

SHM-Link-201

Ruggedized Wireless Structural Health Monitoring Node

NODE OVERVIEW

The SHM-Link-201 structural health monitoring node is used for in-situ, multidimensional measurement and analysis of component strain and fatigue. The SHM-Link-201 has three input channels and is designed to integrate with field-installed strain gauge rosettes.

The SHM-Link-201 embedded processing algorithms provide sophisticated data outputs, including damage estimations using user-configurable strain number curves, estimations along various user-configurable angles, and an ASTM e1049 rainflow-counting histogram output. Sampling modes include continuous and activity-sense. The SHM-Link-201 is designed for extended use with a lithium battery.

To acquire sensor data, the SHM-Link-201 is used with any LORD Sensing data gateway, such as the WSDA[®] -Base -10x -LXRS[®], or the network-ready WSDA[®] -1500 - LXRS[®]. The SensorConnect software interface is used for node configuration, and SensorCloud™ is available for advanced data visualization, aggregation, and analysis. Users can also build custom software interfaces with the MicroStrain Communications Library (MSCL).



Figure 1 - Wireless Sensor Node

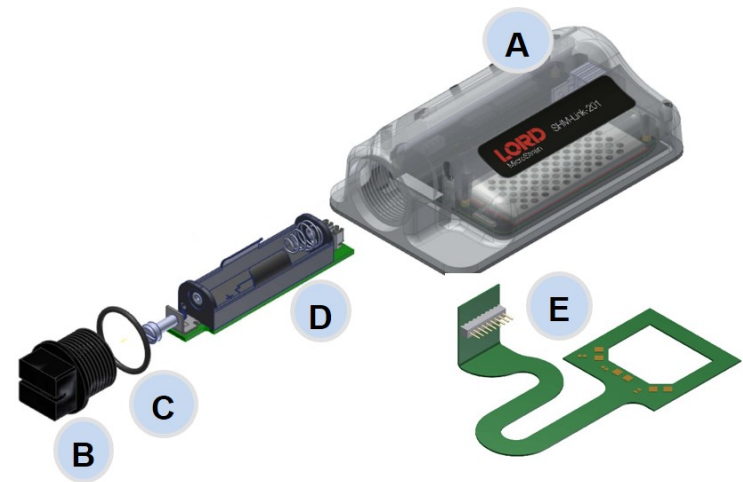
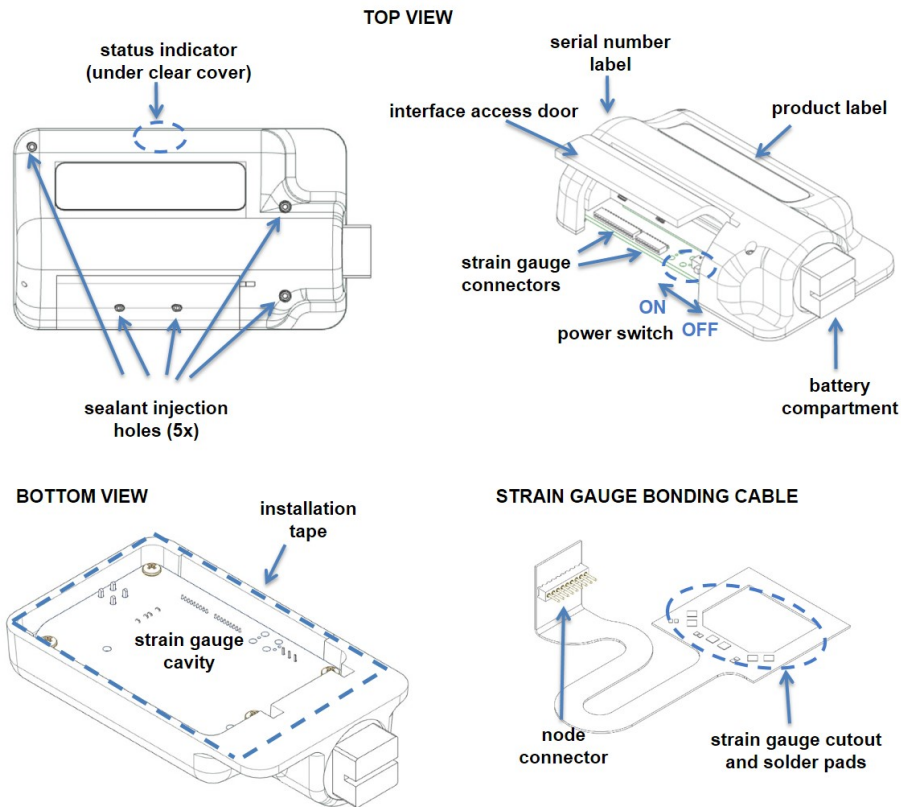


Figure 2 - Node Components

Item	Description	Quantity
A	SHM-Link-201 node assembly	1
B	Battery compartment cap	1
C	Battery compartment o-ring	1
D	Battery tray	1
E	Strain gauge bonding cable	1
F	Dielectric grease (not shown)	1

Table 1 - Component List

The SHM-Link-201 interfaces includes a battery compartment and accommodations for strain gauges and node installation. A device status indicator is visible through a light-pipe below the product label.



Indicator	Behavior	Node Status
Device status indicator	OFF	Node is OFF
	Rapid multi-color flash on start-up	Node is booting up
	Slow pulse ~ once/2 sec	Node is idle and waiting for a command
	Quick blink ~ once/sec	Node is sampling
	Quick blink ~ once/10 sec	Node is in sleep mode

Table 1 - Indicator Behaviors

NODE DEPLOYMENT

The SHM-Link-201 is designed for use with the provided bonding cable. The cable connects the node and strain gauges in a way that allows the gauges to fit underneath the node in the strain gauge cavity, protected from damage. The strain gauge cavity can also be sealed after installation. The following procedure outlines this process. These steps may not be necessary for all applications but provide the best protection for the node circuitry and the gauges.

Install the Node Battery



WARNING

The SHM-Link-201 operates on an internal AA-type battery with a voltage between 1 V dc and 5 V dc. Use only batteries that meet this specification. Do not short circuit, crush, puncture, or otherwise misuse the battery. Disposal is subject to federal and local laws.

1. Remove the SHM-Link-201 battery compartment cap.
2. Position a pliers or a hook-ended tool behind the battery tray screw-head. Pull firmly outward, or leverage the edge of the housing, to release the tray from the terminals inside. It should unseat and slide out.

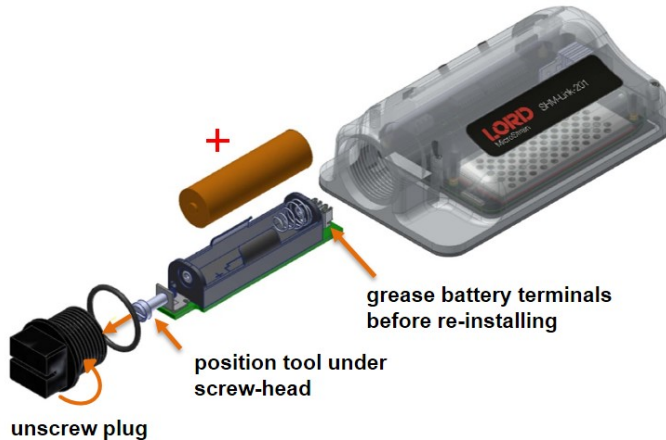


Figure 3 - Battery Compartment Assembly

3. Apply dielectric grease to the battery tray terminals.
4. Install the battery.
5. Firmly re-seat the battery tray in the battery compartment
6. Install the compartment cap, ensuring the o-ring remains intact and properly seated.

Test Fit Node and Gauge Assembly

7. Determine the location of the component to be monitored where the strain gauges will be installed.
8. Place the bonding cable and node in the chosen location to verify gauge placement and that there is space for the node to fit over the top of them. The gauges are installed in the cable cutout, and the node strain gauge cavity fits over the gauges and cable.

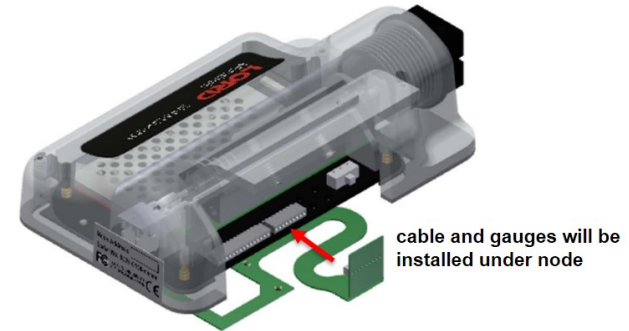


Figure 4 - Gauge and Node Location

Install Strain Gauges

NOTE

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

9. Wire the strain gauges to the bonding cable so that the strain gauge assembly will be positioned in the central cutout .
10. Bond the cable and strain gauges onto the surface of the component to be monitored with strain gauge adhesive or equivalent. Install the gauges in the desired orientation for measurement and in accordance with the strain gauge manufacturers installation instructions.

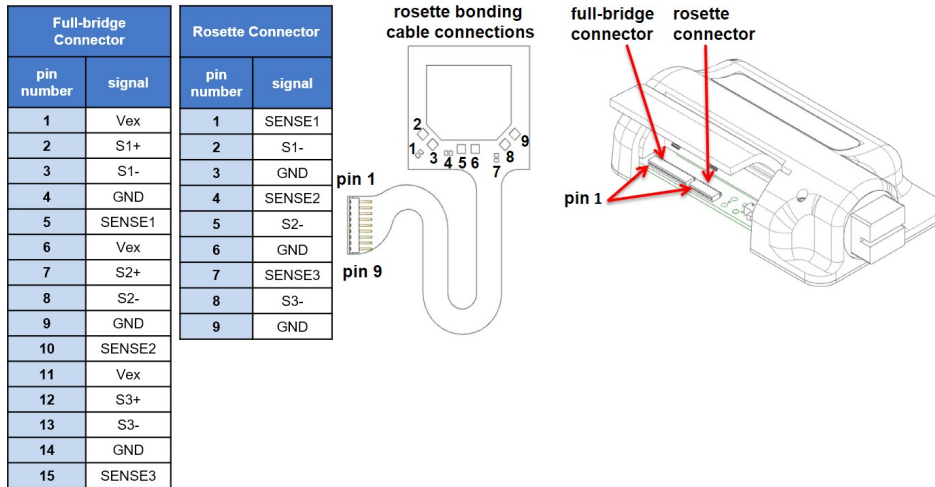


Figure 5 - Strain Gauge Wiring

Connect Node to Strain Gauges and Test

11. Connect the node to the strain gauge assembly. Attach the bonding cable to one of the node connectors in the orientation shown. Two are provided for node positioning convenience and have identical pins. The cable should lay flat against the bottom of the node circuit board and wrap up the edge of it to plug into the connector.
12. Place the node over the strain gauge assembly and verify the strain gauge cavity covers the strain gauge assembly without damaging it.

13. Test the strain gauge installation and basic node functioning by performing an auto-calibration in SensorConnect (See [Calibrate the Node on page 7](#)).



Figure 6 - Connecting to the Node

Install and Seal the Node

14. Remove the node battery or put it in sleep mode (to conserve battery life). Verify the node power switch is in the ON position. Once the node is sealed, the access door will no longer open.
15. Close the node interface access door and remove the installation tape backing from the bottom of the node. Adhere the node in place over the gauges.
16. Apply a high-strength adhesive sealant (such as Sikaflex® 255 FC or equivalent) around the perimeter of the node where it meets the component surface.
17. Remove the set screws from the sealant injection hole, and fill the strain gauge cavity with a flexible, injectable sealant (such as Self-Levling Green, or equivalent). Avoid over-filling the sealant and allowing it to leak into other cavities (such as the battery compartment and under the access door). This is more likely to happen if the node is mounted vertically.

Make System Connections

To acquire sensor data, the SHM-Link-201 is used with a LORD Sensing data gateway such as the WSDA[®]-200-USB or WSDA[®] -1500 - LXRS[®]. Connect the gateway to the computer or network and to a power source as required. Refer to the gateway user manual for more information.

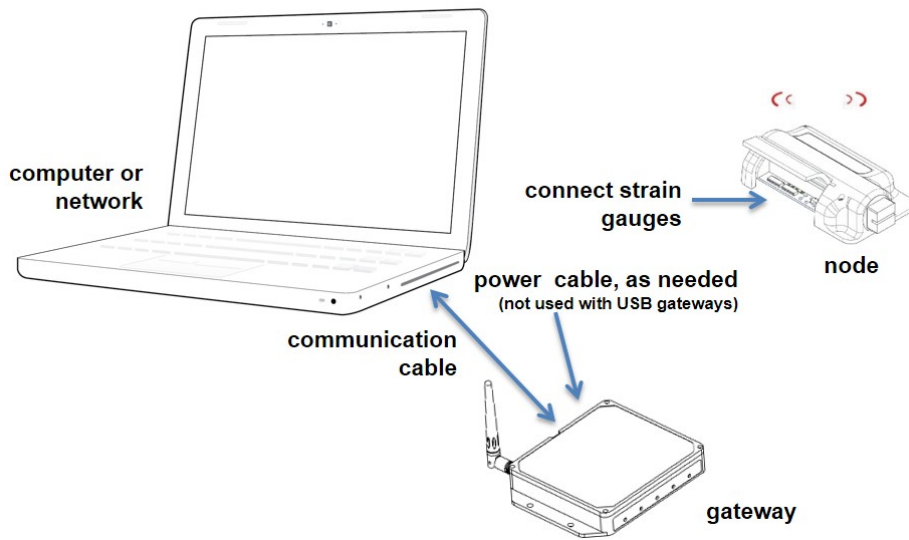


Figure 7 - System Connections

Node Operational Modes

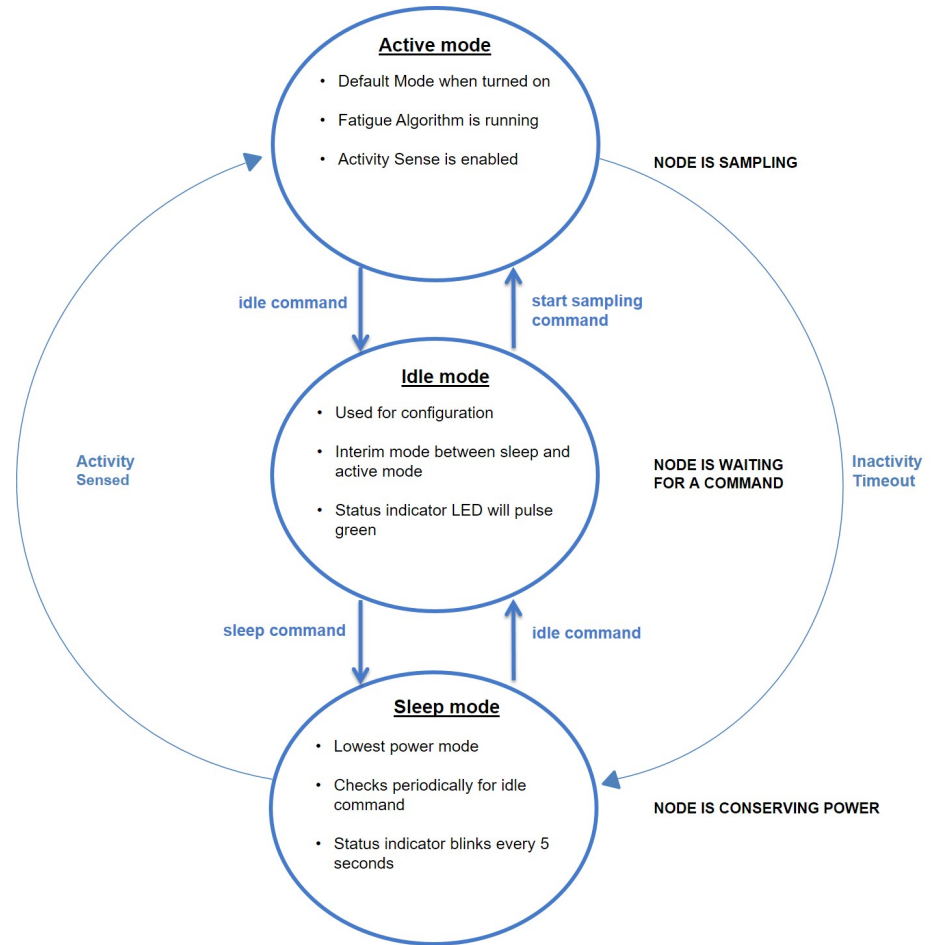


Figure 8 - Node Operational Modes

Synchronized Sampling

Use the Base Station menu to start sampling for multiple nodes in Synchronized Sampling mode. For single nodes, or non-synchronized sampling, the node menu can be used.

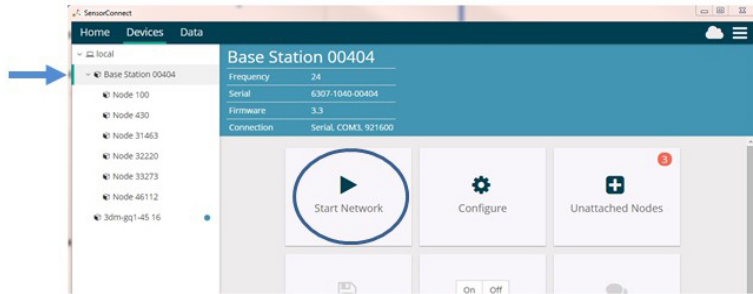


Figure 9 - Base Station Menu

Software Installation and Navigation

SensorConnect can be installed on any Windows operating system (Vista or newer). The installer is downloaded from the LORD Sensing website and is also provided with many products.

There are three main pages: Home, Devices, and Data, which are always accessible at the top of page. A quick-link to the SensorCloud™ platform log-in and a software settings menu is also available here. On start-up the software scans for attached sensors and then opens the home page.

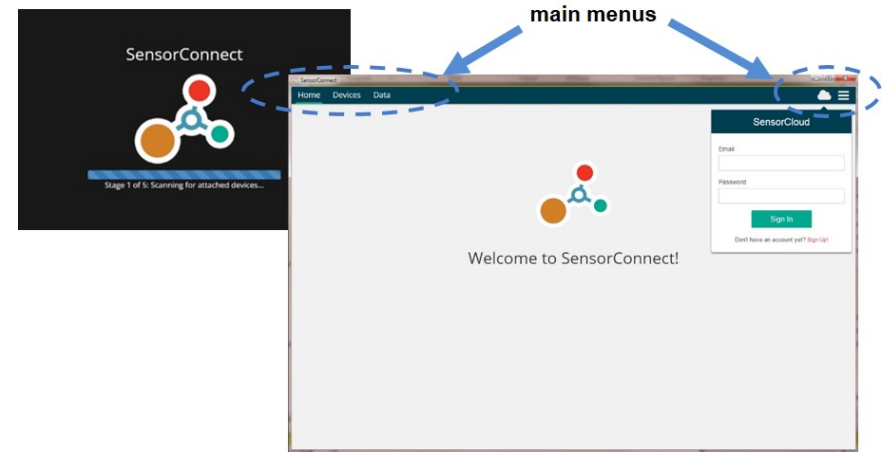


Figure 10 - SensorConnect Home Page

SensorConnect automatically detects any LORD Sensing device plugged into an active port. Device connections are managed on the Devices page. The menu options will vary between devices (such as gateways, nodes, and sensors) but have similar interfaces.

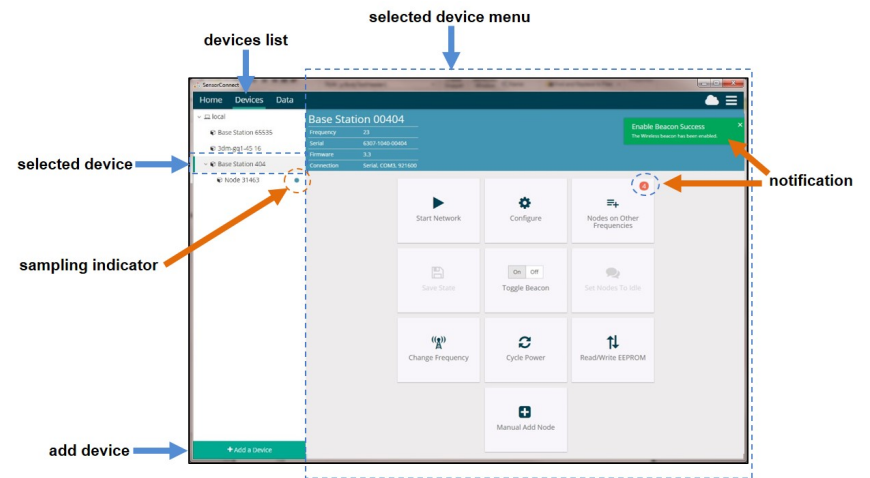


Figure 11 - Devices Page

Devices list - Found devices appear in the device list. This list also includes previously found devices even when the software is restarted.

Selected device and device menu - Each type of device has its own menu. Once selected, the device name is highlighted, and the corresponding menu displayed. Menu options vary between devices but typically include device configuration, start sampling, sensor mode selections, and data downloading. Click on the device name (in the devices list) to get back to the main device menu.

Add Device - Manually add a device if it does not appear automatically. .

Notifications and indicators - information specific to a device, or in response to a requested action, appears next to the applicable device name in the device list, or in the device menu. These notifications provide information about device performance, such as communication and sampling status. Green typically indicates confirmed actions, while orange indicates information that may require further action. Blue indicates they are currently sampling.

Configure the Node

Power settings, some sampling settings, data output options, and gauge settings specific to the SHM-Link-201 are adjustable through the Configure menu. All other settings are adjusted when sampling is started. Click Apply to save changed settings.

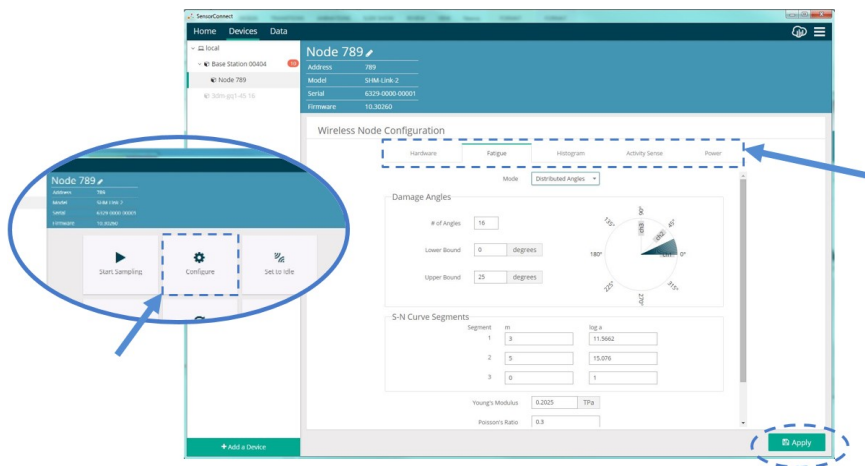


Figure 12 - Configure Menu

Hardware - Set the strain gauge provided by the gauge manufacturer.

Fatigue - Select from data output options that produce fatigue measurements.

Histogram - Set the rainflow-counting bin thresholds and data transmit rate. Data will still be collected at the rate set in the Start Sampling menu.

Activity Sense - Activity sense mode is power-saving mode. When enabled, sampling will only occur when movement is detected by the internal accelerometer. Sampling will occur at the rate set in the Start Sampling menu until the (also configurable) inactivity period has passed.

Power - Set the node transmit power, radio-check interval (when the node goes into sleep mode), and the inactivity timeout.

Calibrate the Node

Calibration of the SHM-Link-201 is done through an internal circuit. With the strain gauges connected, simply open the Auto-Calibrate menu, and select the Calibrate button. This will calibrate all three channels automatically. If the gauges are connected correctly, and the calibration is completed, "Success" will be indicated in the status column. Otherwise it will indicate the sensor is detached.

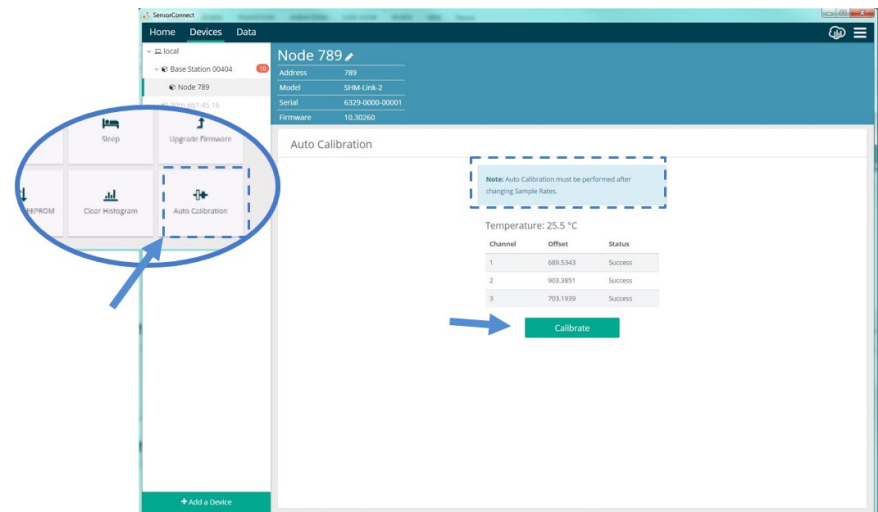


Figure 13 - Calibration Menu

NOTICE

IMPORTANT: Auto-calibration must be performed anytime sampling settings are changed.

Start Sampling

Data sampling is initiated for each device through its device menu. For a wireless sensor network, sampling can also be started for the entire network by initiating sampling from the network gateway menu. The sampling menu options vary depending on the type of device.

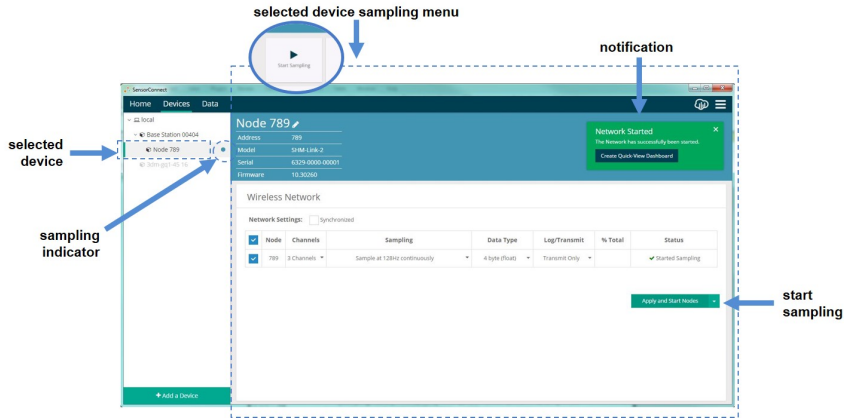


Figure 14 - Sampling Menu

Sampling menu - The sampling menu typically includes options for sampling mode, sample rate, and sample duration. Apply the settings to begin collecting data.

Sampling indicator - The sampling indicator shows when data is being collected from the device. At slow sampling rates it will turn on and off as readings are taken, while at fast sampling rates it will be on continuously.

Create Data Views

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.

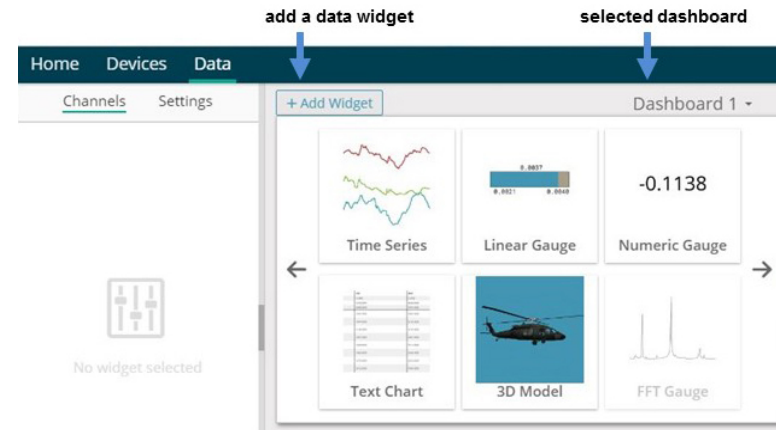


Figure 15 - Data Page

Use the mouse along with the 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 and drag left/right	Zoom window left/right
Shift + mouse left-click and drag up/down	Zoom window up/down
Ctrl + mouse left-click and drag	Zoom box

Table 2 - Graph View Controls

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.



Figure 16 - Widget Configuration Menu

Connect to SensorCloud™

For global data aggregation, visualization, and analysis, data can be uploaded to the SensorCloud web platform. Basic SensorCloud services are available to all users free of charge.

Go to the SensorCloud website and select sign-in to enter the log-in credentials, or register as a new user if needed.

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

The screenshot shows the 'SensorCloud Login' form with fields for 'Email' and 'Password', a 'Forgot your password?' link, and a 'Login' button. At the bottom, there is a link for 'Don't have an account? Sign Up now!'.

Figure 17 - 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. The Data and Settings views are only available once a device is selected from the device list.

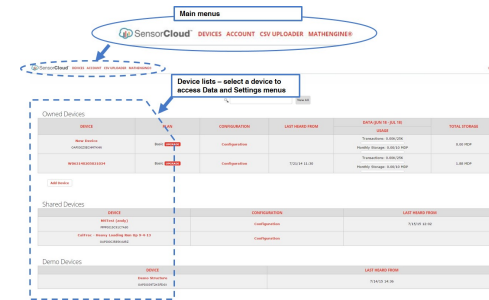


Figure 18 - SensorCloud™ Menu Views

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.

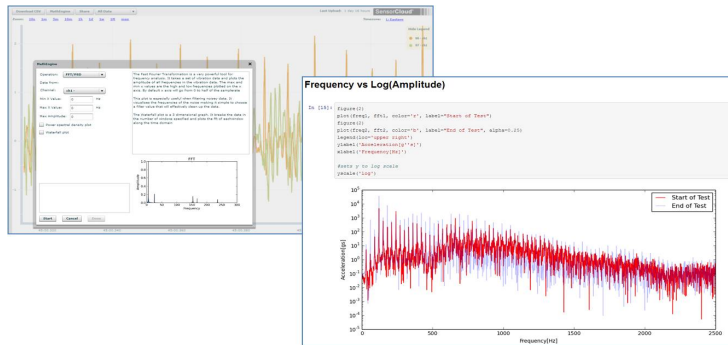


Figure 19 - MathEngine® View

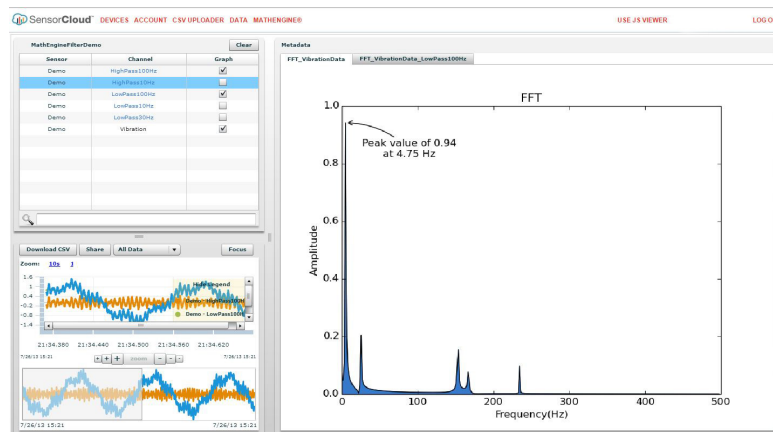


Figure 20 - FFT Graph in SensorCloud™

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

<http://sensorcloud.com>

Radio Specifications

The SHM-Link-201 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 16 separate frequencies ranging from 2.405 GHz to 2.480 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: XJQMSLINK0008

IC ID: 8505A-MSLINK0008

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.

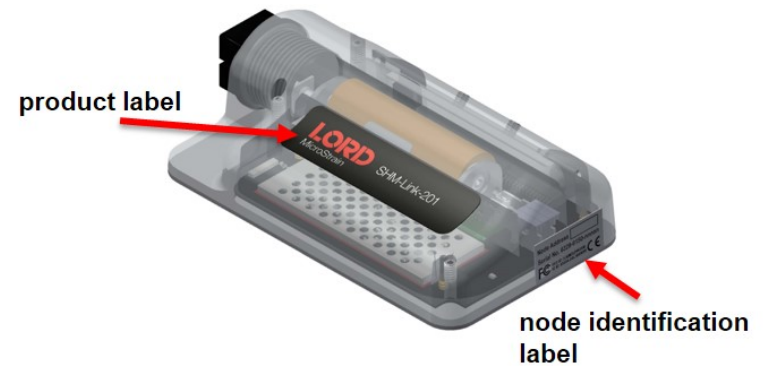


Figure 21 - SHM-Link-201 Identification Labels