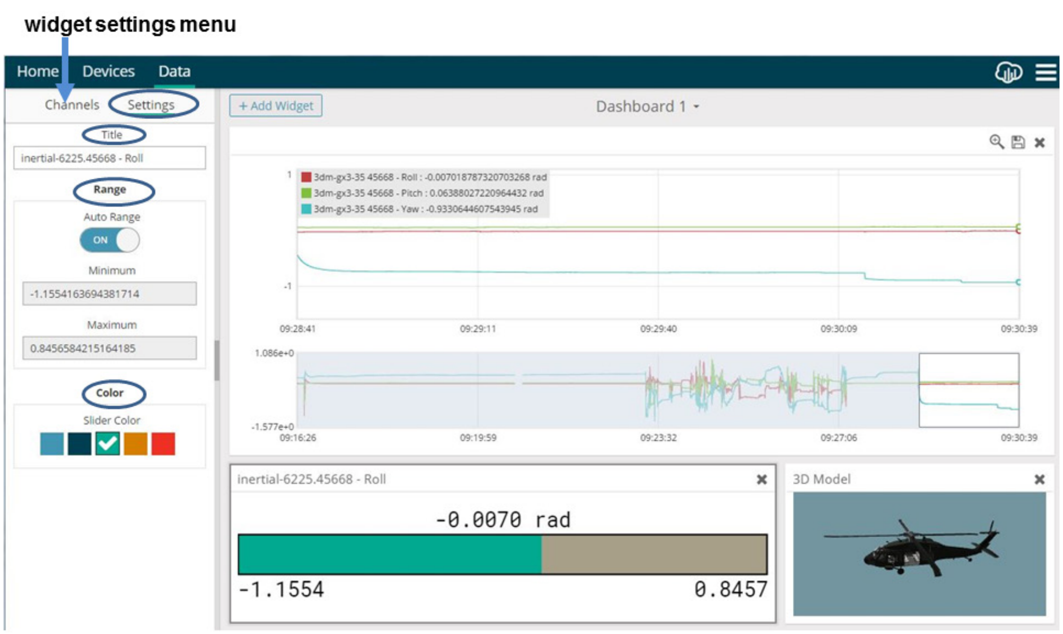


Figure 28. Widget Settings Menu

6.2.4 Time Series Widget Menu

The Time Series Widget menu has two features to help optimize sensor data collection for export to a .csv file. Snap to Latest captures the most recent data and Zoom isolates specific events from a larger data sample.

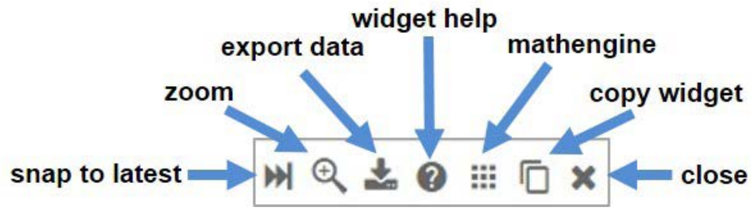


Figure 29. Time Series Widget Menu

6.2.5 Exporting Data Files

To export data to a .csv file, select the Export Data button on the Time Series widget > Export > name the document > save to the preferred location on the host computer.

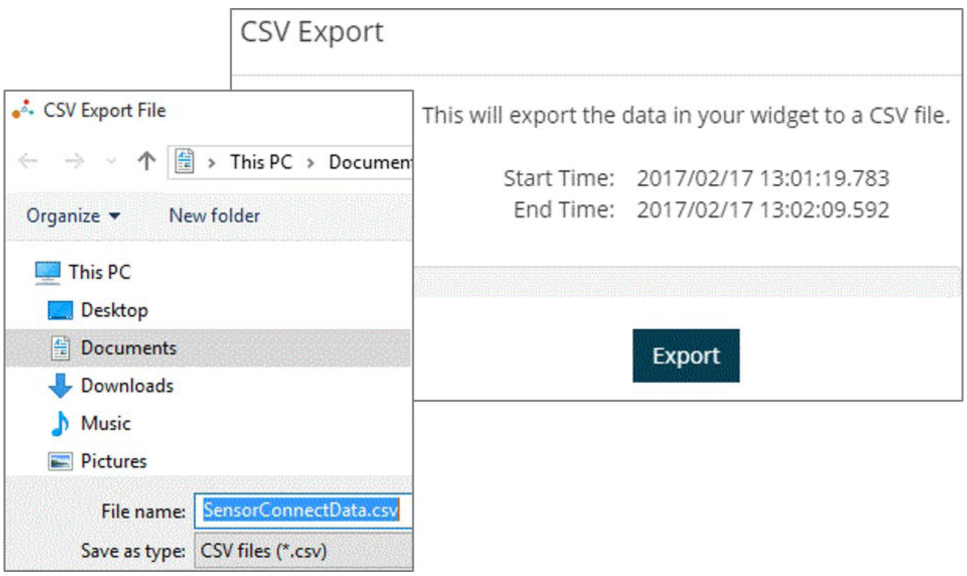


Figure 30. Exporting Data

7. Installing Strain Gauges

The Torque-Link-200 is designed for use with differential input sensors in a Wheatstone Bridge configuration. The node provides a 3 V excitation voltage, signal processing, and programmable gain settings.

Full-bridge configuration with 1000 ohm strain gauges is recommended for torque monitoring with the Torque-Link-200. The Torque-Link-200 can be ordered with two input channels for redundant or additional measurements.

7.1 Node Differential Inputs

The differential measurement channels provide a 3 VDC excitation voltage to the sensor and measure the resulting sensor signal output. The sensor signal goes through a programmable gain amplifier (PGA) and is processed in the node by a16-bit analog-to-digital (A/D) converter over the 3 VDC range. The resolution of the sensor measurement is dependent on the operating range of the sensor. If the application is such that only a small portion of the 3 VDC range is being utilized, better resolution can be achieved by increasing signal amplification and by zeroing the sensor baseline in the appropriate offset biasing range.

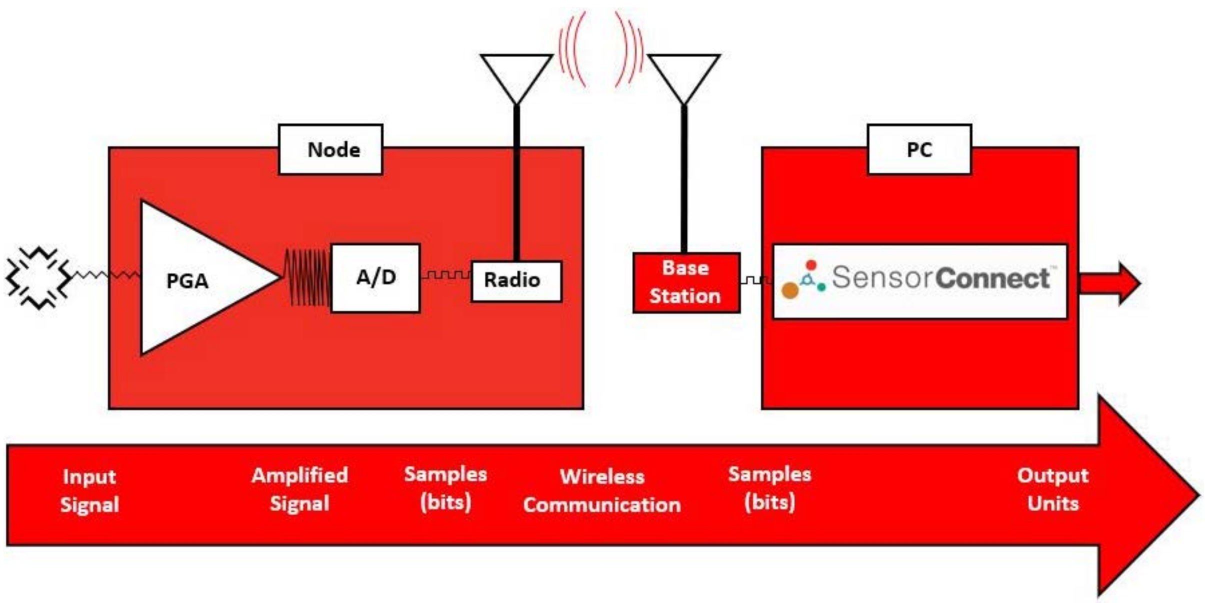


Figure 31. Differential Channel Signal Processing

7.2 Wheatstone Bridge Tutorial

The Wheatstone bridge is a series-parallel array of four resistors used to measure an unknown resistance value, suited for measuring small changes. An excitation voltage (Vex) is applied across the two parallel sets of series resistors, and the resulting voltage measured across the adjacent series resistors (Vo).

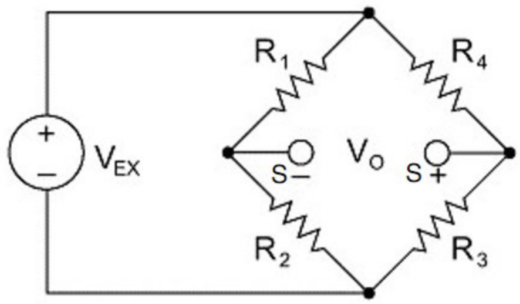


Figure 32. Wheatstone Bridge

The Wheatstone bridge is the basis for all strain gauge configurations. To measure strain, one, two, or four of these resistors are replaced by strain gauges, which function as variable resistors. Replacing one resistor with a strain gauge is a quarter-bridge configuration, replacing two resistors is a half-bridge configuration, and replacing all four resistors is a full-bridge configuration. In all configurations, strain gauges and the circuits they interface with are designed for use with specific circuit impedance values and must be selected accordingly. Common values are 350 or 1000 ohms.

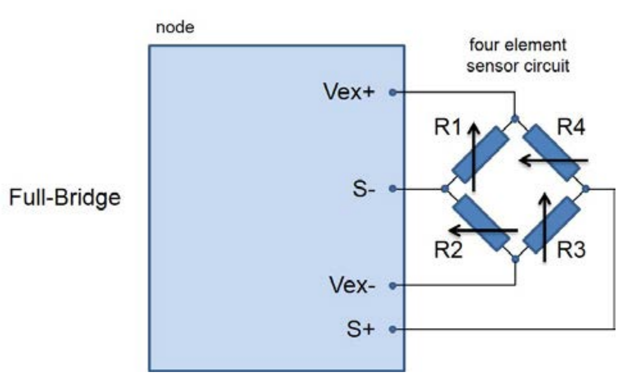


Figure 33. Full Bridge Wiring

The physical placement and orientation of the gauge elements on the object being measured determines what type of strain measurement is achieved. Axial strain, shear strain, and bending strain are three common measurements and represent the axis or direction of the strain on the object. Placing the gauges in a parallel orientation with each other, in adjacent orientation, or in some combination determines the measurement type.

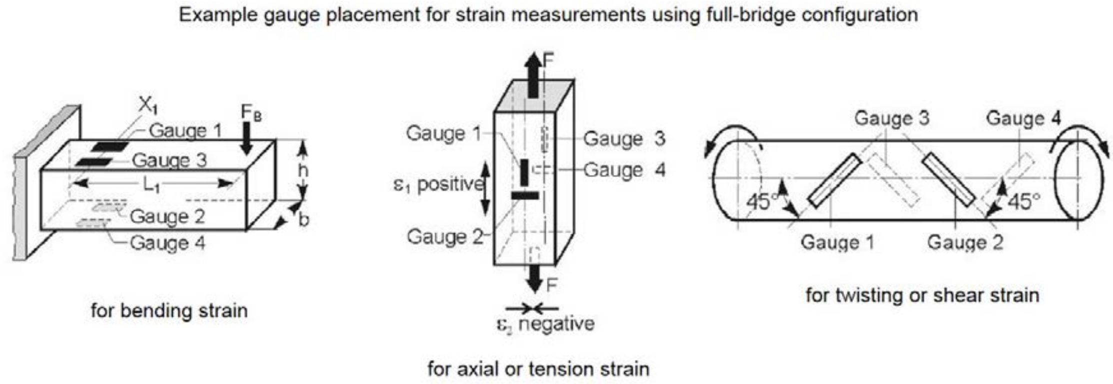


Figure 34. Example Gauge Placement

In addition to the actual strain changes, resistance changes in the Wheatstone bridge circuit can be caused by environmental factors such as temperature fluctuations. Strain in any direction will also cause slight changes in the resistance value of a strain gauge regardless of the gauge orientation. When using a quarter-bridge configuration this is a source of false readings. The half-bridge and full-bridge configurations are capable of rejecting off-axis strain when applied correctly. The full-bridge configuration effectively doubles the relative change in resistance (when compared to the half-bridge configuration), which results in higher accuracy. For these reasons, full-bridge configurations are recommended for measuring torque or axial strain with the Torque-Link-200.

7.3 Strain Gauge Installation

This section describes the recommend strain gauge placement and bridge configuration for torque measurements with the Torque-Link-200.

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 Gauges.

7.3.1 Tools and Equipment

The following are required for installation of the Torque-Link-200 sensor node:

- 9/64 hex key
- Medium strength thread-locker (such as Loctite 425 or equivalent)
- Strain gauges and installation tools, as recommended by the strain gauge manufacturer
- (4x) 1K ohm strain gauges (or two dual element gauges) and a wiring terminal strip
- Gauge fastening and coating compounds
- Strain gauge wire and applicable wire cutting and stripping tools
- Soldering iron and solder
- Standard wrench that will fit on the shaft (for field calibration only)
- Torque wrench (for collar screws and field calibration, if applicable)
- Safety glasses

7.3.2 Strain Gauge Placement

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-200 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.

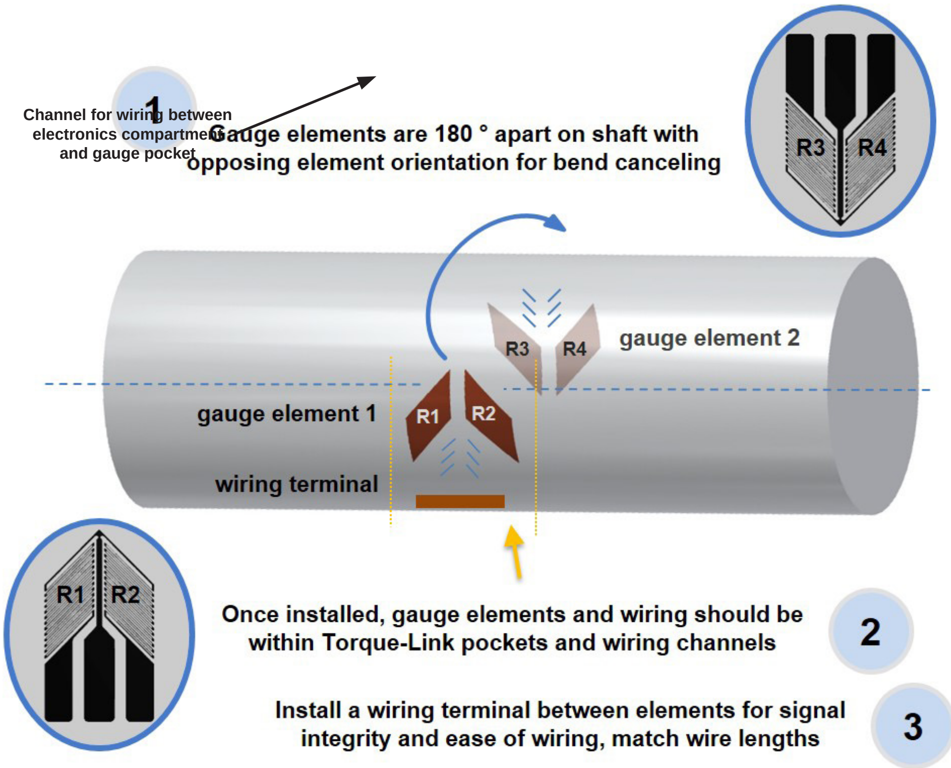
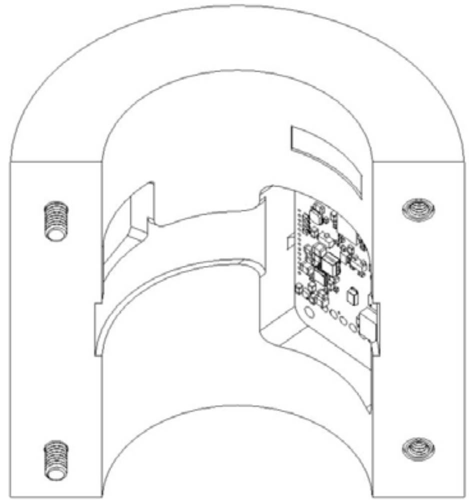


Figure 35. Placement for Full Bridge Torque Measurement

The inner circumference of the Torque-Link-200 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-200 is installed. Check-fit the assembly over the gauges during the gauge installation process to ensure proper clearance. The connectors between the strain gauges and node electronics will be tucked into the strain gauge pocket during final assembly.



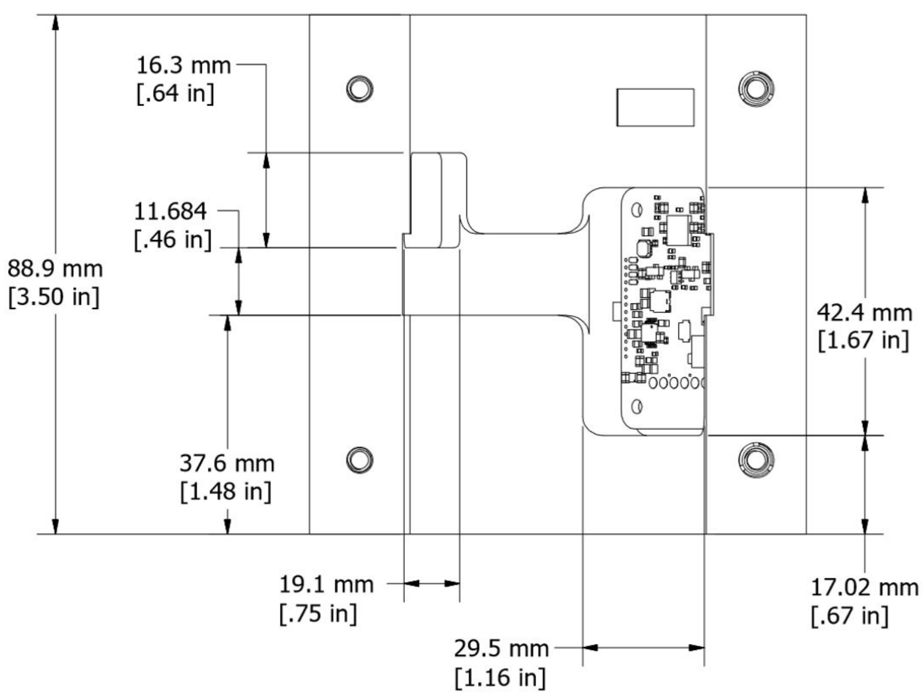
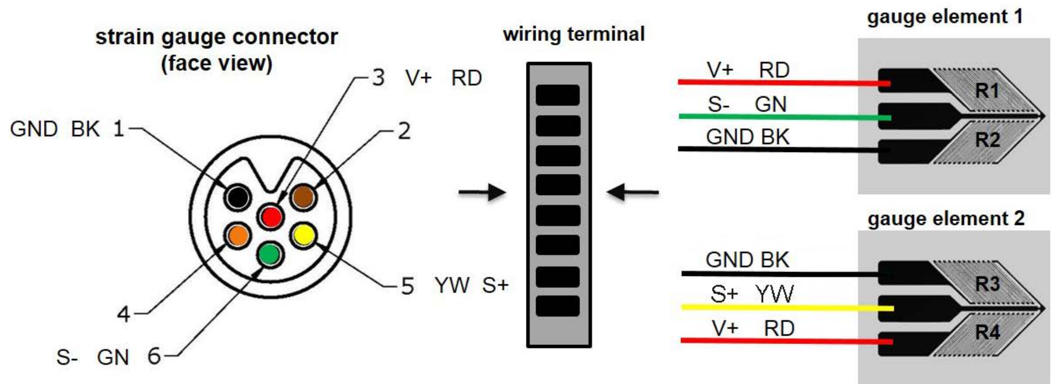


Figure 36. Strain Gauge Placement

7.3.3 Strain Gauge Wiring

Once the strain gauges and wiring terminal are installed on the shaft in the desired location, they are wired to a connector that mates to the node connector. The strain gauge wires and the connector wires will then be attached to the wiring terminal. The connector is included with the node or can be ordered separately.

The wires are soldered on to the strain gauge terminals in accordance with the strain gauge manufacturers signal designations. It is best practice to keep the wires as short as possible and the same length as each other to avoid influencing sensitive measurement. Once connected to the Torque-Link-200, the connectors will be tucked inside the gauge pocket. Wiring is shown for dual-element full-bridge configuration.



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 5. Strain Gauge Wiring

8. Torque-Link-200 Installation

8.1 Mounting the Assembly

The Torque-Link-200 is mounted on the shaft with the cutouts aligned over the gauges and wiring.

Figure 37. Assembly Installation

1. Disassemble the collar into the two halves, if not already done. Remove the collar screws completely.
2. Peel the backing off the collar placement VHB 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. **Secure with 5 inch-pounds of torque**. Do not over-tighten. There should be a small gap (equal on both sides) between the collar halves.

8.2 Re-Using the Assembly

The Torque-Link-200 assembly can be re-used on other shaft assemblies as long as the shaft is the same size. Use new collar placement tape for the new installation. New installations or new strain gauges need to be re-calibrated after installation.

9. Strain Gauge Calibration

Follow the steps below to use the Torque-Link-200 for strain measurements.

1. Attach the wire harness from the node to a load, either the strain gauge or a shunt resistor. Ensure that the node is powered by observing a green LED when batteries are placed in the Torque-Link-200.
2. Open SensorConnect and establish communication with the gateway and node.
3. Navigate to the node of interest. Click “Set to “Idle” if not already in idle (default setting). Click the configure button to configure the node.

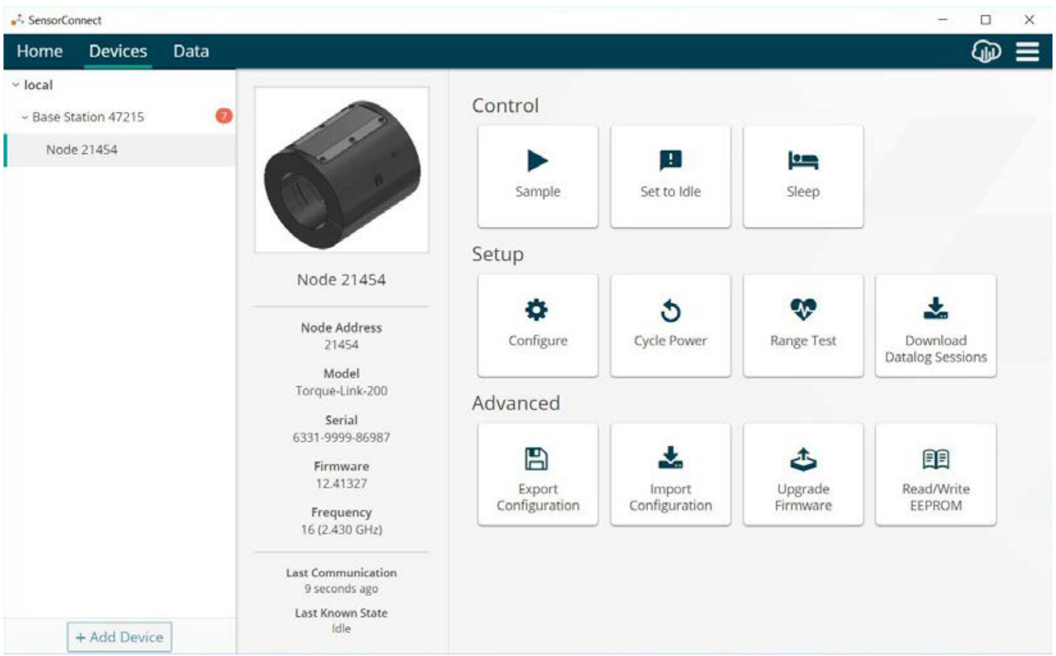


Figure 38. Node Home Screen

4. Under Setup -> Configure -> Hardware make sure all values meet required test specifications. The default values will satisfy most test requirements.

5. To perform a strain calibration, click the “Cal Tools” button under the “Calibration” tab and select the “Strain” button.

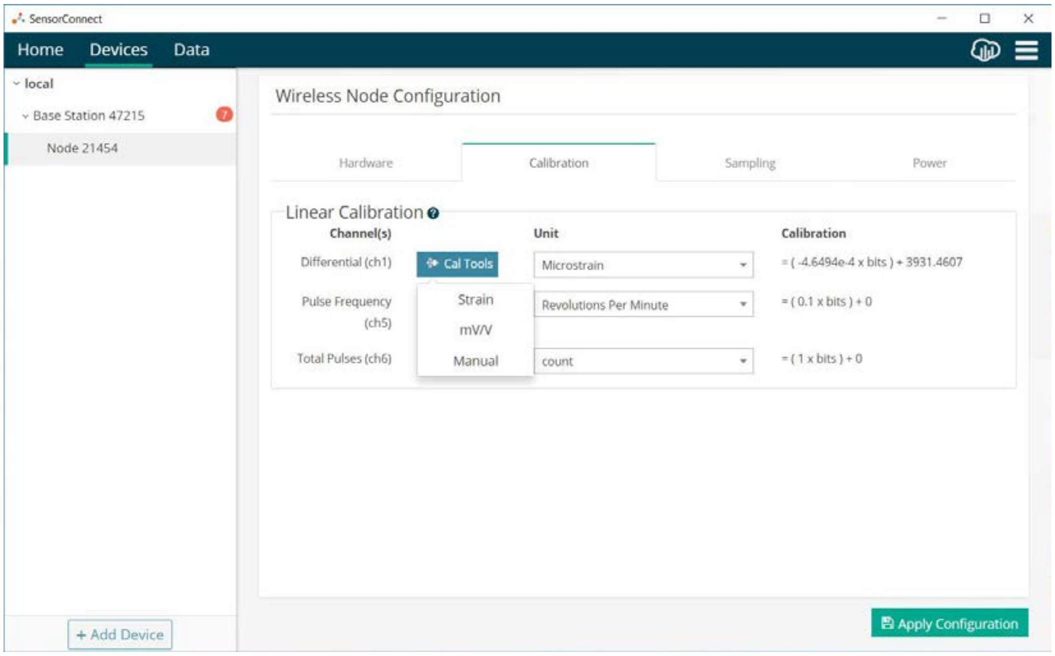


Figure 39. Node Calibration

6. Perform a shunt calibration using the parameters below to set the conversion between bits and strain.

   a. Calibration Mode: Select Internal or External calibration. Internal calibration uses a shunt resistor inside the Torque-Link-200 to apply a fixed load on the strain input. An external calibration uses a user-installed shunt resistor attached to the input.

   b. # Active Gauges: number of strain elements connected (for example: 4 for a full-bridge, and 2 for a half-bridge) Full bridge is the default and is recommended by LORD Microstrain Sensing for the highest accuracy and largest amplitude signal.

   c. Gauge Factor: ratio of mechanical strain to electrical output (a gauge specification).

   d. Gauge Resistance: the strain gauge ohm value (a gauge specification).

   e. Shunt Resistance: 499000 ohms (if using the internal shunt resistor).

   f. Simulated strain: Set this to the simulated strain value that can be simulated electrically or by applying a known torque to the shaft.

When all values are satisfactory, click the “Start Shunt Cal” button.

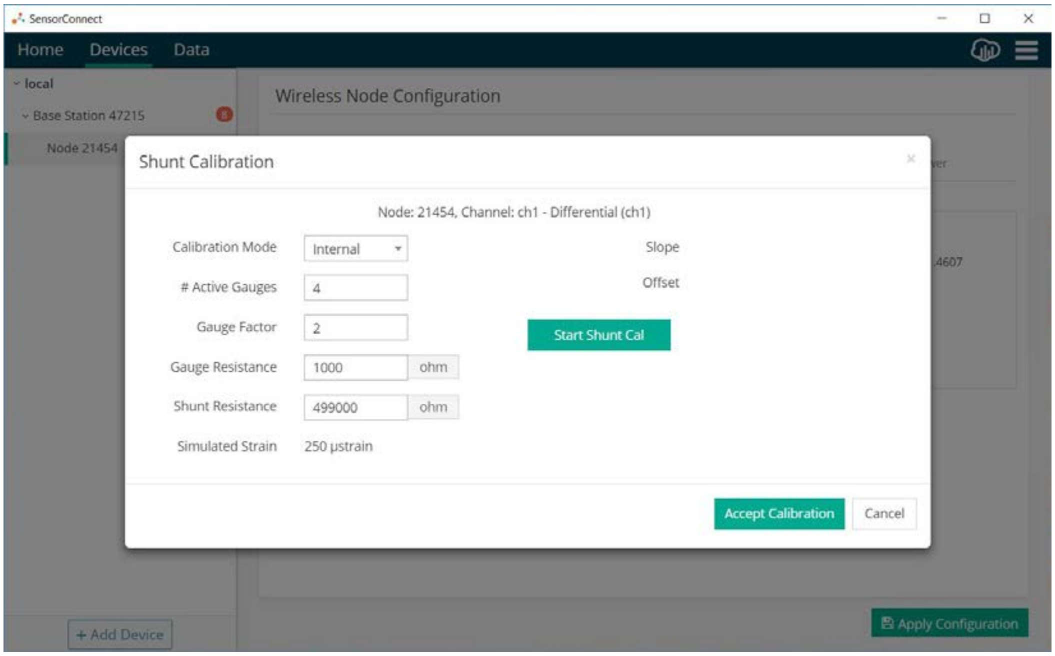


Figure 40. Shunt Calibration setup

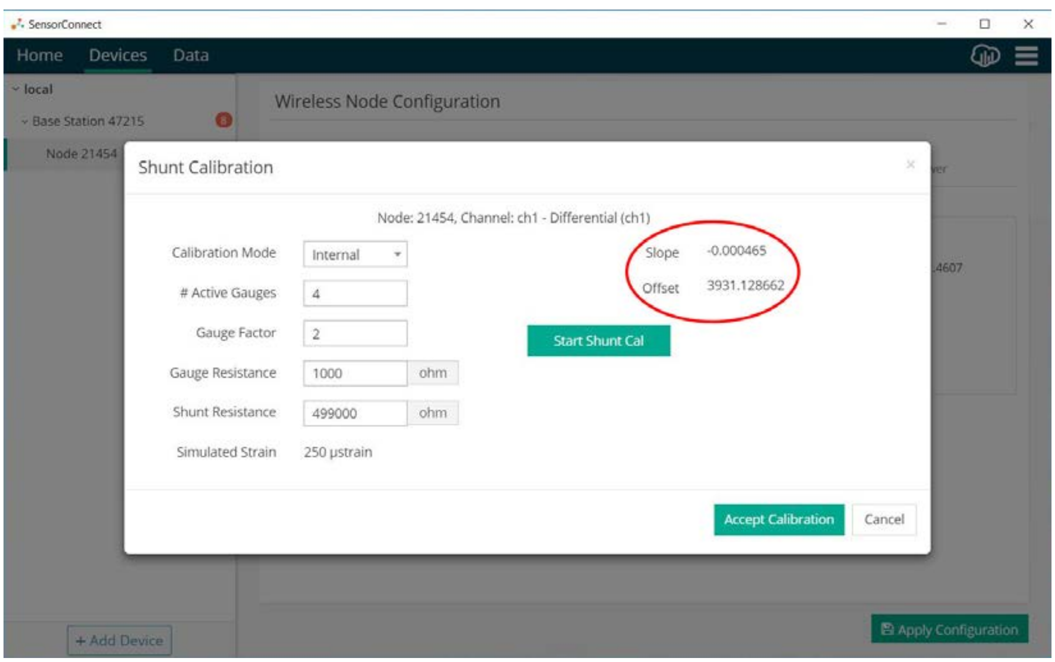


Figure 41. Generate Slope and Offset Values

If satisfactory, click “Accept Calibration”. If the offset is listed as infinite, check the wiring for an open circuit. An infinite offset value occurs when no load is detected.

7. Apply the calibration to the node by clicking “Apply Configuration”. Note the Calibration formulas are populated with the slope and offset from the previous step.

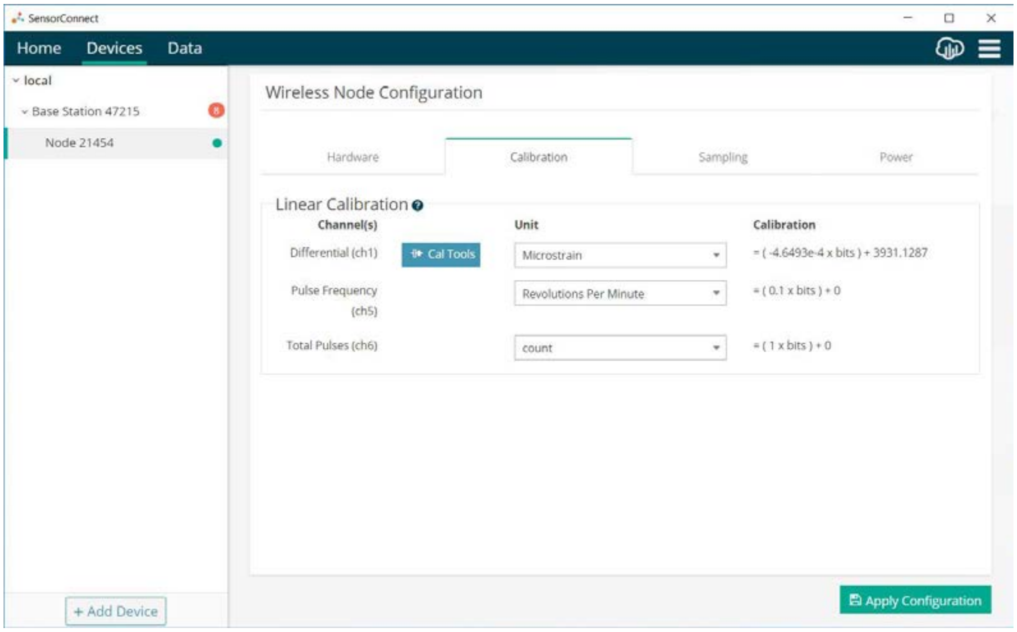


Figure 42. Completed Calibration

8. After calibration, return to the node of interest and complete configuration. Verify the ch-1 Differential strain channel is selected. Click “Apply and Start Network” and run the node by clicking the “Sample” button on the node home screen.

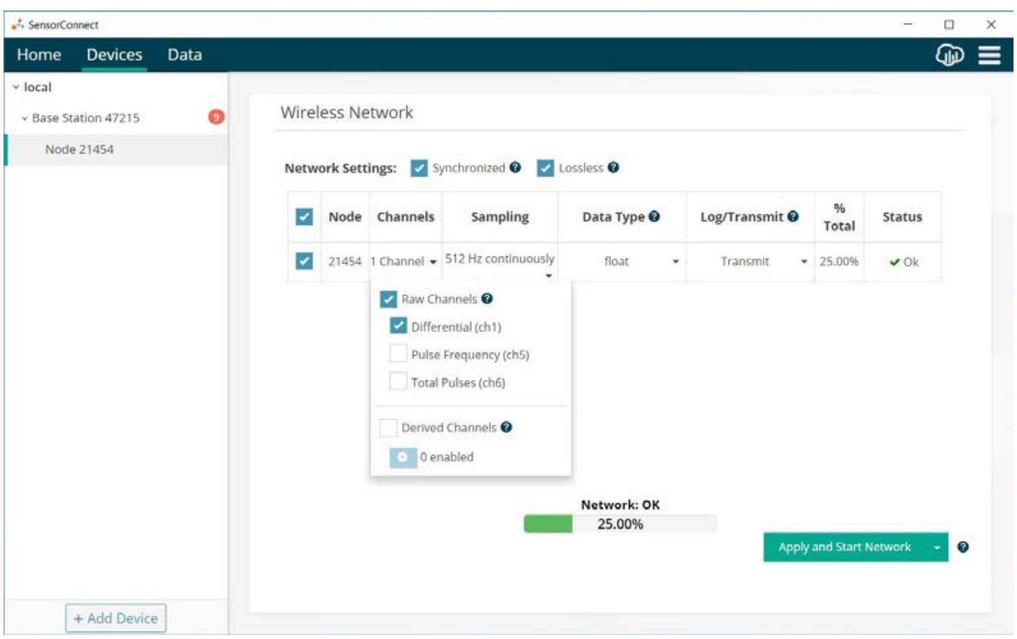


Figure 43. Network and Node Configuration

9. Click on the Data tab on the top ribbon. Add a Time Series widget and select ch1 – Differential of the node of interest.

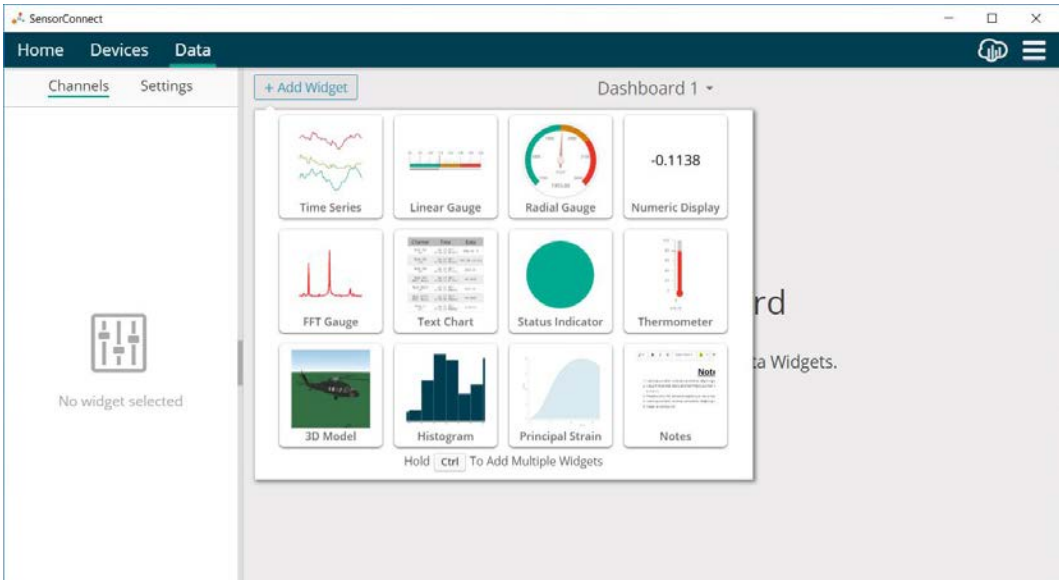


Figure 44. Dashboard Home Screen

10. The red line represents the output of the strain gauge. With no load applied, the signal should go to a near zero value. When shunted, the signal should instantaneously go to the simulated strain value assigned during calibration and produce a square pulse. Calibration is now complete.

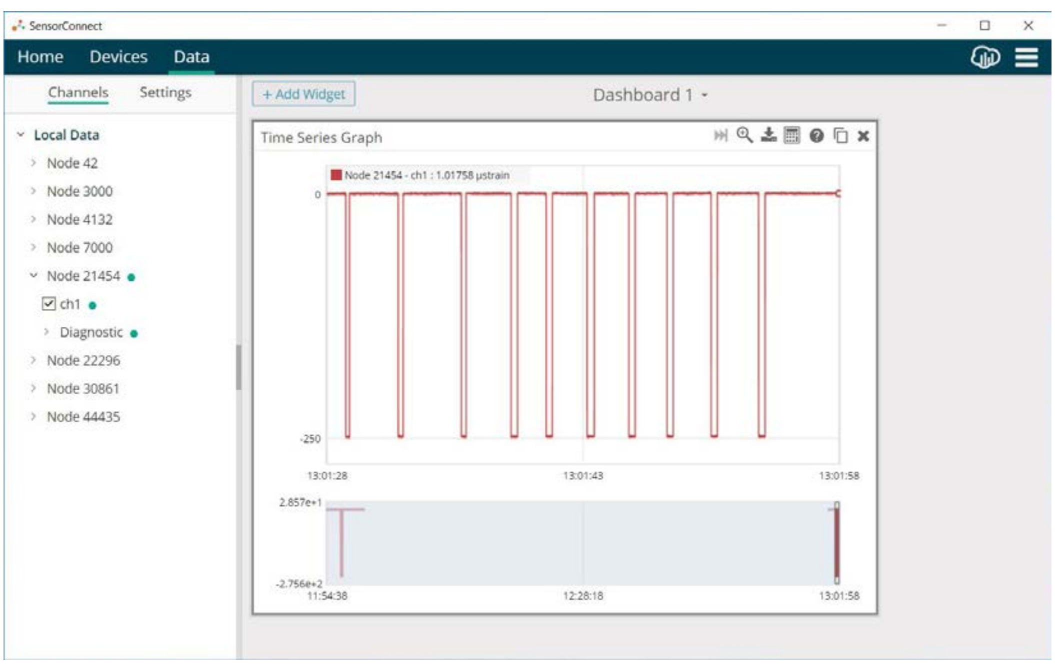


Figure 45. Strain Gauge Calibration

9.1 Theoretical Torque Formula

Use the theoretical torque formula to convert strain measurements into torque units. The relationship between strain is not exactly linear, but is accurate for many applications. If more precision is desired, the calibration slope and offset calculation can be done using strain, and converted from strain to torque using the theoretical torque formula. Accuracy is determined by mitigation of error in shaft measurements, shaft uniformity, and material coefficients.

$$\tau = \frac{\left(\mu \cdot \pi \cdot \left(D_o^4 - D_i^4\right) \cdot E\right)}{\left(192 \cdot D_o \cdot (1 + v)\right)}$$

t = torque
u = strain
D_o = shaft outer diameter
D_i = shaft inner diameter
E = shaft material modulus of elasticity
v = shaft material Poisson ration

Figure 46. Theoretical Torque Formula

10. Maintenance

The replaceable batteries and battery compartment o-ring are the only user serviceable part in the Torque-Link-200. For other service or repair needs contact LORD Sensing Technical Support.

10.1 Changing the Batteries

⚠WARNING

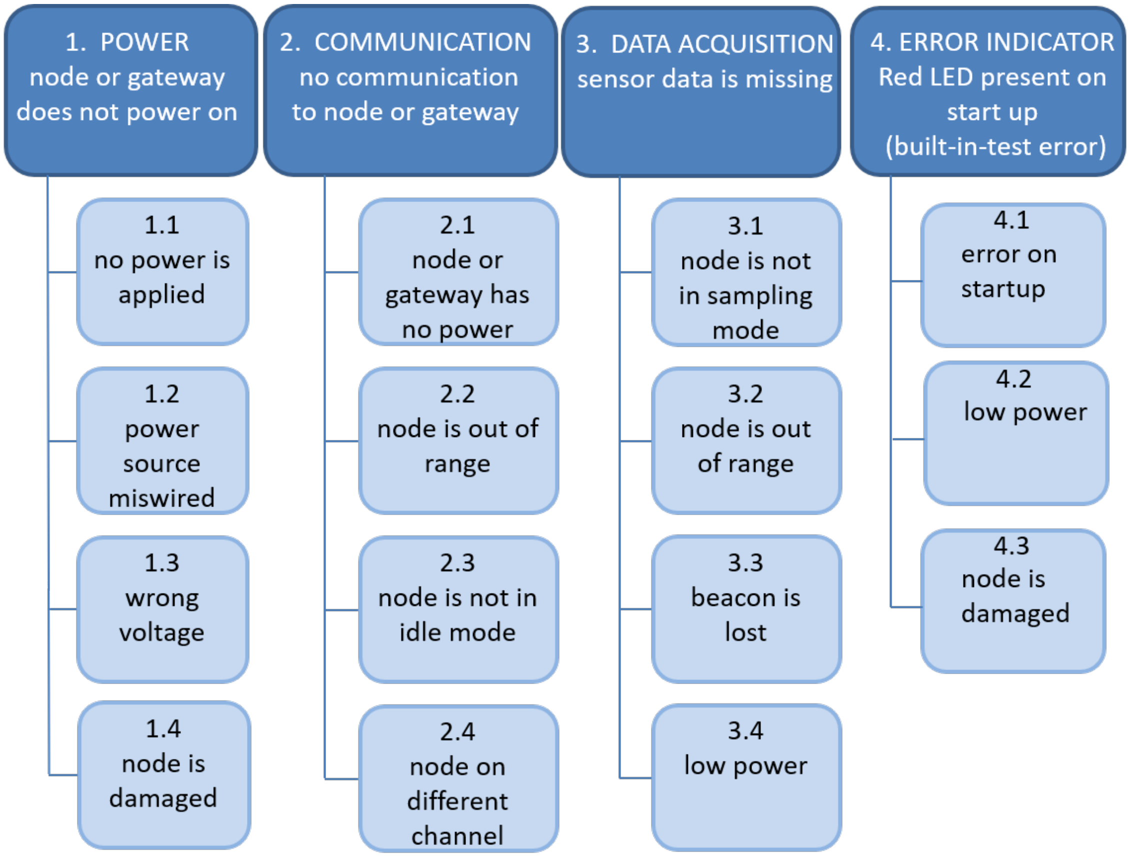
The Torque-Link-200 contains internal, non-rechargeable lithium batteries.

1. Remove the battery compartment cover using a T8 Torx (star) driver.
2. Remove the expired batteries.
3. Install two new AAA Lithium ion batteries.
4. Reinstall the battery compartments cover ensuring the o-ring seal is properly seated in the compartment cover.

Figure 47. Battery Installation

11. Troubleshooting

11.1 Troubleshooting Guide



Possible Cause and Recommended Solution	
1. POWER **Gateway or node does not power on**	**1.1 Node or gateway power is OFF** The status indicator LED on the device may be off. Power the device on, and the status indicator LED should illuminate.
	1.2 Wrong power supply or voltage Using a non-specified power supply or an external supply outside of the device operating range may result in permanent damage to the device or cause it to not work properly.
	1.3 Node battery is dead If the node will not power on, the node battery may need to be replaced.
	1.4 Sensors are drawing too much current The node battery can only supply a limited amount of power to the connected sensors. If an over-current condition occurs, the node will shut down. This may occur if the sensors are wired incorrectly.
	1.5 Node or gateway is damaged If all power settings and connections have been verified, and the node is still unresponsive, contact LORD Sensing Technical Support.

2. COMMUNICATION **Communication fails at the gateway or node**	**2.1 Node or gateway has no power** Verify the node and gateway have power applied and the power switches are on. Power is indicated on both devices by a status indicator LED.
	2.2 Gateway has no communication with the computer Verify gateway communication in the software. Check, remove, and reconnect communications and power cables as applicable.
	2.3 Node cannot be configured Determine the device's state: boot, idle, sample, or sleep. If sampling or sleeping, it cannot be configured. Execute the Set to Idle command in SensorConnect to put the node in idle, allowing for configuration. If the user inactivity timeout is set very low, enter the configuration menu quickly before the timeout, putting the node back in a sample or sleep state.
	2.4 Node is out of range Perform a bench test with the node in close proximity to the gateway to verify they are operational. The system has been tested to operate with the node and gateway up to 2 km apart with clear line of sight.
	2.5 Node is not in normal boot mode If the node boots in a mode other than the normal boot mode, it can be bypassed by cycling the node power rapidly three times, then leaving it on for normal power up. In normal boot mode the communication can be established with automatic node discovery (or manually) once the boot process is complete and the node is in idle state. Start-up mode can then be changed in the software.
	2.6 Node is sampling Determine the device's state: boot, idle, active, or sleep. If the node is sampling, it cannot be configured. In SensorConnect, execute the Set to Idle command to put the node in idle state, allowing configuration to occur.
	2.7 Node is sleeping Determine the device's state: boot, idle, active, or sleep. If the node is sleeping, it cannot be configured. In SensorConnect, execute the Set to Idle command to put the node in idle state, allowing configuration to occur.
	2.8 Gateway or node is damaged Verify all connections, power, and settings. If available, try installing alternate nodes and gateways one at a time to see if the faulty device can be identified. If no conclusion can be determined or to send a device in for repair, contact LORD Sensing Technical Support.

<table>
<tr><td rowspan="6">3. DATA ACQUISITION

Sensor data is missing or incorrect</td><td>3.1 No communication to node or gateway
Verify connections and power to the node and gateway. Verify they are powered on and communicating with the software. Enter a configuration menu to verify that the node can be accessed.</td></tr>
<tr><td>3.2 Sampling settings are incorrect
If the sampling mode, rate, or duration are not performing as expected, enter the node configuration menu, and verify the sampling settings.</td></tr>
<tr><td>3.3 Sampling has not started
If sampling is occurring, the sampling mode displays next to the node name in SensorConnect. The node device status indicator will also be flashing the sampling mode code. If the node is not sampling, activate it in the software or with a sample on start up boot sequence.</td></tr>
<tr><td>3.4 Sensor is connected incorrectly
Verify connections and wiring. For non-standard connections contact LORD Sensing Technical Support.</td></tr>
<tr><td>3.5 Sensor channel configured incorrectly
Verify that the sensor is configured on the correct channel and has been enabled for data acquisition.</td></tr>
<tr><td>3.6 Sensor calibration is invalid</td></tr>
<tr><td rowspan="3">4. Strain Measurement</td><td>4.1 No shunt cal detected</td></tr>
<tr><td>4.2 Infinite offset value</td></tr>
<tr><td>4.3 Unrealistic slope value</td></tr>
</table>

11.2 Device Status Indicators

The following is a complete summary of the Torque-Link-200 status indicators.

<table>
<tr><th>Indicator</th><th>Behavior</th><th>Node Status</th></tr>
<tr><td rowspan="9">Device Status Indicator</td><td>OFF</td><td>Node is OFF or sleeping</td></tr>
<tr><td>OFF, with occasional flash</td><td>Node is sleeping with radio check intervals enabled (default is every 5 seconds)</td></tr>
<tr><td>Ten rapid flashes green when power is initially applied</td><td>Node is booting normally and sending out a status message.</td></tr>
<tr><td>1 second pulse green</td><td>Node is idle</td></tr>
<tr><td>Continuously ON green</td><td>Node is datalogging</td></tr>
<tr><td>1 Hz pulse green</td><td>Node is sampling in low duty cycle or synchronized sampling mode</td></tr>
<tr><td>ON bright green</td><td>Node is in synchronized sampling mode and is re-syncing or taking a burst sample</td></tr>
<tr><td>Pulses for each ping</td><td>Node is sending out communication requests (such as in ping command, range test, or EEPROM read/write)</td></tr>
<tr><td>Four to seven slow pulses when power is initially applied</td><td>Fault condition</td></tr>
</table>

Table 6. Device Status Indicators

11.3 Optimizing the Radio Link

NOTE: In the event of communication difficulties, it may be necessary to disable WIFI on the host computer, or use a USB extender when collecting data.

The best method for ensuring optimal radio communication is to conduct an RF survey of the installation site. Use SensorConnect's Range Test feature to quantify the radio signal strength (RSSI) in various scenarios. The following are general guidelines for maximizing communication range:

- **Line of Sight (LOS)** between the node and gateway. Try to avoid obstructions such as buildings, terrain, vegetation, or other physical barriers.
- **Increase the Mounting Height** of the node to allow a clearer LOS path to the gateway. Height above the ground is also important because reflections off of the ground can interfere at the receiver. Generally, the higher above the ground the better.
- **Minimize Radio Frequency Interference (RFI)** from other wireless devices, especially those operating in the same frequency range. This includes other nodes and 2.4 GHz WIFI routers. If other wireless devices are required nearby, mount at different heights to minimize interference. A different radio frequency may be selected using SensorConnect software.
- **Minimize Electromagnetic Interference (EMI)** such as that which is generated by power transmission equipment, microwaves, power supplies, and other electromagnetic sources.
- **Metal Objects** in close proximity to either antenna, particularly ferrous metals such as steel and iron, can be problematic for wireless communications. The larger the object, the greater the influence.

11.3.1 Range Test

After establishing communication between node and gateway, use the range test feature in SensorConnect to monitor the signal strength and to optimally position the nodes, gateway, and antennae for installation. Maximum achievable range is determined by the gateway and node power settings (found in the device Configure menu) and is highly dependent on the physical environment surrounding the devices.

1. Select the node name > Range Test

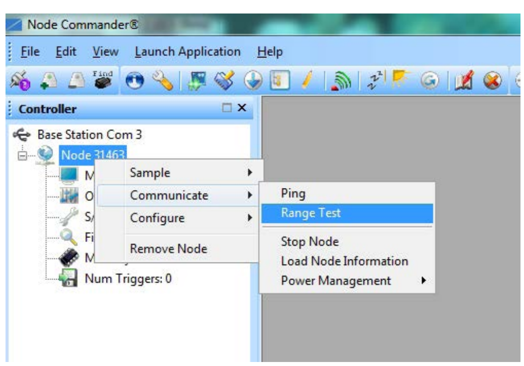


Figure 48. Range Test Menu

2. RSSI is a measure of signal strength between the node and the base station. A higher RSSI value (closer to zero), will result in better node to base station communication. Reliable communication can be achieved with a signal strength greater than -75 dBm, in the absence of radio frequency interference. Position the node and gateway antennas where the best RSSI value is observed.

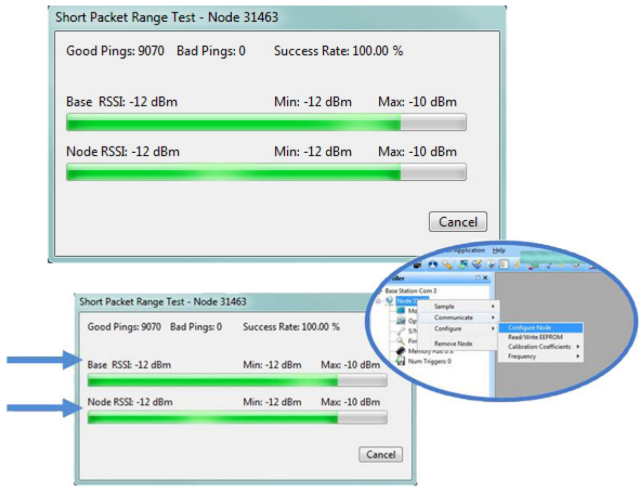


Figure 49. Range Test Statistics

11.4 Updating Node Firmware

Under the recommendation of LORD Sensing Technical Support Engineers, nodes can be upgraded to the latest available firmware to take advantage of new features or correct operating issues. SensorConnect version 5.0.0 or greater can be used to update any mXRS or LXRS node or gateway firmware to the most current version. Updates are found on the LORD Sensing website product page under the Downloads tab.

1. Download the Firmware Upgrade file from the LORD Sensing website product page under the Downloads tab.
2. Once downloaded, extract the contents of the .zip file into a folder on the computer. Verify there is a file with a .zhex extension.
3. Launch SensorConnect, and establish communication between the node and gateway as normal.
4. Select the Node address > Upgrade Firmware > select Browse > select the Firmware Upgrade file > Start Upgrade

12. Parts and Configurations

12.1 Standard Configurations

The Torque-Link-200 is available in standard sizes based on the shaft size it will be installed on. It is also available with one or two channels for attaching strain gauges.

Description	LORD Sensing Part Number
Torque-Link-200 with lithium batteries, 2.05" inner diameter, and one sensor channel	PN 6331-1205
Torque-Link-200 with lithium batteries, 4.55" inner diameter and two sensor channels	PN 6331-2455

Table 7. Example Torque-Link-200 Part Numbers

12.2 Replaceable Parts

Description	LORD Sensing Part Number
1.5V, AAA Lithium Batteries (Commercially available)	9021-0050
Strain gauge connector harness, Female (strain gauge side)	9008-0398
Strain gauge connector harness, Male (Torque-Link side)	9008-0397
Battery compartment screw - button head Torx 4-40 x 5/16”	9100-0247
Battery compartment o-ring - Buna-N size 037	9117-0028
Collar placement tape - 3M VHB	9203-0008

12.3 Recommended Strain Gauges

Description	Manufacturer and Part Number
Dual-element shear/torque pattern strain gauge	Vishay 062UV series
Strain gauge terminal strip for wiring	Vishay MM Bondable

12.4 Wireless System Equipment

Model	Description	LORD Sensing Part Number
WSDA-1500-SK	Ethernet Data Gateway Starter Kit	6314-1501
--	Node Commander Software	6301-0300
--	SensorCloud Software Subscription (contact LORD Sensing Sales)	6600-0001
--	Replacement USB cable	9022-0029
--	USB Gateway cable extender	6307-0900
--	Replacement serial cable	4005-0005
WSDA-1500	Ethernet Data Gateway	6314-1500
WSDA-BASE-104	USB Gateway	6307-1040
WSDA-BASE-102	RS232 Serial Output Gateway	6307-1020
WSDA-BASE-101	Analog Output Gateway	6307-1010
G-Link-LXRS	Wireless Accelerometer Node	various models
G-Link2-LXRS	Wireless Accelerometer Node	various models
SG-Link-LXRS	Wireless 2-Channel Analog Input Sensor Node	various models
SG-Link-OEM	Wireless 2-Channel Analog Input Sensor Node	various models
SG-Link-RGD	Ruggedized Wireless Analog Sensor Input Node	various models
V-Link-LXRS	Wireless 7-Channel Analog Input Sensor Node	various models
TC-Link-LXRS	Wireless Thermocouple Node	various models
DVRT-Link-LXRS	Wireless Displacement Sensor Node	various models
ENV-Link-Pro	Wireless Environmental Sensor Node	various models
Watt-Link-LXRS	Wireless Energy Monitoring Sensor Node	various models
RTD-Link-LXRS	Wireless RTD Sensor Node	various models
IEPE-Link -LXRS	Wireless IEPE Accelerometer Node	various models

Product Ordering

Products can be ordered directly from the LORD Sensing website by navigating to the product page and using the Buy feature.

http://www.microstrain.com/wireless

For further assistance, our sales team is available to help with product selection, ordering options, and questions.

Sales Support

sensing_sales@LORD.com

Phone: 802-862-6629

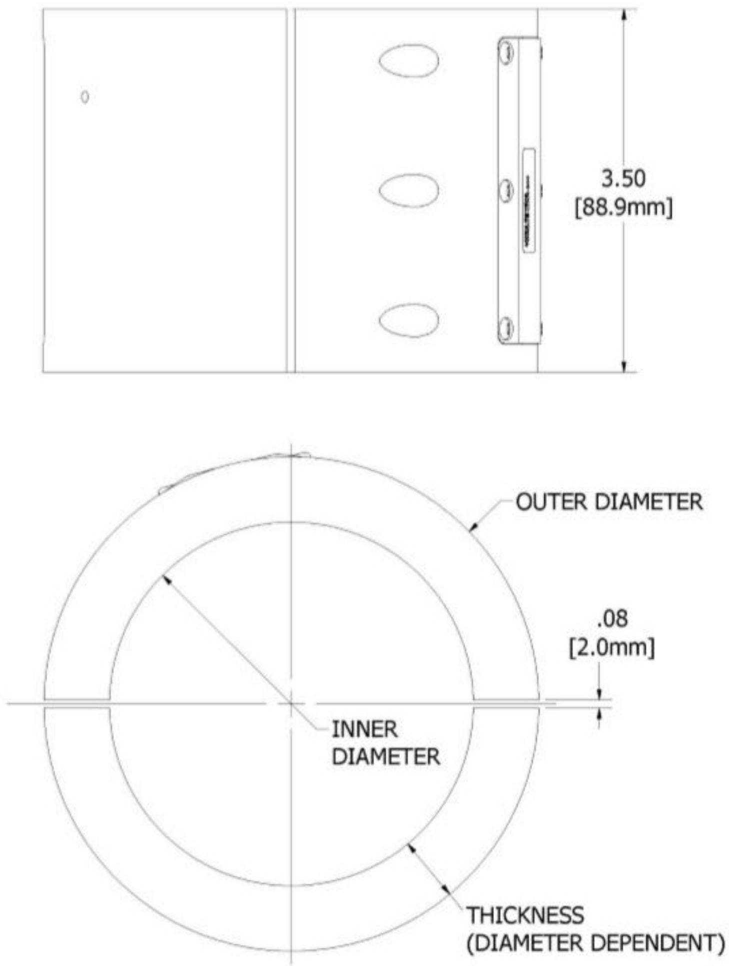
Fax: 802-863-4093

9:00 AM to 5:00 PM (Eastern Time US & Canada)

13. Specifications

13.1 Physical Specifications

The Torque-Link-200 is available in many sizes to fit a variety of standard shaft diameters. All variations are the same height.



Example Diameters (other sizes available)		
Shaft Diameter	Torque-Link Thickness	Torque-Link Outer Dia.
2.00in [50.8mm]	.675in [17.1mm]	3.37in [85.6mm]
3.00in [76.2mm]	.646in [16.4mm]	4.31in [109.5mm]
4.00in [101.6mm]	.618in [15.7mm]	5.26in [133.5mm]
5.00in [127.0mm]	.589in [15.0mm]	6.20in [157.4mm]
6.00in [152.4mm]	.560in [14.2mm]	7.14in [181.4mm]

Figure 50. Torque-Link-200 Dimensions

13.2 Operating Specifications

General	
Sensor input channels	1 Differential analog input, 1 RPM/pulse, 1 Internal temperature
Data storage capacity	16 M Bytes (up to 8,000,000 data points)
Analog Input Channels	
Resolution	24-bit
Digital filter*	Configurable SINC4 low pass filter for reducing noise
Bridge excitation voltage	Configurable: 1.5 V or 2.5 V (100 mA)
Adjustable gain	1 to 128
ADC resolution	24-bit
Temperature stability	0.172 µV/°C (typical)
Digital filter**	Configurable SINC4 low pass filter for reducing noise
Strain calibration	Onboard shunt resistor for deriving linear strain calibration coefficients
Shunt calibration resistor	499k Ohm (± 0.1%)
Integrated Temperature Channel	
Accuracy	±0.25°C
Operating Parameters	
Wireless communication range	Line of sight: 1 km (ideal), 400 m (typical) | Indoor/obstructions: 50 m (typical)
Radio frequency (RF) transceiver carrier	License-free 2.405 to 2.480 GHz with 16 channels
RF communication protocol	IEEE 802.15.4
Power source	High performance: 1.5 V Lithium AAA (L92) recommended Lower performance: Alkaline AAA - decreased temperature range and battery life
Power consumption	Configuration dependent (see user manual section 13.4)
Operating temperature	-40°C to +60°C
Angular acceleration limit	500*g* sustained, 1000*g* intermittent
Maximum RPM	Operating condition dependent (see user manual section 13.3)
Sampling	
Sampling modes	Continuous, periodic burst, or event triggered
Sampling rates	Up to 1024 Hz
Sample rate stability	±5 ppm
Network capacity	Up to 127 nodes per RF channel depending on settings: http://www.microstrain.com/configure-your-system
Synchronization between nodes	± 50 µsec
RPM Sensing	
Sensor input	Open collector, open drain or digital pulses from hall effect or other source
Range	0.1 to 100 Hz (6 to 6000 RPM)
Accuracy	±0.1%(typical)
Physical Specifications	
Dimensions	(see user manual section 13.3)
Environmental rating	IP 66, tested to DO-160 standards for temperature variation, humidity, and vibration
Enclosure material	ABS thermoplastic
Integration	
Compatible gateways	All WSDA gateways
Software	SensorCloud™, SensorConnect™, Windows 7, 8 & 10 compatible
Software development kit (SDK)	http://www.microstrain.com/software/mscl
Regulatory compliance	FCC (U.S.), IC (Canada), CE (European Union), ROHS

13.3 Torque-Link RPM Limits

The maximum g-force that can be applied to the Torque-Link-200 is 500*g* sustained, 1000*g* intermittent. Depending on the size of the Torque-Link-200, there is a corresponding limit on the rotational speed (revolutions per minute-RPM) that will produce that *g*-force. Contact LORD Sensing Technical Support if your application exceeds this limit.

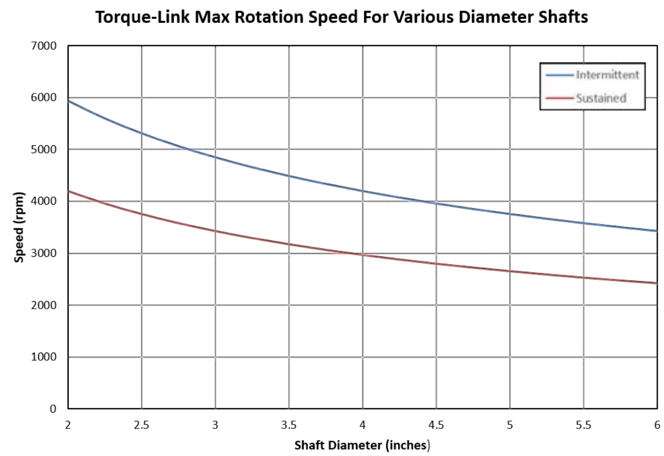


Figure 51. Maximum Rotation Speed

13.4 Power Profile

Node power use is highly dependent on the operational parameters such as sample mode and rate. More active channels and higher sample rates equate to increased power use. Below is an example approximation of the power profile of a Torque-Link-200 over a range of sample rates operating in Synchronized Sampling mode. Note the values below are for a constant condition of 25C (performance and battery life varies with temperature). Powered by standard two AAA lithium ion batteries (provided). For a more detailed power analysis see your battery data sheets and “SG-Link-200-OEM Power Profile” on www.microstrain.com.

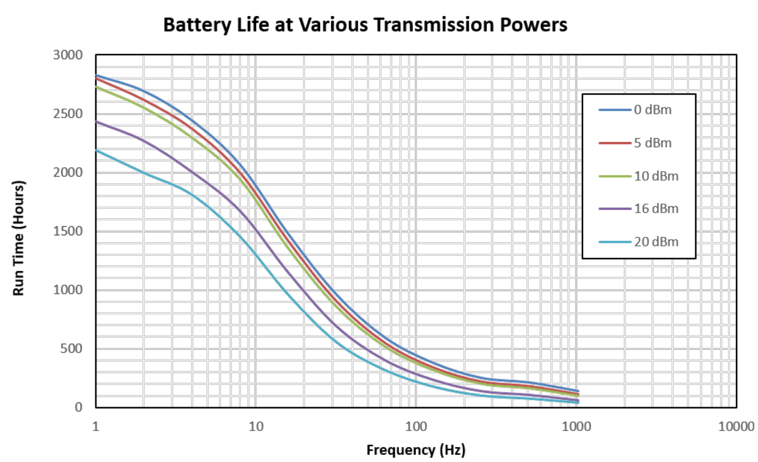


Figure 52. Example Torque-Link-200 Power Profile

13.5 Radio Specifications

The Torque-Link-200 employs a 2.4GHz IEEE 802.15.4- compliant radio transceiver for wireless communication. The radio is a direct- sequence spread spectrum radio and can be configured to operate on 14 separate frequencies ranging from 2.405 GHz to 2.475 GHz. Following the 802.15.4 standard, these frequencies are aliased as channels 11 through 26. For all newly manufactured nodes, the default setting is 2.425 GHz (channel 15).

FCC ID: XJQMSLINK000
IC ID: 8505A-MSLINK000
Torque-Link-200

This device complies with Part 15 of the United States FCC Rules, and Industry Canada's license-exempt RSSs. Operation is subject to the following two conditions: 1) This device may not cause interference, and 2) This device must accept any interference, including interference that may cause undesired operation of the device. Changes or modifications, including antenna changes not expressly approved by LORD Corporation could void the user's authority to operate the equipment.

Cet appareil est conforme à la Partie 15 des Règles de la FCC des États-Unis et aux RSSS exempts de licence d'Industrie Canada. Le fonctionnement est soumis aux deux conditions suivantes: 1) Cet appareil ne doit pas causer d'interférences et 2) Cet appareil doit accepter toute interférence, y compris les interférences pouvant entraîner un fonctionnement indésirable de l'appareil. Les changements ou modifications, y compris les changements d'antenne non expressément approuvés par LORD Corporation, pourraient annuler l'autorisation de l'utilisateur d'utiliser l'équipement.

13.6 Frequency Setting

NOTES: The gateway can automatically manage nodes operating on different frequencies by using the Node Discovery feature in SensorConnect. In this routine, the gateway listens for node broadcasts on the frequency channel to which it is set.

If the node is in normal boot-up mode, it will provide the broadcast when it is initially powered on, and it will broadcast on all channels. As long as the node is powered on after activating the Node Discovery feature, the gateway will link to it and remember the channel setting for future node queries.

Manually matching the node and gateway frequency channels is required in some applications. For example, when sending broadcast messages from the gateway to multiple nodes (including the synchronized sampling beacon) all nodes must be on the same channel as the gateway in order to receive the broadcast.

Assigning channels is also a good idea when multiple gateways are attached to one host computer or when other wireless equipment is nearby and frequency or transmission interference may occur.

14. Safety Information

This section provides a summary of general safety precautions that must be understood and applied during operation and maintenance of components in the LORD Sensing Wireless Sensor Network.

14.1 Battery Hazards

⚠WARNING **⚠CAUTION** ***NOTICE***

The Torque-Link-200 contains internal, non-rechargeable Lithium Iron Disulfide (Li/FeS_^{2}) batteries. Li/FeS_^{2} batteries are a fire and explosion hazard. Do not store or operate the node at temperatures above 212°F (100°C). Do not disassemble, short circuit, crush, puncture, or otherwise misuse the battery. Do not attempt to recharge the batteries. Do not expose the batteries to water.

When replacing batteries, use only the batteries specified for the node. Follow the battery installation instructions, observing polarity and battery orientation and taking care not to short circuit the battery terminals.

Li/FeS_^{2} batteries contain toxic chemicals that are harmful to humans and the environment. Disposal is subject to federal and local laws. Do not discard the battery or the node in the trash. Follow proper battery disposal protocol, or contact LORD Sensing Technical Support for information on extracting the battery or returning the product for proper recycling and disposal.

14.2 Disposal and Recycling

⚠WARNING **⚠CAUTION** ***NOTICE***

The Torque-Link-200 contains internal batteries, printed circuit boards , and electronic components. These items are known to contain toxic chemicals and heavy metals that are harmful to humans health and the environment. Disposal is subject to federal and local laws. Do not discard the device or batteries in the trash. Follow proper electronic and battery waste disposal protocol, as dictated by federal and local authorities. Some states have programs for extracting reusable parts for recycling.

15. References

15.1 Related Documents

References are available on the LORD Sensing website including product user manuals, technical notes, and quick start guides. They may provide more accurate information than printed or file copies.

Document	Where to find it
Online Wireless Network Calculator	http://sensorcloud.com/?onlyCalc=true
Node Commander Software User Manual	http://www.microstrain.com/support/docs
SensorCloud Overview	http://www.sensorcloud.com/
SensorCloud Pricing	http://sensorcloud.com/pricing
MathEngine® Overview	http://www.sensorcloud.com/mathengine
LORD Sensing Wireless Sensors Network Software Development Kit	https://github.com/LORD-MicroStrain/SensorCloud
Product Datasheets	http://www.microstrain.com/wireless/sensors
Product Manuals and Technical Notes	http://www.microstrain.com/support/documentation
Product Application Notes	http://www.microstrain.com/applications
NIST Calibration Procedures	http://www.nist.gov/calibrations/
ASTM Testing Procedures	http://www.astm.org/Standard/standards-and-publications.html
ASTM Strain Gauge Installation Guide ASTM E1237-93	http://www.astm.org/Standards/E1237.htm

Table 8. Related Documents

16. GLOSSARY

A

A/D Value
The digital representation of analog voltages in an analog-to-digital (A/D) conversion. The accuracy of the conversion is dependent on the resolution of the system electronics. Higher resolution produces a more accurate conversion.

Acceleration
The change in the rate of speed (velocity) of an object over time.

Accelerometer
A sensor used to detect and measure magnitude and direction of an acceleration force (g-force) in reference to its sensing frame. For example, at rest perpendicular to the Earth's surface an accelerometer will measure 9.8 meters/second squared as a result of gravity. If the device is tilted the acceleration force will change slightly, indicating tilt of the device. When the accelerometer is moving it will measure the dynamic force (including gravity).

Adaptive Kalman Filter (AKF)
A type of Extended Kalman Filter (EKF) that contains an optimization algorithm that adapts to dynamic conditions with a high dependency on adaptive technology. Adaptive technology refers to the ability of a filter to selectively trust a given measurement more or less based on a trust threshold when compared to another measurement that is used as a reference. Sensors with estimation filters that rely on adaptive control elements to improve their estimations are referred to as an AKF.

AHRS (Attitude and Heading Reference System)
A navigation device consisting of sensors on the three primary axes used to measure vehicle direction and orientation in space. The sensor measurements are typically processed by an onboard algorithm, such as an Estimation Filter, to produce a standardized output of attitude and heading.

Algorithm
A step-by-step process used for calculations.

Altitude
The distance an object is above the sea level.

Angular rate
The rate of speed of which an object is rotating. Also known as angular frequency, angular speed, or radial frequency. It is typically measured in radians/second.

API (Applications Programming Interface)
A library and/or template for a computer program that specifies how components will work together to form a user application: for example, how hardware will be accessed and what data structures and variables will be used.

ASTM (Association of Standards and Testing)
A nationally accepted organization for the testing and calibration of technological devices.

Attitude
The orientation of an object in space with reference to a defined frame, such as the North-East-Down (NED) frame.

Azimuth
A horizontal arc measured between a fixed point (such as true north) and the vertical circle passing through the center of an object.

B

Bias
A non-zero output signal of a sensor when no load is applied to it, typically due to sensor imperfections. It is also called offset.

C

Calibration
To standardize a measurement by determining the deviation standard and applying a correction, or calibration, factor.

Complementary Filter (CF)
A term commonly used for an algorithm that combines the readings from multiple sensors to produce a solution. These filters typically contain simple filtering elements to smooth out the effects of sensor over-ranging or anomalies in the magnetic field.

Configuration
A general term applied to the sensor indicating how it is set up for data acquisition. It includes settings such as sampling rate, active measurements, measurement settings, offsets, biases, and calibration values.

Convergence
When mathematical computations approach a limit or a solution that is stable and optimal.

D

Data Acquisition
The process of collecting data from sensors and other devices.

Data Logging
The process of saving acquired data to the system memory, either locally on the device, or remotely on the host computer.

Data rate
The rate at which sampled data is transmitted to the host.

Delta-Theta
The time integral of angular rate expressed with reference to the device local coordinate system, in units of radians.

Delta-velocity
The time integral of velocity expressed with reference to the device local coordinate system, in units of g*second where g is the standard gravitational constant.

E

ECEF (Earth Centered Earth Fixed)
A reference frame that is fixed to the earth at the center of the earth and turning about earth's axis in the same way as the earth.

Estimation Filter
A mathematical algorithm that produces a statistically optimum solution using measurements and references from multiple sources. Best known estimation filters are the Kalman Filter, Adaptive Kalman Filter, and Extended Kalman Filter.

Euler angles
Euler angles are three angles use to describe the orientation of an object in space such as the x, y and z or pitch, roll, and yaw. Euler angles can also represent a sequence of three elemental rotations around the axes of a coordinate system.

Extended Kalman Filter (EKF)
Used generically to describe any estimation filter based on the Kalman Filter model that can handle non-linear elements. Almost all inertial estimation filters are fundamentally EKFs.

G

GNSS (Global Navigation Satellite System)
A global network of space-based satellites (GPS, GLONASS, BeiDou, Galileo, and others) used to triangulate position coordinates and provide time information for navigational purposes.

GPS (Global Positioning System)
A U.S. based network of space-based satellites used to triangulate position coordinates and provide time information for navigational purposes.

Gyroscope
A device used to sense angular movements such as rotation.

H

Heading
An object's direction of travel with reference to a coordinate frame, such as latitude and longitude.

Host (computer)
The host computer is the computer that orchestrates command and control of attached devices or networks.

I

IMU
Inertial Measurement System

Inclinometer
Device used to measure tilt, or tilt and roll.

Inertial
Pertaining to systems that have inertia or are used to measure changes in inertia as in angular or linear accelerations.

INS (Inertial Navigation System)
Systems that use inertial measurements exclusively to determine position, velocity, and attitude, given an initial reference.

K

Kalman Filter
A linear quadratic estimation algorithm that processes sensor data or other input data over time, factoring in underlying noise profiles by linearizing the current mean and covariance to produces an estimate of a system's current state that is statistically more precise than what a single measurement could produce.

L

LOS (Line of Sight)
Describes the ideal condition between transmitting and receiving devices in a wireless network. As stated, it means they are in view of each other with no obstructions.

M

Magnetometer

A type of sensor that measures the strength and direction of the local magnetic field with reference to the sensor frame. The magnetic field measured will be a combination of the earth's magnetic field and any magnetic field created by nearby objects.

MEMS (Micro-Electro-Mechanical System)

The technology of miniaturized devices typically made using micro fabrication techniques such as nanotechnology. The devices range in size from one micron to several millimeters and may include very complex electromechanical parts.

N

NED (North-East-Down)

A geographic reference system.

O

OEM

Acronym for Original Equipment Manufacturer.

Offset

A non-zero output signal of a sensor when no load is applied to it, typically due to sensor imperfections. Also called bias.

Orientation

The orientation of an object in space with reference to a defined frame. Also called attitude.

P

Pitch

Pitch occurs when vertical force is applied at a distance forward or aft from the center of gravity of the platform, causing it to move up or down with respect to the sensor or platform frame origin.

Position

The spatial location of an object.

PVA

Position, Velocity, Attitude.

Q

Quaternion
Mathematical notation for representing orientation and rotation of objects in three dimensions with respect to the fixed earth coordinate quaternion. Quaternions convert the axis–angle representation of the object into four numbers and to apply the corresponding rotation to a position vector representing a point relative to the origin.

R

Resolution
In digital systems, the resolution is the number of bits or values available to represent analog voltages or information. For example, a 12-bit system has 4096 bits of resolution and a 16-bit system has 65536 bits.

RMS
Root Mean Squared.

Roll
Roll occurs when a horizontal force is applied at a distance right or left from the center of gravity of the platform, causing it to move side to side with respect to the sensor or platform frame origin.

RPY
Roll, Pitch, Yaw.

RS232
A serial data communications protocol.

RS422
A serial data communications protocol.

S

Sampling
The process of taking measurements from a sensor or device.

Sampling Rate
Rate at which the sensors are sampled.

Sampling Rate
The frequency of sampling.

Sensor
A device that physically or chemically reacts to environmental forces and conditions and produces a predictable electrical signal as a result.

Sigma
In statistics, sigma is the standard deviation from the mean of a data set.

Space Vehicle Information
Refers to GPS satellites.

Streaming
A device sending data at a specified data rate continuously, without requiring a prompt from the host.

U

USB (Universal Serial Bus)
A serial data communications protocol.

UTC (Coordinated Universal Time)
The primary time standard for world clocks and time, similar to Greenwich Mean Time (GMT).

V

Vector
A measurement with direction and magnitude with reference from one point in space to another.

Velocity
The rate of change of position with respect to time, also called speed.

W

WAAS (Wide Area Augmentation System)
An air navigation aid developed to allow aircraft to rely on GPS for all phases of flight, including precision approaches to any airport.

WGS (World Geodetic System)
A protocol for geo-referencing such as WGS-84.

Y

Yaw
Yaw occurs when rotational force is applied at a distance forward or aft from the center of gravity of the platform, causing it to move around the center axis of a sensor or platform frame origin.

17. Repair and Support

17.1 Repair and Calibration

General Instructions

In order to return any LORD Sensing product, you must contact LORD Sensing Sales or Technical Support to obtain a Return Merchandise Authorization (RMA) number. All returned merchandise must be in the original packaging, including manuals, accessories, cables, etc. with the RMA number clearly printed on the outside of the package. Removable batteries should be removed and packaged in separate protective wrapping. Please include the LORD Sensing model number and serial number, as well as your name, organization, shipping address, telephone number, and email. Normal turnaround for RMA items is seven days from receipt of item by LORD Sensing.

Warranty Repairs

LORD Sensing warrants its products to be free from defective material and workmanship for a period of one (1) year from the original date of purchase. LORD Sensing will repair or replace, at its discretion, a defective product if returned to LORD Sensing within the warranty period. This warranty does not extend to any LORD Sensing products that have been subject to misuse, alteration, neglect, accident, incorrect wiring, mis-programming, or use in violation of operating instructions furnished by LORD Sensing. It also does not extend to any units altered or repaired for warranty defect by anyone other than LORD Sensing.

Non-Warranty Repairs

All non-warranty repairs/replacements include a minimum charge. If the repair/replacement charge exceeds the minimum, LORD Sensing will contact the customer for approval to proceed beyond the minimum with the repair/replacement.

17.2 Technical Support

There are many resources for product support found on the LORD Sensing website including technical notes, FAQs, and product manuals.

http://www.microstrain.com/support_overview.aspx

For further assistance our technical support engineers are available to help with technical and applications questions.

Technical Support sensing_support@LORD.com

Phone: 802-862-6629

Live Chat is available from the website during business hours: 9:00 AM to 5:00 PM (Eastern Time US & Canada)

17.3 Sales Support

Products can be ordered directly from the LORD Sensing website by navigating to the product page and using the Buy feature.

http://www.microstrain.com/inertial

For further assistance, our sales team is available to help with product selection, ordering options, and questions.

Sales Support sensing_sales@LORD.com

Phone: 802-862-6629

9:00 AM to 5:00 PM (Eastern Time US & Canada)

18. Safety

WARNING

PERSONAL INJURY

DO NOT USE these products as safety or emergency stop devices or in any other application where failure of the product could result in personal injury.

Failure to comply with these instructions could result in death or serious injury.

WARNING

IMPROPER INSTALLATION

Consult with local safety agencies and their requirements when designing a machine-control link, interface, and all control elements that affect safety.

Strictly adhere to all installation instructions.

Failure to comply with these instructions could result in death or serious injury.