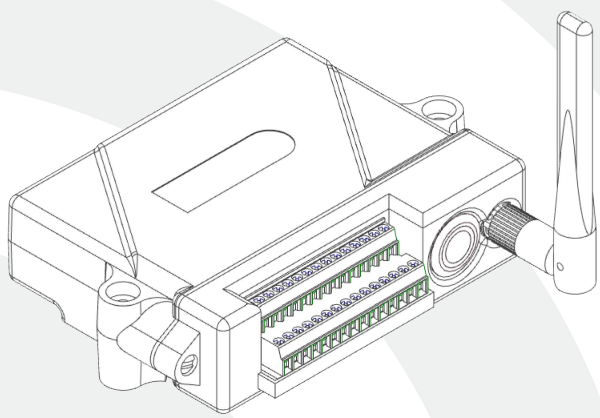
LORD USER MANUAL

V-Link-200

Wireless 8 Channel Analog Input Sensor Node



LORD SENSING MicroStrain

LORD Sensing Systems
459 Hurricane Lane
Suite 102
Williston, VT 05495
United States of America

Phone: 802-862-6629
Fax: 802-863-4093

http://www.microstrain.com
sensing_support@LORD.com
sensing_sales@LORD.com

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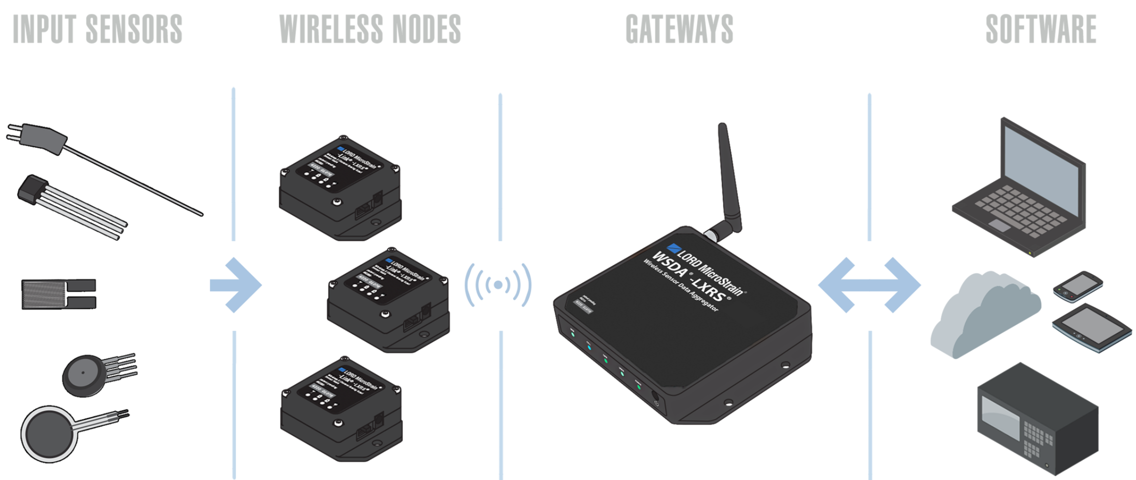
1. Wireless Sensor Network Overview

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 from up to two kilometers away. 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 allows interface with many types of sensors, including accelerometers, strain gauges, pressure transducers, load cells, torque and vibration sensors, magnetometers, 4 to 20mA 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 are IEEE 802.15.4-compliant and 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 Sensing Systems are strain sensor measurement, accelerometer platforms, vibration monitoring, energy monitoring, environmental monitoring, and temperature monitoring.

2. Node Overview

The V-Link-200 wireless sensor node features eight analog input channels designed to accommodate a wide range of Wheatstone bridge and analog sensors, including strain, load cell, torque, pressure, acceleration, vibration, magnetic field, displacement, and geophones. There are four channels for single-ended sensor measurement, four channels for differential sensor measurement, and an on-board internal temperature sensor.

The V-Link-200 wireless accelerometer node features an on-board triaxial accelerometer that allows high-resolution data acquisition at noise levels as low as 25 µg√Hz, lossless data transmission and node-to-node synchronized sampling at ±50 microseconds. There are four derived channels including, Vrms, Arms, App, and Crest Factor which allow long-term monitoring of key performance indicators while maximizing battery life.

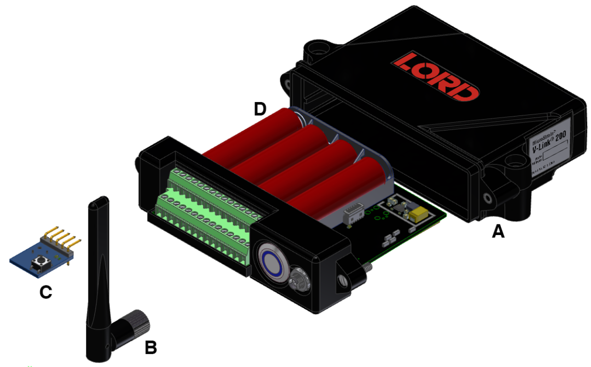
V-Link-200 inputs are 18-bit resolution with ± 0.1% full scale measurement accuracy. The node can log data to internal memory, transmit real-time synchronized data, and it supports event driven triggers with both pre- and post- event buffers.

To acquire sensor data, the V-Link-200 is used with a LORD Sensing data gateway such as the WSDA 101 or WSDA-1500 Base.

Figure 1 - V-Link-200 Wireless Sensor Node

2.1 Components List

V-Link-200 sensor nodes come with the following components and options. For a complete list of available configurations, accessories, additional system products and ordering information *see Parts and Configurations on page 84*.



Item	Description	Quantity
A	V-Link-200 Wireless Sensor Node	1
B	Antenna with right angle adapter	1
C	Node Tester Board	1
D	AA Lithium Batteries (3.6 V dc, 2.4 Ah)	43
--	Calibration Certificate	1

Table 1 - V-Link-200 Components List

2.2 Interface and Indicators

The indicators on the V-Link-200 include operational modes showing when the node is booting up, idle and waiting for a command, sampling, resynchronizing, or if there is an error. The following table describes basic indicator behavior.

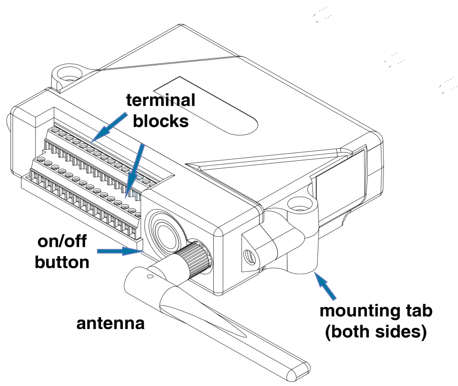


Figure 2 - Interface and Indicators

Indicator	Behavior	Node Status
Device status indicator	OFF	Node is OFF
	Rapid green flashing on start-up	Node is booting up
	1 (slow) green pulse per second	Node is idle and waiting for a command
	1 green blip every 2 seconds	Node is sampling
	Blue LED during sampling	Node is resynchronizing
	Red LED	Error

Table 2 - Indicator Behaviors

2.3 Node Diagnostics

In the Wireless Node Configuration menu under the Sampling tab, there are four user-set data points to provide information about the status of the Node.

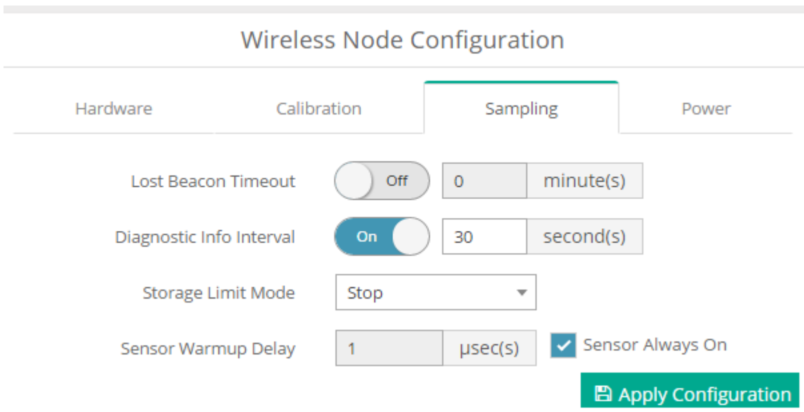


Figure 3 - Node Diagnostic Menu

- **Lost Beacon Timeout:** The time a node will search for a beacon before determining there is no base station connectivity. User-set between 2 minutes and 600 minutes
- **Diagnostic Info Interval:** The report rate of the diagnostic packet. User-set between 30 seconds and 65536 seconds. The following data channels are available.
    - **Current State:** The current state of the device when the Diagnostic Packet is sent.
        - 0 = Idle
        - 1 = Deep Sleep
        - 2 = Active Run
        - 3 = Inactive Run
    - **Run Time:** The number of seconds the Node has been in each state.
    - **Reset Counter:** The number of times the Node has reset.
    - **Low Battery Indicator:** If 1, a low battery event has been detected since the last Diagnostic Packet.

- **Sample Info:**
    - **Sweep Index:** The total number of sweeps (good and bad).
    - **Bad Sweep Count:** The total number of failed sweeps.
- **Transmit Info:**
    - **Total Transmissions:** Number of unique packets transmitted (not including retransmissions.)
    - **Total Retransmissions:** Number of retransmitted packets. Packets are retransmitted when a node does not receive acknowledgment from the base station.
    - **Total Dropped Packets:** Number of packets the Node has discarded due to buffer overflow, or exceeding the maximum number of retransmissions per packet.
- **Built in Test Result:** The result of the Built in Test function.
- **Event Trigger Index:** The index of the most recent Event Trigger logged to the Node. When this number changes, a new event has occurred.
- **External Power:** Flag indicating if external power is connected or not.
    - 0 = Not Connected
    - 1 = External Power Connected
- **Internal Temperature:** The internal temperature of the Node in degrees Celsius.

- **Storage Limit Mode:** Determines the behavior of the storage as either first in, first out (FIFO), or stops when the storage is full. Set at Stop by default with an Overwrite option in the drop down menu

- **Sensor Warm Up Delay:** The delay time before sampling after excitation is enabled. Sensor Always On is set by default and indicated by a check mark. To manually set this feature, uncheck the box and set between 1 µsecond and 66000 µseconds.

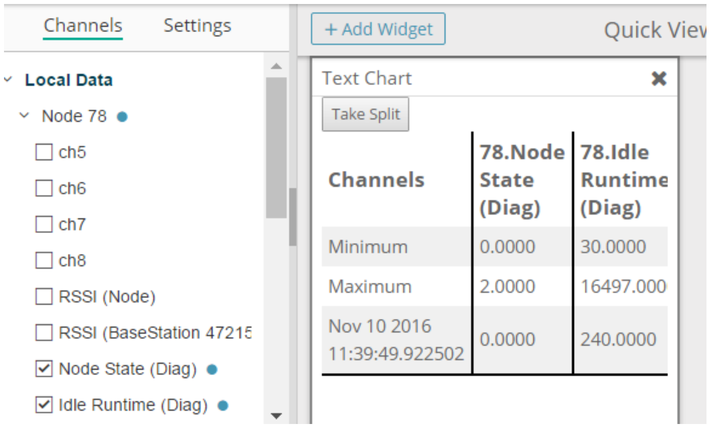


Figure 4 - Viewing Node Diagnostic Data

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. Idle mode is used for configuring node settings (such as frequency and sampling rates) and is the only way to stop sampling or go between active and sleep modes. Sleep mode is an ultra low-power mode. The node will automatically go into sleep mode after a user-determined period of inactivity. The node will not go into sleep mode while sampling.

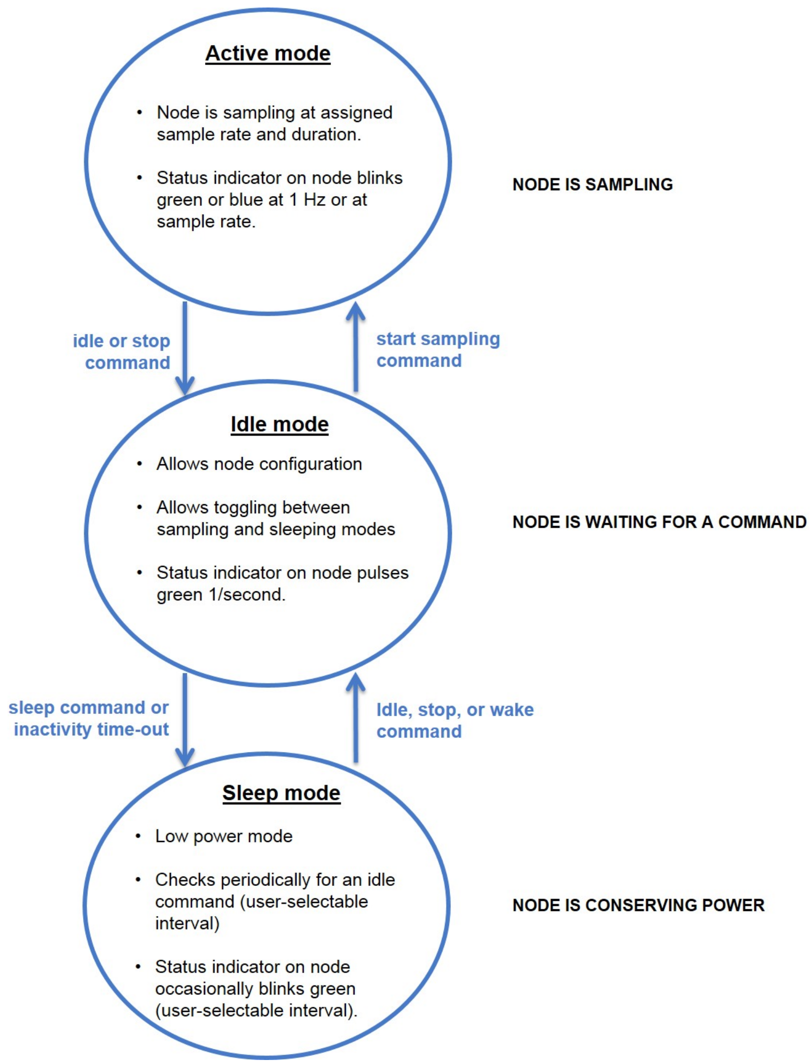


Figure 5 - Node Operational Modes

3. System Operational Overview

To acquire sensor data, nodes are used with any LORD Sensing data gateway, such as the WSDA-101 or WSDA-1500 Base, and a software interface.

LORD Sensing has two software programs available for data acquisition from the wireless sensor network: SensorCloud and SensorConnect. SensorCloud is an optional web-based data collection, visualization, analysis, and remote management platform based on cloud computing technology. SensorConnect is used for configuring gateways and nodes, selecting sampling modes and parameters, initializing data acquisition, and viewing and saving data.

The operational overview describes system hardware and software setup, and the basic navigation of SensorConnect used to configure the node and begin data acquisition. A brief overview of porting data to SensorCloud is also included. This section is included as a quick start guide and is not a complete demonstration of all system and software capabilities.

3.1 Software Installation

To install SensorConnect on the host computer, run the installer executable file and follow the on-screen prompts. The software is provided with all gateways and is also available on the LORD Sensing website (*see References on page 96*).

SensorCloud is an optional data collection, visualization, analysis, and remote management tool. It is based on cloud computing technology and is accessed directly from a web connection. Automatic, real-time data collection is available through Ethernet gateways, such as the WSDA-1500. Data files can also be uploaded. For more information *see Data Handling on page 27*.

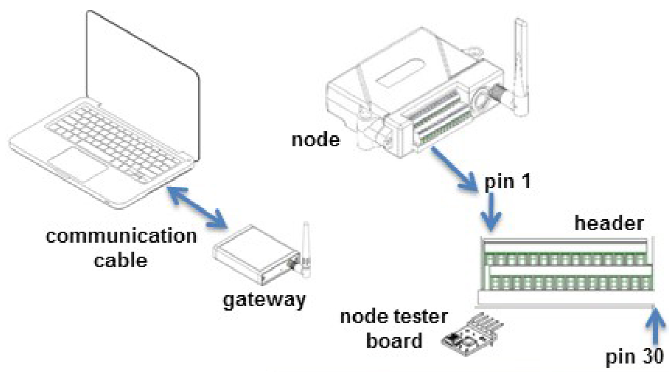
Users can also design custom programs with the open source data communications protocol (*see References on page 96*).

3.2 System Connections

To acquire sensor data the following components are needed: a LORD Sensing data gateway, and a host computer with access to the data acquisition software. For a connections overview refer to *3.2 System Connections*.

Nodes will communicate with any LORD Sensing data gateway. The sensor, node, gateway, and software selection are application-dependent, but the basic interfaces are the same. Communication protocols between the gateway and host computer vary depending on which model gateway is used, but they all require interface to a host computer or network. The WSDA-1500 gateway utilizes Ethernet communications and can be used with SensorConnect and SensorCloud, although system configuration is completed using SensorConnect.

Users can also write custom programs by utilizing the LORD Sensing Wireless Sensors Network Software Development Kit.



Node Pin Number	Signal	Node Pin Number	Signal
1	SP+	16	SP+
2	S1+	17	S4+
3	S1-	18	S4-
4	GND	19	GND
5	S1 S	20	S4 S
6	SP+	21	Ain5
7	S2+	22	GND
8	S2-	23	Ain6
9	GND	24	GND
10	S2 S	25	Ain7
11	SP+	26	GND
12	S3+	27	NC
13	S3-	28	NC
14	GND	29	GND
15	S3 S	30	Vin

terminal block connections

3.3 Gateway USB Communication

The WSDA-101-Base USB gateway is used in this example. For information on how to use other gateways, refer to the gateway or SensorConnect user manual (see References on page 96).

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

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

2. Open the SensorConnectsoftware. 

3. The gateway should appear in the Controller window automatically with a communication port assignment (Figure 6 - USB Gateway Communication). 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.

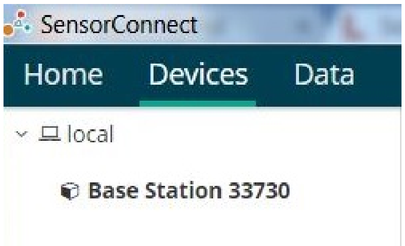


Figure 6 - USB Gateway Communication

3.4 Connect to Nodes

The node can be connected with the automatic node discovery feature and by manually entering the node address and then searching for it on the current gateway communication frequency.

1. In the automatic node discovery feature, if the base and node are on the same operating frequency, the node will populate below the Base Station listing when powering on the V-Link-200.

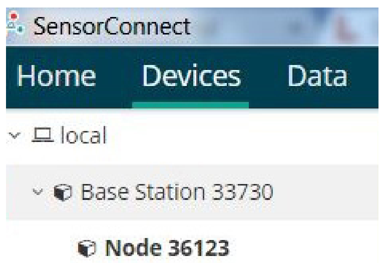


Figure 7 - Automatic Node Discovery

2. If a red circle with a number appears next to Base Station, select Nodes on Other Frequencies.

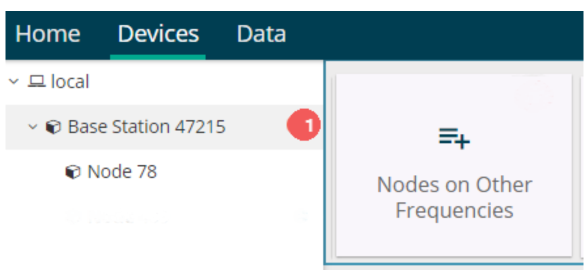


Figure 8 - Nodes On Other Frequencies

3. Highlight the new node being added. Select Move Node to Frequency (#).

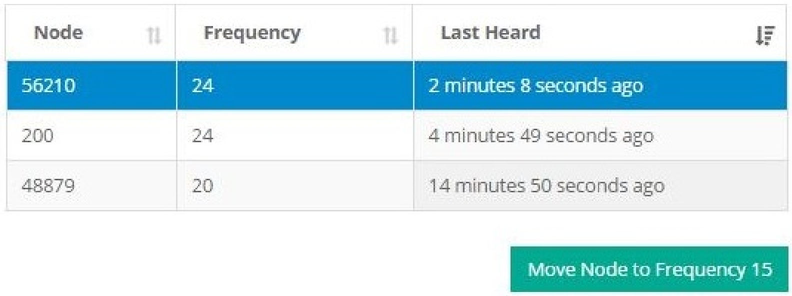


Figure 9 - Move Node

4. When manually entering the node address, select Manual Add Node, enter Node Address, last known Frequency (factory default is 15), and select Add Node.

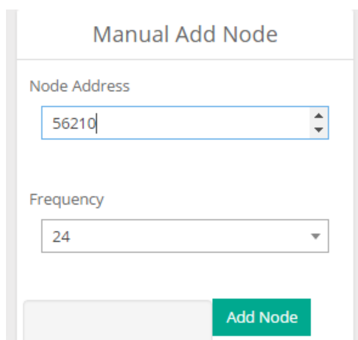


Figure 10 - Adding a Node by Address

> **NOTE**
>
> Automatic node discovery may not work in some boot-up modes. If the node is not in normal boot up mode, the assigned one can be bypassed to enable node discovery. For more information *see Troubleshooting Guide on page 71*.

3.5 Configure Node

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

For this example the V-Link-200 tester board is on channel 1.

1. Select Hardware > Input Range for channel 1, select +/-2 mV from the drop down menu.

2. Under Hardware Offset, select Balance Target for channel 1, select Mid (50%) from the drop down menu.

3. Select Auto-Balance. When auto-balance is complete, a blue information window will indicate the balance result.

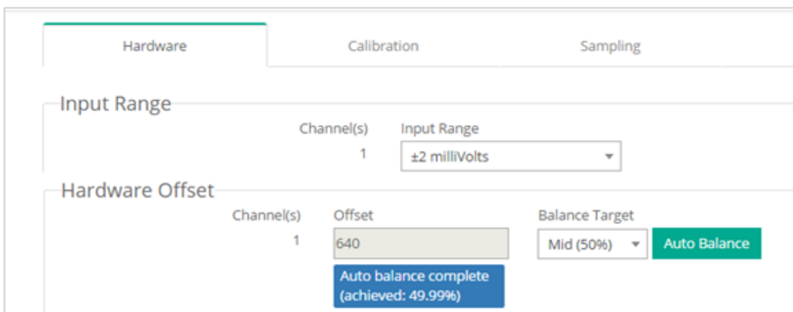


Figure 11 - Auto-Balance

4. Select Calibration.

5. Select Microstrain from the Unit drop down menu, and select the Shunt Cal button enabled on the right.

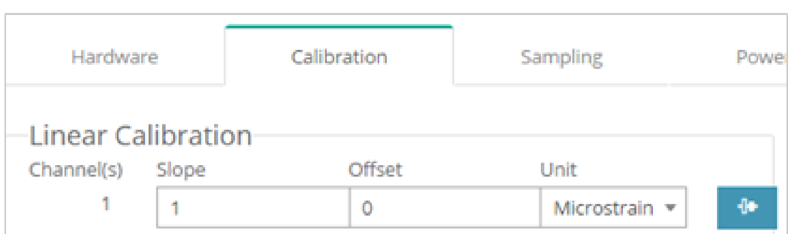


Figure 12 - Node Configuration Menu

6. Use the following settings:
    a. **Calibration Mode:** Internal
    b. **Number of Active Gauges:** 4
    c. **Gauge Factor:** 2
    d. **Gauge Resistance:** 1000
    e. **Shunt Resistance:** 499000
7. Select Start Shunt Cal for Slope and Offset calibrations.
8. Select Accept Calibration.

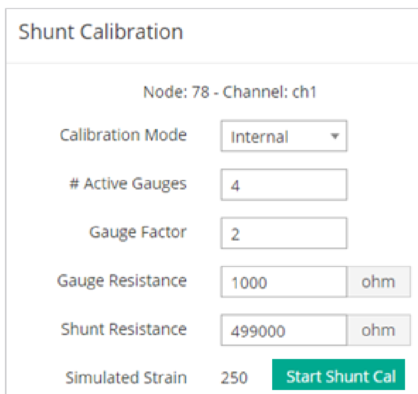


Figure 13 - Channel Settings

9. When the calibration is complete, the Wireless Node Configuration window will appear.
10. Select Apply Configuration to write to node memory.

For this example, the V-Link-200 is using the default settings found under Configure > Hardware, see *Figure 14 - Node Configuration*

Input Range: ± 2 G's (acceleration)

Low Pass Filter: 1,000 Hz

High Pass Filter: Disabled

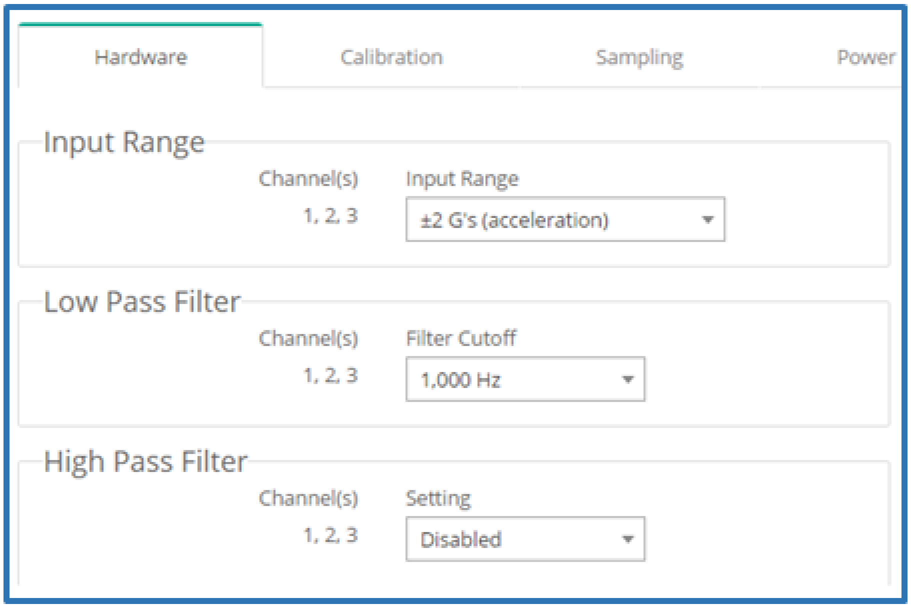


Figure 14 - Node Configuration

3.6 Sampling Configuration

To start a sampling session, nodes can be selected individually by selecting the Node > Start Sampling, or as a group by selecting the Base Station > Start Sampling. As a group, they will all be set to the same sampling mode. When the Base Station is selected, all the nodes will appear in a list with a check mark to the left, all of the nodes checked off will be included in the sampling. Uncheck the nodes to be excluded from the sampling.

The Network Settings menu includes Synchronized and Lossless sampling options, while the Node settings menu offers multiple configuration options to customize the data sampling for a single node, or a group of nodes.

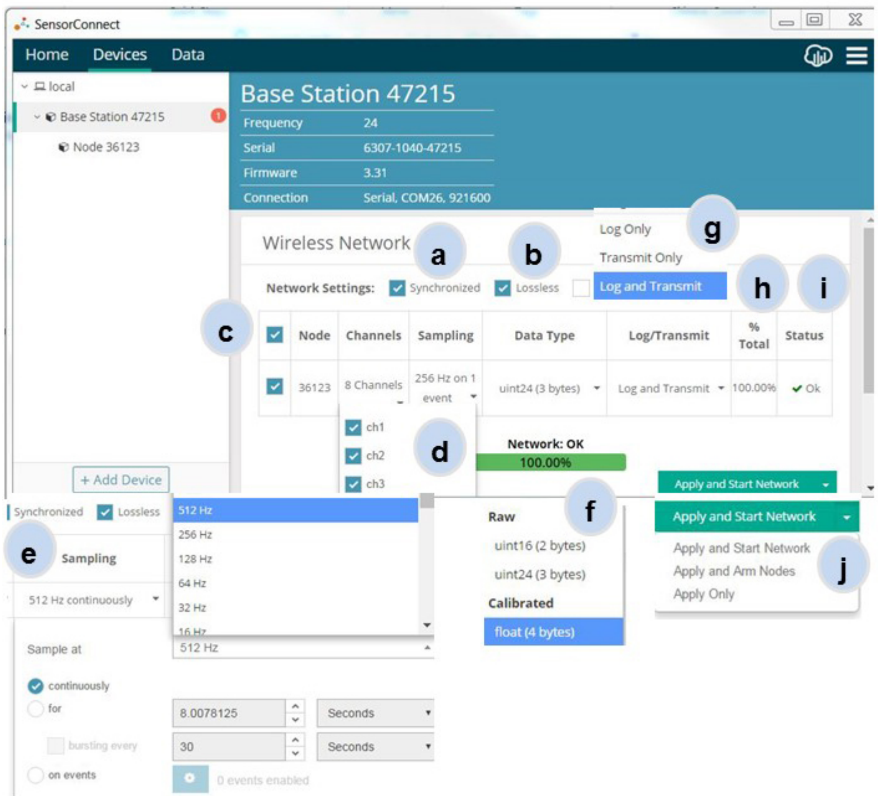


Figure 15 - Network and Node Configuration Menu

a. **Synchronized Sampling:** A sampling mode that automatically coordinates all incoming node data to a particular gateway. This mode is designed to ensure data arrival and sequence.

b. **Lossless Sampling:** Enables the lossless data protocol to enable buffering and retransmission of data in order to provide 100% data collection success. Using this feature may increase data display latency.

c. **Node:** Indicates the node serial number beside a box with a check mark. This box is checked by default to include the node in the sampling. Uncheck the box to exclude the node from the sampling.

d. **Channels:** Provides a drop-down menu to select the desired channel for the node.

e. **Sampling:** Displays a drop-down menu to select the sample rate. Check Continuously to sample indefinitely, check For to specify a fixed sampling time-frame, and check Bursting to indicate the frequency of the sampling within the fixed sampling configuration.

f. **Data Type:** Select the size of the data desired.

g. **Log/Tranmsit:** Select data logging and transmission preferences including, Log Only which sends data to the node, Transmit Only which sends data to the Base Station, or Both which sends data to both the node and the Base Station.

h. **% Total:** Indicates the percentage of total bandwidth consumed for each node.

i. **Status:** Displays network errors.

j. **Apply and Start Network:** Applies all of the settings, starts the entire network and the Base Station's beacon. A drop-down menu displays options to Apply and Arm all of the nodes without starting the beacon, or Apply Only to save the settings to memory and not start the network.

3.7 VIEWING DATA

3.7.1 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.

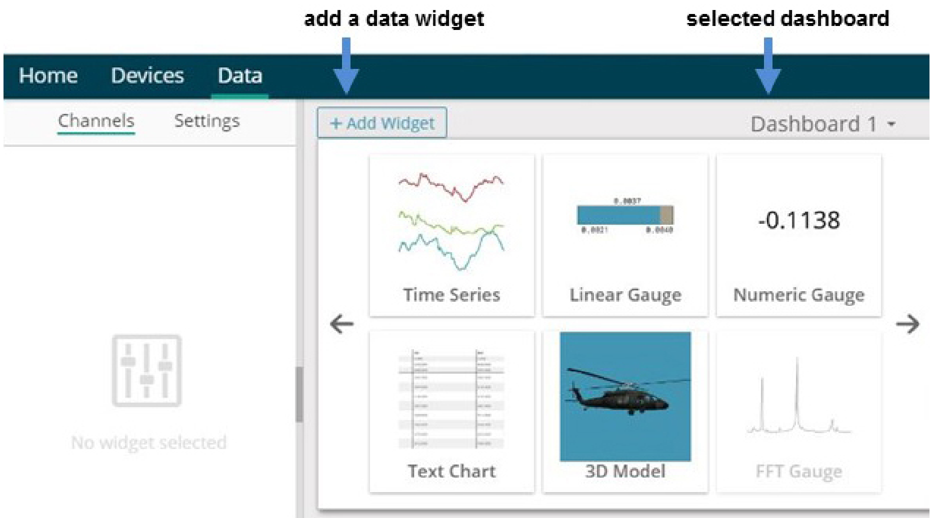


Figure 16 - Data Page

3.7.2 Navigating Graphs

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 3 - Graph View Controls

3.7.3 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.

Figure 17 - Widget Configuration Menu

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.

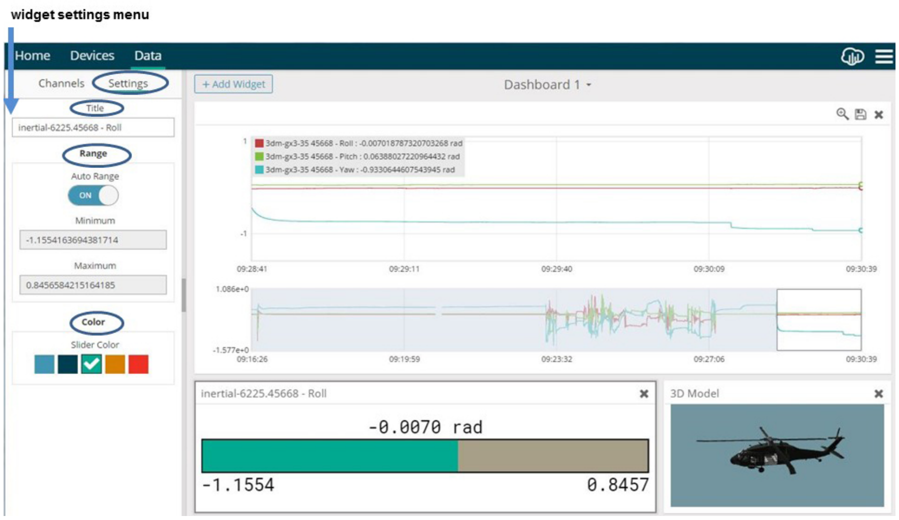


Figure 18 - Widget Settings Configuration Menu

3.8 Data Handling

Data acquired through SensorConnect is automatically saved on the host computer (*see Sensor Data Files on page 31*) and can also be viewed from the web-based SensorCloud portal. Saved data can be uploaded to SensorCloud and 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 (*see Connecting to SensorCloud on page 28*).

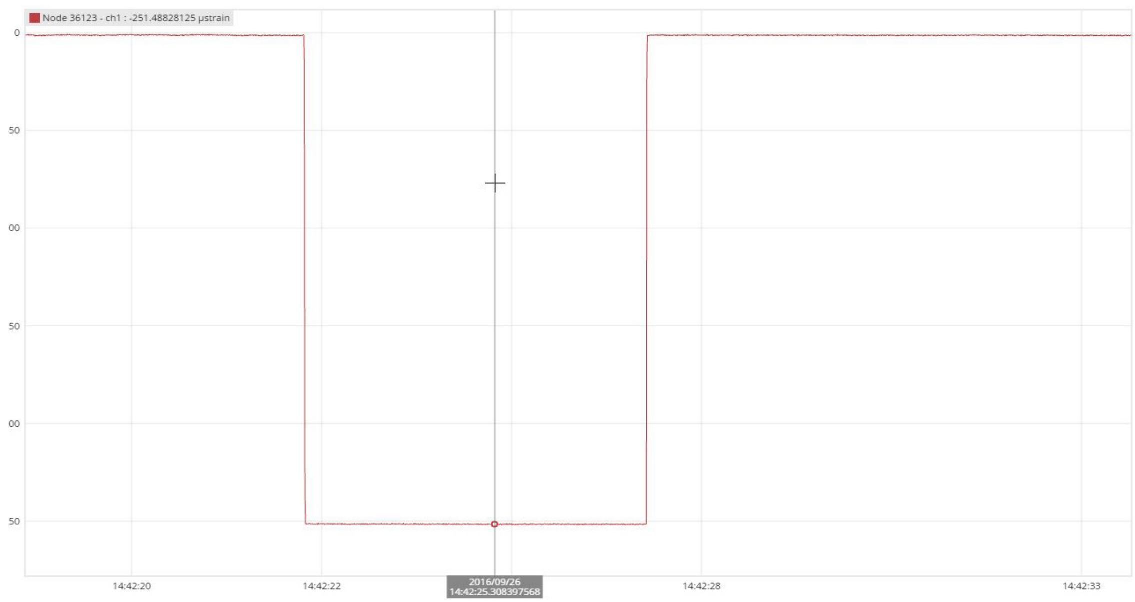


Figure 19 - Data Storage, Display and Processing

3.8.1 Connecting to SensorCloud

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

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

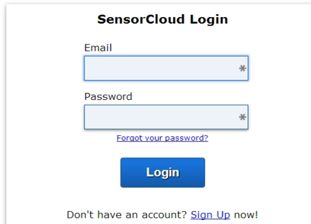


Figure 20 - SensorCloud Log-in or Register

The SensorCloud interface has **six main views**. When logging in as a registered user, the Device view is the default. Navigate to other views by clicking the view name at the top of the page (*Figure 21 - SensorCloud Menu Views*). The Data and Settings views are only available once a device is selected from the device list.

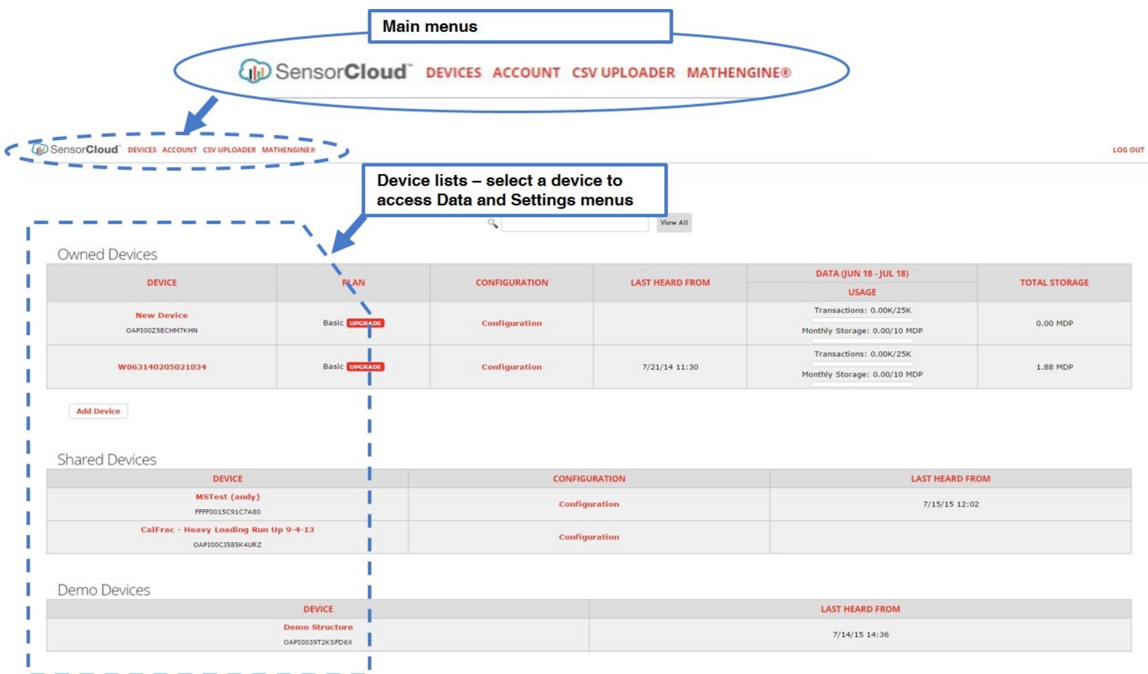


Figure 21 - SensorCloud Menu Views

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 22 - SensorCloud Data View

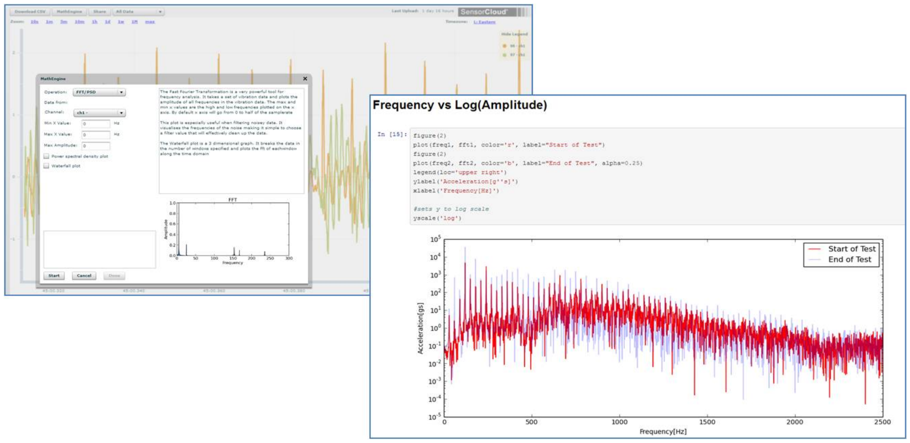


Figure 23 - MathEngine® View

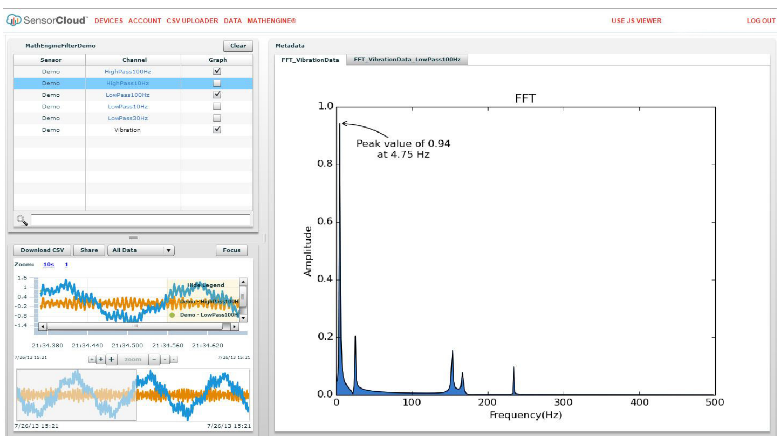


Figure 24 - FFT Graph in SensorCloud

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

http://sensorcloud.com

3.8.2 Sensor Data Files

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

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

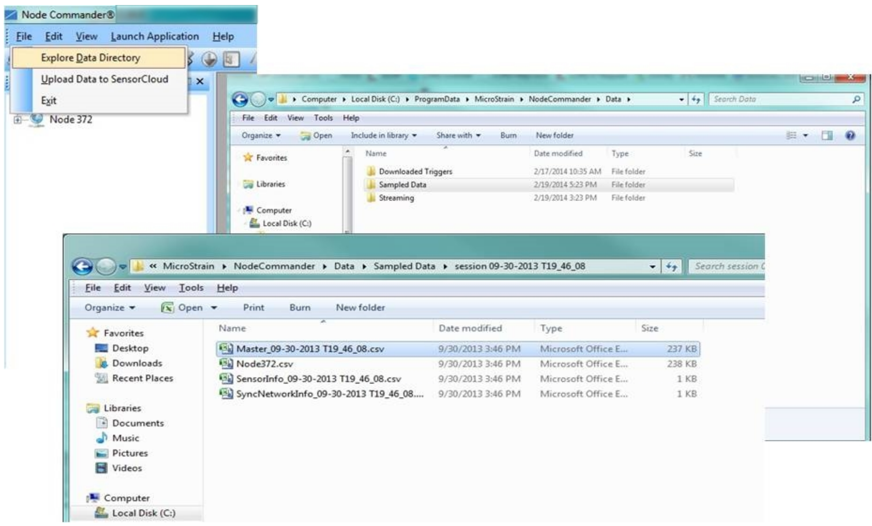


Figure 25 - Exploring Data

> **NOTE**
>
> The Microsoft Excel the Time data column in the data file may have to be changed to "m/d/yyyy h:mm:ss:000" format to make it more readable.

4. Node Installation

4.1 Mounting Recommendations

The V-Link-200 is rated for indoor use only, unless housed in a ruggedized outdoor enclosure. Enclosures for the V-Link-200 are available from LORD Sensing. Some also accommodate D cell batteries, extending the battery operating capacity and duration.

There are two mounting tabs on the node, with holes for fastening.

The node can be mounted in any orientation, but it is recommended that it is mounted in a way that optimizes wireless communications, typically with the antenna pointing upward. For more information *See Optimizing the Radio Link on page 33*.

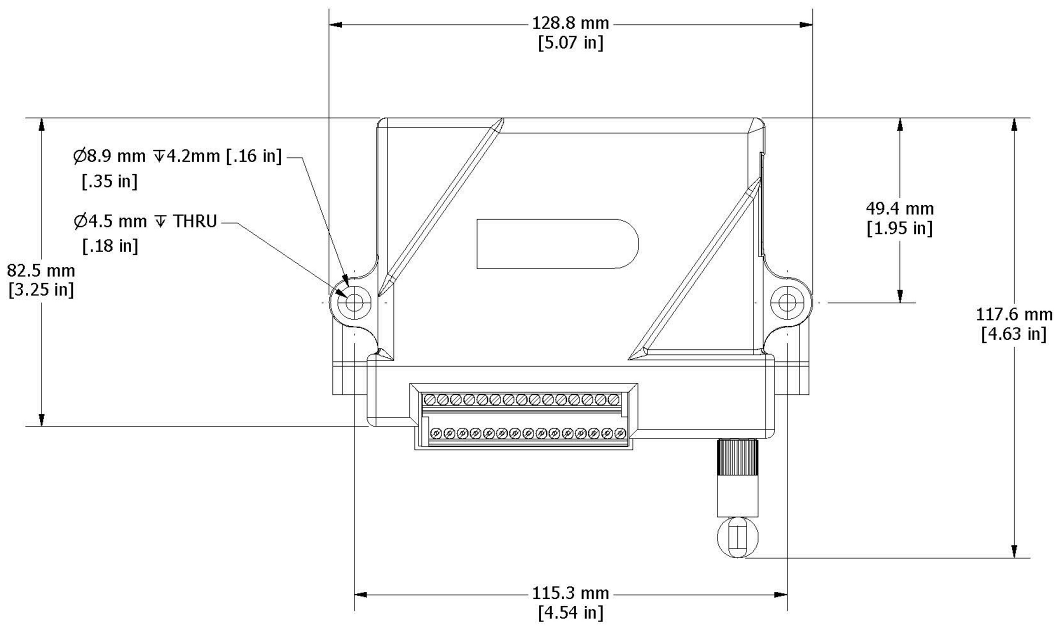


Figure 26 - Mounting the Node

4.2 Optimizing the Radio Link

In ideal conditions, the nodes and gateway can communicate up to two kilometers apart. In order to accomplish this, the node and gateway must be installed in a manner that optimizes the wireless transmission. The V-Link-200 operates at a 2.4GHz transmission frequency and comes standard with an antenna that has an omni-directional radiation pattern. The antenna has a joint in the middle that allows it to be rotated and aimed. Using any other antenna than the one that is included with the node will void FCC compliance.

The best method for ensuring optimal radio communication is to conduct an RF survey of the installation site. This is easily accomplished in SensorConnect by using the range test feature to quantify the radio signal strength (RSSI) in various scenarios. *See Range Test on page 33* for instructions on using SensorConnectfor measuring RSSI. The following are general guidelines for maximizing transmission range:

- **Establish Line of Sight (LOS)** between the node and gateway antennaas best as possible. Try to avoid obstructions between the antennae, such as buildings, terrain, vegetation, or other physical barriers. Increase the mounting height of the nodeto 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)** such as other equipment antennae, especially those operating in the same frequency range. This includes other nodes. If other antennae are required nearby, mount them at different heights to minimize interference. Additionally, the specific node frequency is selectable within its operational range using theNode Commander software. Set the devices to different transmission frequencies.
- **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.

4.2.1 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 header > Range Test

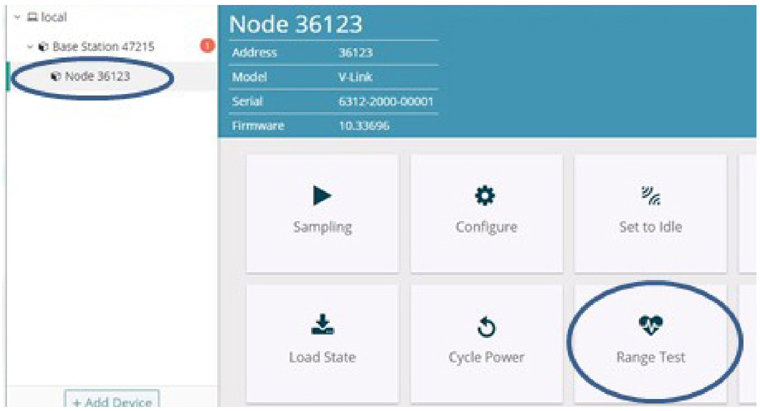


Figure 27 - Range Test Menu

2. The total RSSI range for the node and gateway is -90 to 0 dBm. The higher the value (closer to zero), the better, but reliable communication can be achieved between -75 dBm and 0 dBm. The devices is still able to communicate between -90 dBm and -75 dBm, but it could be intermittent or result in data loss. Position the node and gateway antennas where the best RSSI value is observed.

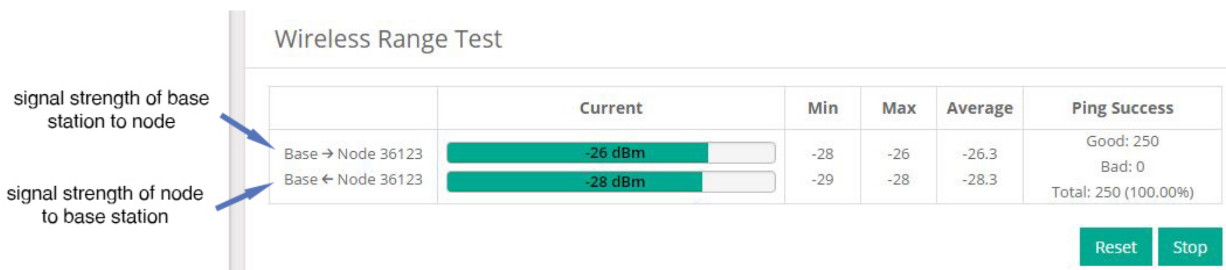


Figure 28 - Range Test Statistics

5. Connecting Sensors

⚠WARNING	The V-Link-200 contains internal, non-rechargeable lithium batteries. When replacing batteries, use only the batteries specified for the node. Do not disassemble, short circuit, crush, puncture, or otherwise misuse the battery. Do not attempt to recharge the batteries. Do not expose to water. Disposal is subject to federal and local laws. For important precautions *see Safety Information on page 94*.

The V-Link-200 wireless sensor node features eight analog input channels that interface with a wide range of available sensor technologies, essentially converting them into wireless sensors. The node accommodates Wheatstone Bridge and analog sensors for applications in wireless strain gauge monitoring, such as torque, force, and pressure measurement, as well as sensors for other applications like wireless accelerometers, vibration sensors, magnetic field and displacement sensors. Environmental sensing can be achieved with wireless RTD and wireless thermocouple monitoring.

The V-Link-200 includes four single ended and four differential channels for sensor measurement. Differential channels may need to be factory-set to work for specific types of sensors. For information about channel configurations *see Differential Input Channels on page 40*. For ordering information *see Parts and Configurations on page 84*.

5.1 Sensor Requirements

Below are guidelines for selecting sensors for use with the V-Link-200. For interfacing with sensors outside of these parameters, or not included in the examples in the following sections, contact Technical Support (*see Technical Support on page 82*).

Sensor Impedance:

- Differential sensor inputs using a Wheatstone Bridge must have an impedance that is ≥ 120 Ω. For half-bridge and quarter-bridge configurations, the node impedance value is set to match the sensor when the node is manufactured and must be specified at the time of order. For more information *see Parts and Configurations on page 84*. Custom bridge completion impedance values are available on request.

Sensor Signal Voltage:

- Differential sensor inputs include a hardware gain and offset stage before the sensor input signal is processed by the analog to digital voltage converter within the node. The combination of the gain, offset, and sensor signal voltage cannot exceed the 5 V dc input range of the analog to digital converter. For more information *see Differential Input Gain and Offset on page 66*.

- Single-ended sensor signal voltages are measured with respect to the system ground and must be between -10.24 to +10.24 V dc.

Sensor Power:

- The total current available for all connected sensors must be less than 150mA. The voltage is 4.096 V dc.

5.2 Wiring Recommendations

It is good practice that all sensor wiring be done with shielded cable. The shield is connected to the system ground only at one end to avoid ground loops. For sensitive small voltage signals (such as strain gauges) sensor wire leads should be of matched lengths so the lead resistance for each connection is as close to the other as possible. For long lengths of wire, a system calibration is recommended over a sensor calibration. *See Sensor Calibration on page 50*.

5.3 Sensor Power

⚠CAUTION Total sensor current draw of more than 150mA can cause permanent damage to the node and should be avoided.

Sensors can be powered by the node or with an external power supply. The node sensor excitation voltage is 4.096 V dc and can provide up to 150mA total on all channels. If a higher voltage or more current is required for the sensor, an appropriately sized external power supply can be used. For example, using the node battery for current intensive devices such as 4 to 20mA sensors will drain the battery quickly. For these applications, an external source is recommended for the sensor or the node.

Drain on the battery can also be limited by selecting low resource sampling modes and low duty sampling rates, which automatically switch the node excitation voltage off after sampling. This feature can also be utilized to turn switches on and off to further control resource use. *See Using the Excitation Output as a Switch on page 46*.

External battery holders and ruggedized outdoor housings that accommodate larger batteries are available for the V-Link-200 and can be used to extend battery operating capacity and duration. *See Node Accessories on page 85*.

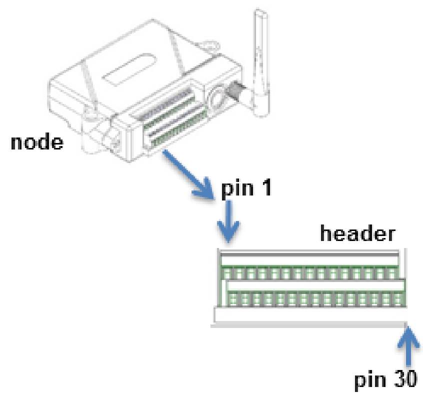
5.4 Node Channels Designations

Channel	Description	Pin Nomenclature
1	differential channel 1	S1
2	differential channel 2	S2
3	differential channel 3	S3
4	differential channel 4	S4
5	single ended channel 1	Ain1
6	single ended channel 2	Ain2
7	single ended channel 3	Ain3
8	single ended channel 4	Ain4

Table 1 - Channel Designations

5.5 Terminal Block Connections

When inserting the sensor leads into the terminal block ensure the lead wire is being clamped under the terminal screw and not the lead insulation. If the sensor wires are a very fine gauge, folding and tinning them may be useful to provide more area for the terminal screw to make contact. Failure to provide adequate connection may result in erroneous data.



Node Pin Number	Signal	Node Pin Number	Signal
1	SP+	16	SP+
2	S1+	17	S4+
3	S1-	18	S4-
4	GND	19	GND
5	S1 S	20	S4 S
6	SP+	21	Ain5
7	S2+	22	GND
8	S2-	23	Ain6
9	GND	24	GND
10	S2 S	25	Ain7
11	SP+	26	GND
12	S3+	27	NC
13	S3-	28	NC
14	GND	29	GND
15	S3 S	30	Vin

Table 4 - Terminal Block Connections

5.6 Pin Descriptions

Signal	Description	Pin Type	Range
Vin	**Node external power supply** An alternate to the node power jack. *See Powering the Node on page 68*.	power input	7.5 to 36 V dc sufficient current capacity for sensors
GND	**Return** For node power and sensor excitation	power return	return
S+	**Sensor excitation** Power to external sensors. At sampling rates under 32Hz, it is only active when the node is sampling the sensors.	output	4.096 V dc maximum combined load on all excitation pins is 150 mA.
Sx+	**Differential sensor input +** Positive input to the node programmable gain amplifier (PGA). Used with S-.	input	0 to 5 V dc including gain and offset Wheatstone Bridge compatible sensor with 120 Ω input impedance recommended
Sx-	**Differential sensor input +** Negative input to the node programmable gain amplifier (PGA). Used with S+.		
Sx S	**Three wire input** Used only for three wire configuration of quarter bridge strain gauge bridges. Leave unconnected for non quarter strain gauge bridge applications.	input	4.096 V dc including gain and offset Wheatstone Bridge compatible sensor with 120 Ω input impedance recommended
Ainx	**Single ended sensor input** Routed directly to the node analog to digital (A/D) converter. Return is node GND.	input	-10.24 to +10.24 V dc

Table 5 - Node Pin Descriptions

5.7 Differential Input Channels

The differential measurement channels provide a 5 V dc excitation voltage to the sensor and measure the resulting sensor signal output. The sensor signal goes through a programmable gain amplifier (PGA) and is then processed in the node by a18-bit analog-to-digital (A/D) converter over the 5 V dc 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 5 V dc 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. Sensor gain and offset values are configurable in SensorConnect. *See Configure Node on page 19*.

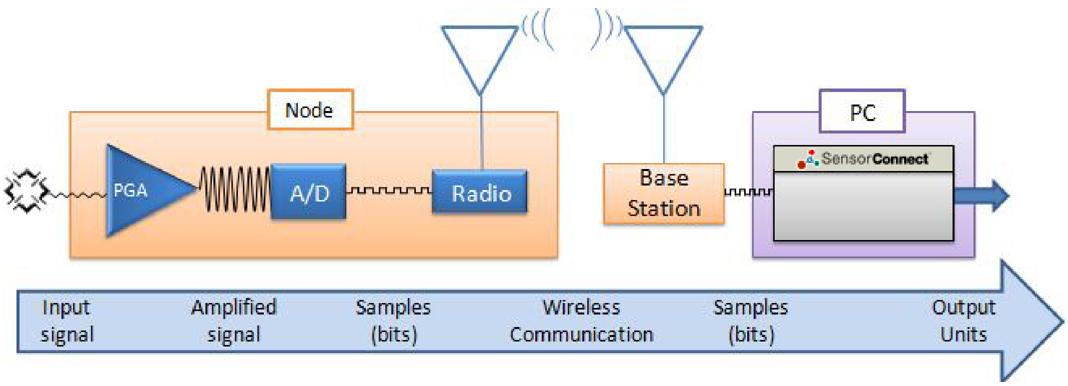


Figure 29 - Differential Channel Signal Processing

5.7.1 Differential Sensors

Sensors that are classified as differential sensors often utilize a Wheatstone Bridge configuration. These sensors are essentially a resistive load that use the bridge configuration to detect very small resistive changes and produce a precise voltage output as a result. Some examples include strain gauge elements or strain gauge-based sensors, such as some load cells and pressure transducers, as well as some soil moisture, temperature, and other sensors. For use with the V-Link-200, sensors with an impedance of ≥ 120 Ω are recommended.

Calibration in the SensorConnect software for these devices varies depending on the type of sensor and includes using the shunt calibration for strain gauges. The following diagrams show how to connect these types of sensors. *See Sensor Calibration on page 50* for more information.

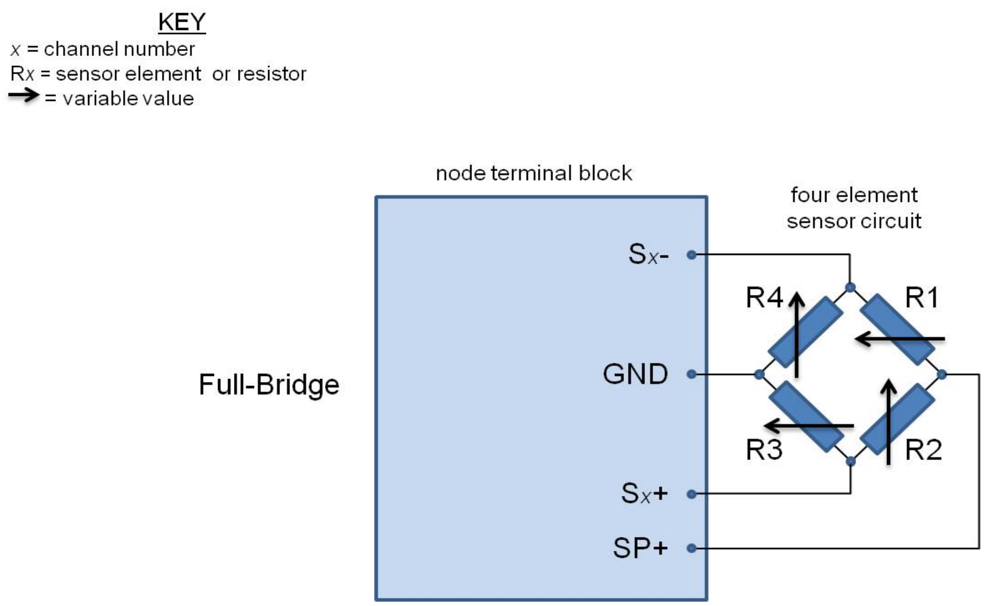


Figure 30 - Full Bridge Wiring

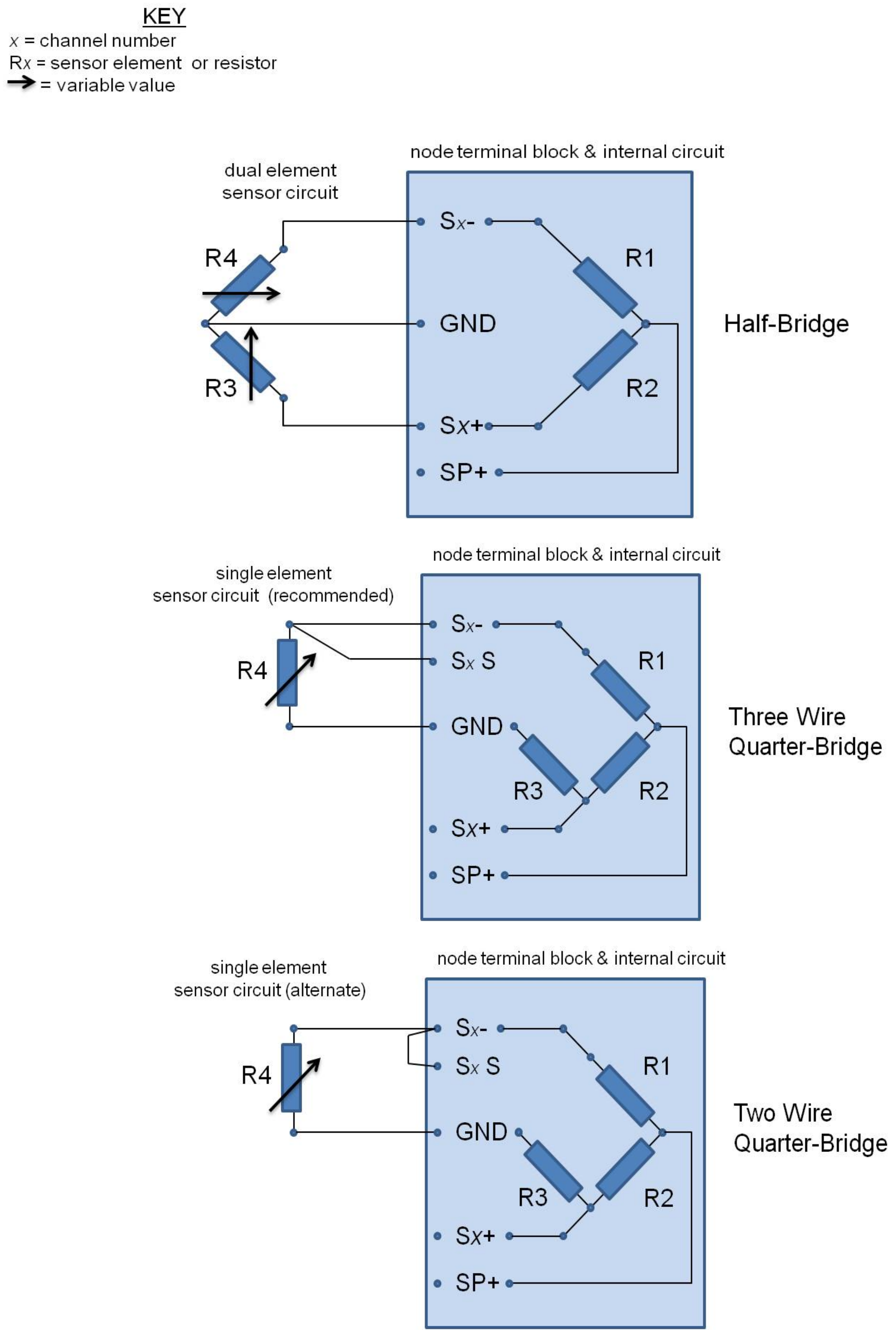


Figure 31 - Half and Quarter-Bridge Wiring

5.7.2 Measuring Small Voltages

Some sensor types that have small signal voltages (around 20 mV or less) may be better measured by biasing the sensor signal to the mid range of the node input range with a voltage divider, as shown in *Figure 32 - Small Voltage Measurement*.

Channel configuration will include adjusting the gain setting accordingly in the SensorConnect software.

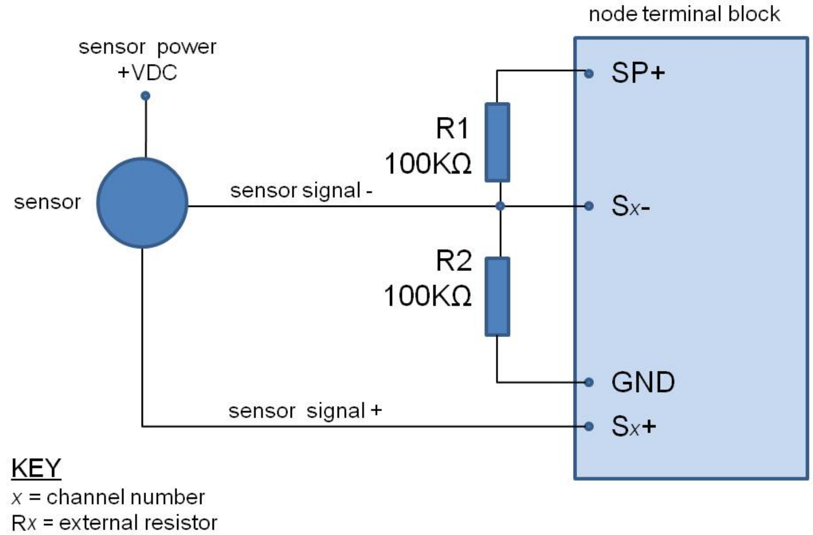


Figure 32 - Small Voltage Measurement

5.8 Single-Ended Input Channels

Single-ended channels are designed to measure voltages with reference to the system ground and can accommodate many analog sensors types including accelerometers, pressure transducers, geophones, temperature sensors, inclinometers, and more. These channels can also be used to measure reference voltages.

Sensors that operate on 4.096 V dc can be powered with the node excitation voltage. Alternately, sensors can be powered with an external source.

The single-ended channels can measure signals from -10.24 to +10.24 V dc with reference to the system ground. Sensor output must be positive going voltage in order to operate correctly with the V-Link-200. If the sensors output is greater than 4.096 V dc, a voltage divider can be used to decrease the scale. The impedance of the sensor must be less than 5 KΩ.

The sensor output signal is processed in the node by an 18 -bit analog to digital (A/D) converter, over the -10.24 to +10.24 V dc range. The resolution of the sensor measurement is dependent on the full scale output range of the sensor. More resolution can be achieved by changing the single-ended channel input range, see below.

Value	Scaled input range
0	+/- 10.24 V
1	+/- 5.12 V
2	+/- 2.56 V
5	+ 10.24 V
6	+ 5.12 V

Table 6 - Single-ended Channel Input Range

The following sections provide examples of how various sensors can be connected to the node. For other applications, *see Technical Support on page 82*.

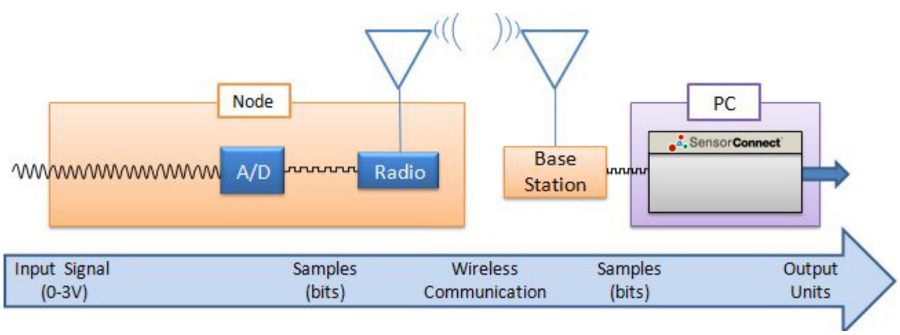


Figure 33 - Single Ended Signal Processing

5.8.1 Measuring Small Currents (4 to 20mA Sensors)

LORD Sensing nodes with analog inputs, such as theV-Link-200 and , support a wide range analog sensors including acceleration, vibration, strain, load cells, torque, pressure, magnetic fields, displacement, geophones, and more. To support these sensors, the nodes measure small voltage. Additionally, sensors with small current outputs, such as 4 to 20mA sensors, can be used with the nodes by adding a precision sampling resistor across a single-ended input channel to the node. An example circuit is shown in *Figure 34 - Small Current Measurements* .

- **Node Channel and Sensor Output Range:** Either the single- channel or differential analog input channel can be used to measure current. The external circuit and node settings are different for each. The single-ended option is simpler allows less adjustment. For applications in which very small currents will be measured, the differential inputs offer better noise immunity and programmable gain settings. Available gain settings vary between node models. Differential inputs can be factory configured for various bridge completion and impedance values. For this application, the standard full- bridge configuration is assumed. For other configurations contact LORD Sensing Technical Support.

- **Power Source:** If the sensor will be operating continuously in the 20mA range, or if multiple analogs inputs are in use, it is recommended that an external source be used to power the sensor or the node. Typically nodes can only supply 50mA (to all sensors), so 20mA would be a significant portion of the node capacity and would drain the internal battery quickly. However for applications with lower current requirements and measurement ranges, the internal battery may be a better option to mitigate potential noise sources, especially when using differential channels.

For battery life and current draw information see Using the Internal Node Battery on page 69. The current limitations can be mitigated by using an external power source for the sensor or the node. If using node excitation power is the best for the application, drain on the battery life can be limited by only switching the node excitation voltage on just before sampling and then turning it off afterward. This happens automatically at low duty sampling rates (32Hz or lower) and can be set up for other sample rates with external circuitry. For more information see Using the Excitation Output as a Switch on page 46.

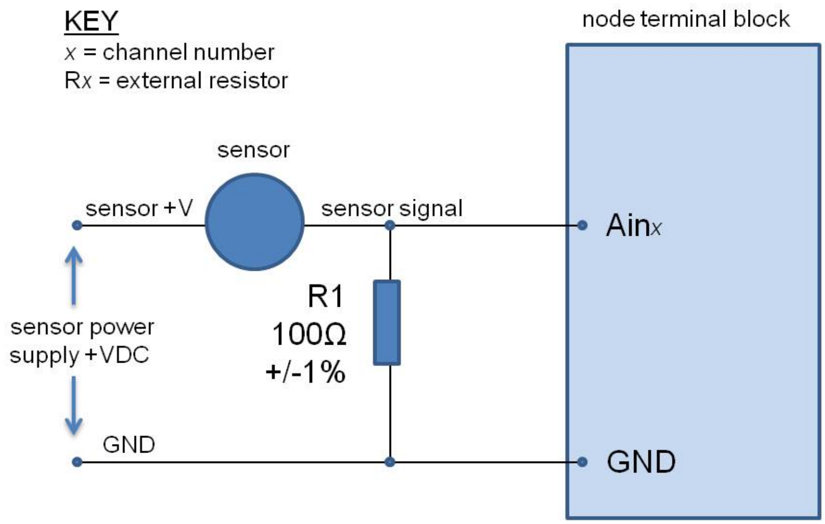


Figure 34 - Small Current Measurements

5.9 Using the Excitation Output as a Switch

At low sampling rates (under 32Hz) the node automatically switches the excitation voltage output off when the sensor is not being sampled, in order to conserve battery life. This feature can also be used in applications where a switch is desired, such as for turning sensor power on and off when the sensor is powered by the node but has a large current draw. It can also be used as a general purpose switch, such as for controlling a relay or transistor. The same limitations apply as to a sensor; the device must operate on 4.096 V dc and not require more than 150mA when combined with all other sensor current draw. To use the excitation output in this way, connect the control line of the device (example: relay coil or NPN transistor base) to the excitation pin on the node terminal block (SP+) and reference (example: other side of the relay coil or the NPN transistor emitter) to the node ground pin (GND).

5.10 Thermocouples

Thermocouples can be used on the differential input channels by simply adding a high-impedance resistor to the input. An example circuit is shown in *Figure 35 - Connecting a Thermocouple*.

Thermocouples should be calibrated by first selecting the appropriate baseline offset range, output range, or gain and then applying know loads and calculating the slope and offset values. Using water as the known load medium (submerging the thermocouple in ice and hot water baths) is a simple method that can be used for calibration.

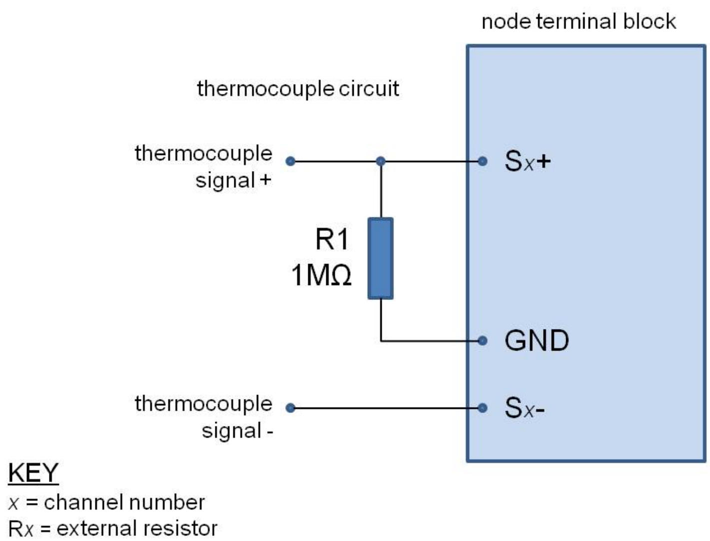


Figure 35 - Connecting a Thermocouple

5.11 Connecting Accelerometers

LORD Sensing bridge type accelerometers, such as the Triaxial Accelerometer Cubes, can be used with V-Link-200 to create wireless acceleration sensor platforms. Connect each accelerometer axis output to a node differential input channel. Power is provided to the accelerometer from the node excitation supply.

For additional information on LORD Sensing accelerometers compatible for use with the V-Link-200, *see Recommended Sensors on page 86*. For information on integrating other types of sensors not described in this manual, contact Technical Support (*see Technical Support on page 82*).

5.12 On-board Temperature Sensor

- The V-Link-200 has an on-board, solid state temperature sensor mounted on the surface of the circuit board.
- Available as a channel in the Diagnostic Packet.
- The temperature sensor has a measurement range of -40˚C to +85˚C range with an accuracy of ± 0.5˚C @25˚C.

6. Sensor Settings

LORD Sensing sensor nodes are designed to accept many sensor types. The node configuration interface includes settings for measurement units and conversion values. There are preset measurement units, as well as a user-defined field. Because the wireless sensor system is digital, the analog voltage readings from the sensors are converted into a digital equivalent value based on the volt-to-bit scale of the internal analog-to-digital voltage converter (A/D converter). Sensor readings can be displayed and recorded in A/D value (bits) directly or further converted to engineering units by applying conversion values and a conversion formula. For more information, *See Sensor Conversion Values on page 60.*

Some sensors require calibration to determine more accurate conversion values. Calibration incorporates coefficients that normalize the sensor output to a known reference device and guarantee accuracy of conversions.

External sensors can be attached to any channel that is suitable for sensor type. *Table 7 - Example External Sensor Types* , describes example sensors, units, and calibration options.

channel type	example external sensors	units	calibration options
analog differential input	strain gauges in full, half, quarter/custom Wheatstone Bridge configurations	strain volts A/D value custom	shunt calibration user entry from manufacturer data, lab or field calibration
	other Wheatstone Bridge sensors such as: some pressure sensors some force sensors some mass sensors some displacement sensors some accelerometers some temperature sensors 4-20mA sensors	g-force A/D value volts custom English and metric measurements for; mass, pressure, force, distance, and temperature.	user entry from manufacturer data, lab or field calibration
analog single ended input	sensors with voltage outputs referenced to the system ground.	volts A/D value custom	user entry from manufacturer data, lab or field calibration
thermocouple	thermocouples	temperature A/D value custom	user entry from manufacturer data, lab or field calibration

Table 7 - Example External Sensor Types

6.1 Sensor Calibration

Many sensors require calibration coefficients to accurately report measurements. Methods for determining the calibration coefficients depend on the type of sensor measurement and application. The SensorConnect software facilitates multiple calibration methods. Calibration calculators for some applications are also available by contacting LORD Sensing Technical Support. *See Technical Support on page 82*.

- **Sensor manufacturer's specifications or calibration:** The slope and offset values, or the data to derive them, are provided with the sensor by the manufacturer to prove its accuracy and describe expected voltage output. Some sensors are calibrated individually, while others are manufactured to a standard sensitivity value (plus or minus some tolerance), which is provided in the device specifications.
- **Sensor lab calibration:** If the manufacturer's calibration is not available or outdated, calibration of the sensor can be performed with calibrated equipment in a controlled environment. The calibration equipment and process will typically be traceable to an industry standard, such as NIST or ASTM in the United States. Fixed loads are applied to the sensor while the sensor output is recorded. The load is applied or measured by a calibrated reference device. The known load value from the calibrated device is then plotted against the measured output of the sensor to determine the calibration slope and offset. In SensorConnect this can be accomplished by taking sensor readings while applying the known loads.

Sensor wiring, tolerances in system electronics, and differences in mounting techniques are examples of systemic variables that can influence the sensor readings. Sensors that are making small measurements or are otherwise sensitive to these slight differences may benefit from a system calibration. The following techniques are system calibrations:

- **System shunt calibration (internal and external):** This option is only available for Wheatstone bridge-type sensors (such as strain gauges) in SensorConnect. In the shunt calibration process, an internal or external precision resistor is used to load part of the sensor bridge while the sensor remains unloaded. The bridge output is measured and used as a loaded calibration point for the sensor. In addition to the no-load value it can be used to derive the calibration slope and offset. The internal shunt resistor is suitable for most applications, however an external shunt may be beneficial in high gain scenarios.
- **System field calibration:** The field calibration is a similar methodology to the sensor lab calibration. Known loads are applied to the sensor while the sensor output is recorded. The load is applied or measured by a reference device. In this scenario, the sensor may be installed in final field configuration, and the load may be applied with the actual stimulus that

the sensor will be monitoring. The known load value from the reference device is then plotted against the measured output of the sensor to determine the calibration slope and offset. In SensorConnect this can be accomplished by taking sensors readings while applying the known loads.

6.1.1 EXAMPLE: Internal Shunt Calibration

NODE: V-Link-200, 18 bit (262144 A/D values)

CHANNEL TYPE: differential analog input, 0 to 5 V dc input range

SENSOR TYPE: strain gauge, Wheatstone Bridge, full bridge configuration

SENSOR PARAMETERS: application voltage range: +/-2 mV

This is the expected output voltage of the strain gauge based on the range of strain being measured in the application and the sensitivity of the gauge (volts/strain).

DESIRED OUTPUT: engineering units, microstrain

PROCEDURE:

1. Open SensorConnect and establish communication with the gateway and node. (*See System Operational Overview on page 14*).
2. Select Hardware > Input Range for channel 1, select +/-2 mV from the drop down menu.
3. Under Hardware Offset, select Balance Target for channel 1, select Mid (50%) from the drop down menu.
4. Select Auto-Balance. When auto-balance is complete, a blue information window will indicate the balance result.

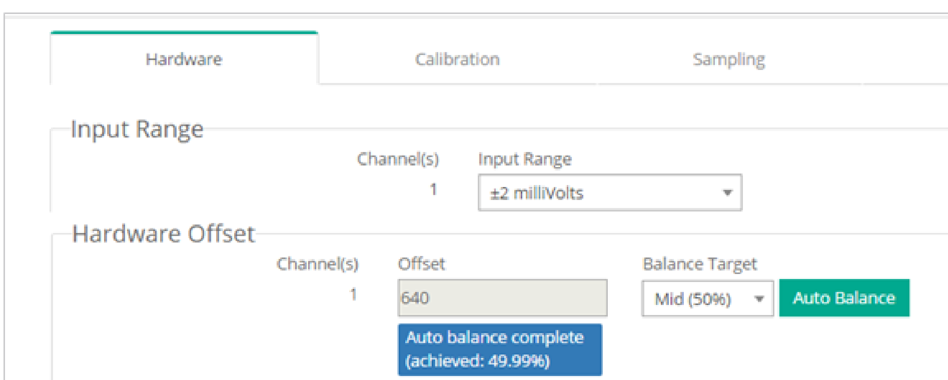


Figure 36 - Auto-Balance

5. Select Calibration.

6. Select Microstrain from the Unit drop down menu, select the Shunt Cal button enabled on the right.

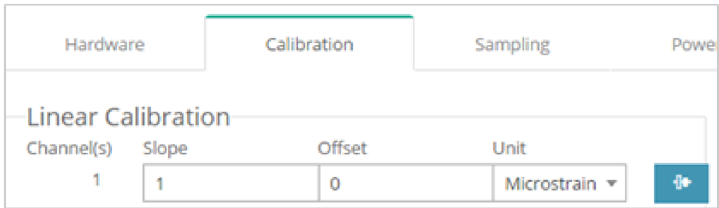


Figure 37 - Node Configuration Menu

7. Use the following settings:
    a. **Calibration Mode:** Internal
    b. **Number of Active Gauges:** 4
    c. **Gauge Factor:** 2
    d. **Gauge Resistance:** 1000
    e. **Shunt Resistance:** 499000

8. Select Start Shunt Cal for Slope and Offset calibrations.

9. Select Accept Calibration.

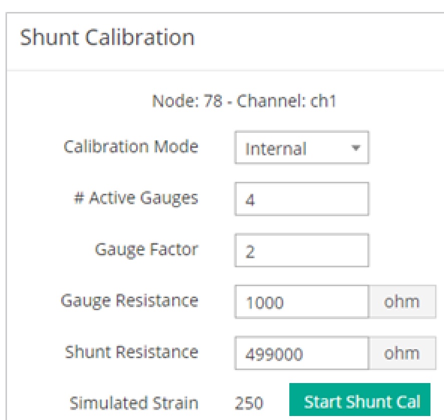


Figure 38 - Channel Settings

10. When the calibration is complete, the Wireless Node Configuration window will appear.

11. Select Apply Configuration to write to node memory.

6.1.2 Calibration Lab or Field

The lab and field calibrations use similar methodology. *See Sensor Calibration on page 50*. The primary difference is the traceability and calibration environment. Lab calibrations are performed in controlled environments with traceable equipment and procedures. Field calibrations are more improvised, although calibrated equipment can still be used to improve accuracy.

NODE: V-Link-200, 18 bit (262144 A/D values)

CHANNEL TYPE: differential analog input, 0 to 5 V dc input range

SENSOR TYPE: load cell

SENSOR PARAMETERS: application voltage range: +/-2 mV

This is the expected output voltage of the sensor based on the range of force being measured in the application and the sensitivity of the sensor (V/engineering units)

DESIRED OUTPUT: engineering units (EU), force (lbs)

PROCEDURE:

1. Open SensorConnect and establish communication with the gateway and node (*See System Operational Overview on page 14*).
2. Select Hardware > Input Range for channel one, select +/-2 mV from the drop down menu.
3. Under Hardware Offset, select Balance Target for channel one, select Mid (50%) from the drop down menu.
4. Select Auto-Balance. When auto-balance is complete, a blue information window will indicate the balance result.

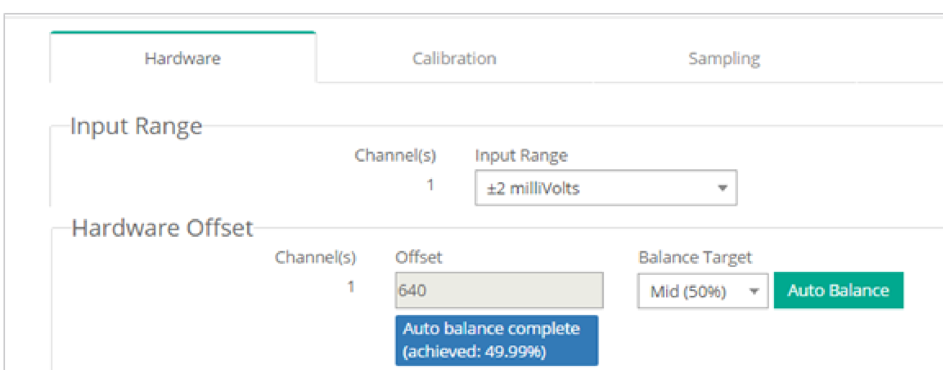


Figure 39 - Auto-Balance

5. Select Calibration.
6. Use the following settings:
    a. **Slope:** 1
    b. **Offset:** 0
    c. **Units:** Bits
7. Select Apply Configuration. When the settings have been applied, a green pop up window will confirm the process is complete.

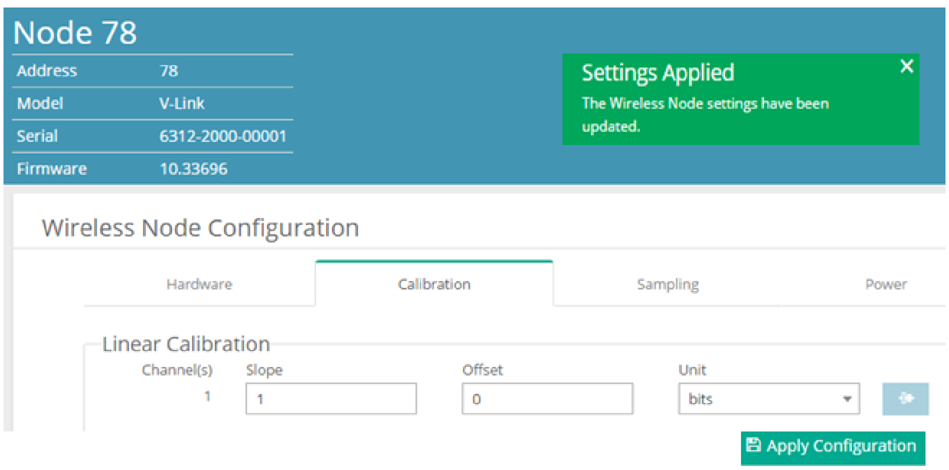


Figure 40 - Node Configuration Menu

8. To start sampling, click on the node name and select Sampling

9. The node is included in the sampling by default and is indicated by a white check mark in the blue box to the left of the Node number. Uncheck any nodes to be excluded in the sampling.

10. Use the following settings:

    a. **Channel:** 1

    b. **Hertz:** 128

    c. **Float:** 4

    d. **Log/Transmit:** Transmit Only

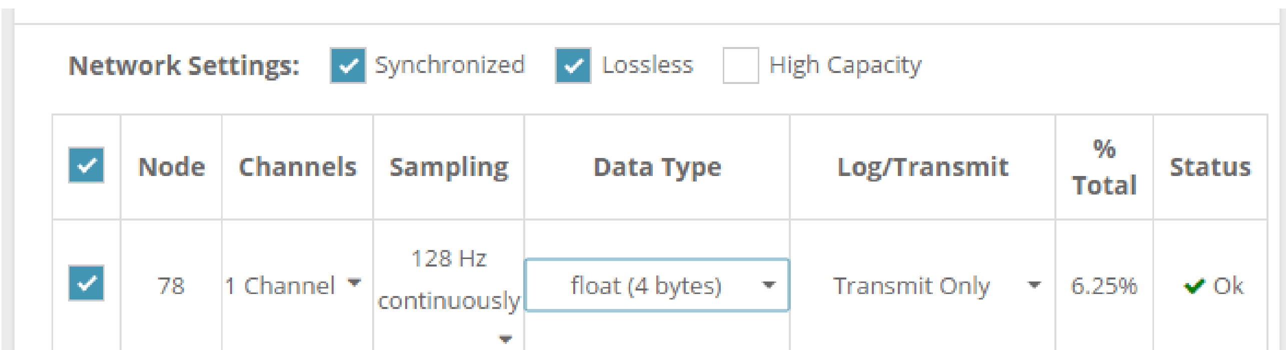


Figure 41 - Channel Settings

11. Select Apply and Start Network.

12. Select the Quick View Dashboard pop up window to view sampling.

13. After making all measurements, calculate a slope from the data using the formula *y=mx+b* in a data analysis program, such as Microsoft Excel. *See Calculating a Linear Slope on page 63*.

14. Return to the Wireless Node Configuration screen for the sensor channel, select Calibration, and enter the Slope and Offset values derived in the data analysis program.

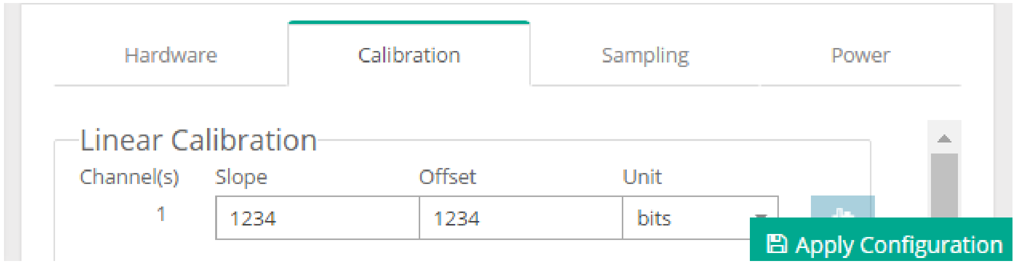


Figure 42 - Enter Calibration Values

15. Select Apply Configuration to save the values selected.

16. Collect data again with no load on the sensor.

17. Observe the value in the stream graph. If the value is not at zero, return to the Wireless Node Configuration menu, and adjust the offset by increasing or decreasing the value.

18. Once the offset has been zeroed, verify the calibration by applying known loads on the sensor throughout the load range, observing and verifying the measurement in engineering units.

6.1.3 Manufacturer Calibration

NODE: V-Link-200 ,18 bit (262144 A/D values)

CHANNEL TYPE: differential analog input, 0 to 5 V dc input range

SENSOR TYPE: pressure transducer, voltage output, positive going

SENSOR PARAMETERS:

From the manufacturer calibration sheet included with the sensor;

sensor range: 0-250 psi
sensor zero load output: 0.0032 V dc
sensor full scale output (FSO) with 10V excitation: 86.07 mV

From the application parameters;

sensor excitation in application: 4.096 V supply from the node

DESIRED OUTPUT: engineering units (EU), psi

CALCULATIONS:

Because the sensor will be powered from the node with 4.096 V, and the sensor manufacturer calibrated it a 10 V, the manufacturer full scale output (FSO) value needs to be scaled to 3V.

(4.096 V/10 V) * 86.07 mV = 35.25 mV

Select a gain and offset scale value appropriate for the sensor. (*See Differential Input Gain and Offset on page 66*).

The closest gain setting that accommodates 35.25 mV is +/- 39.0 mV. Using a lesser value would exceed the input voltage capacity of the node when the sensor is at higher pressures. For more information about gain values and associated input ranges, *See Table 1 - Differential Gain Values on page 67*

Multiply the sensor FSO by the gain setting to get the sensor voltage after amplification. For this example, the range is 39.0 mV for a gain of 64.

64 * 35.25 mV = 2.256 V

Scale the (gained) sensor input voltage/EU ratio to the node input voltage/EU ratio to determine the equivalent node FSO value (*x*).

2.256 V/250 psi = 4.096 V/x
(250 psi * 4.096 V)/2.256 V = x = 453.9 psi

The node converts voltage inputs to A/D values. For an 18-bit node, there are 262144 A/D values over the 4.096 V input range. Divide the node EU FSO by the A/D value to get the ratio, or slope, of EU to A/D value.

453.9 psi/262144 bits = 0.00173 = slope

Once the slope is entered, the sensor offset value can be measured in a data sampling session, such as streaming. Sample the sensor channel with no load applied, and read the EU value. Enter this as a negative value for the offset in order to have it subtracted from readings.

6.2 Sensor Conversion Values

NOTE

In order to report accurate readings, many sensors require calibration. Calibration coefficients normalize the sensor output to a known reference device and are often expressed in the measurement unit conversion values; the only difference being the use of a traceable reference. Calibration can be used to account for the variations between individual sensors, wiring, system electronics, sensor mounting and environmental conditions.

The conversion values include the slope, offset, gain, scale, and formula for converting the sensor A/D value (bits) to engineering units. The bits are the digital representation of the sensor voltage output. The type of sensor, channel, and desired engineering units determine what conversion values are available. The conversion values are entered through SensorConnect and saved in the node memory for the applicable channel.

Conversion values for the V-Link-200 are determined mathematically from the sensor sensitivity specifications, from the sensor manufacturer calibration data, or through a calibration process. Calibration incorporates coefficients that normalize the sensor output to a known reference device in order to guarantee accuracy of the sensor readings, especially when making small or precise measurements. *See Sensor Calibration on page 50* for more information. Not all sensors require calibration.

Conversion Formula: The conversion formula assumes a linear relationship between the original units (such as volts or A/D bits) and new engineering units (such as strain), and it is expressed mathematically as $y=mx+b$, where y is the engineering units at a given point (measurement), m is the slope of the line that represents the linear ratio, *x* is the original unit value at a given point, and *b* is a unit conversion offset (in the case of unit conversions) or the fixed zero load offset of the sensor (in the case of measurement calibration coefficients). Negative values may be entered for any coefficient.

Slope: is the linear scaling slope coefficient. The slope is the ratio of original units to new engineering units (EU), and it is used to convert the sensor measurements. The slope conversion value will vary depending on the engineering units desired. For example if the original unit is A/D values (bits), and the desired engineering units are acceleration in g-force, the slope conversion would describe how many bits equal one unit of *g*-force (bits/*g*). Mathematically, the slope is *m* in the formula $y = mx + b$.

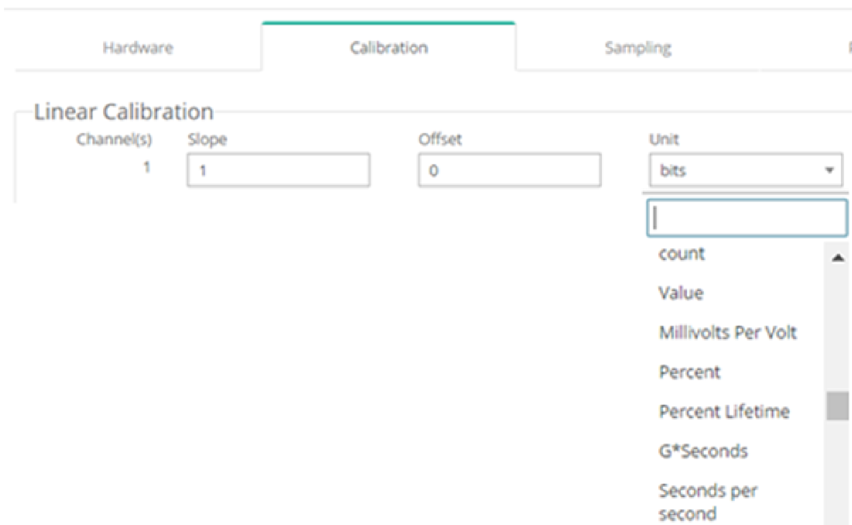


Figure 43 - Conversion Values Menu

Input Range (Gain): This sets the amplification of the signal within the node and is only available for channels with differential inputs and gain amplifiers.

Hardware Offset: is the linear scaling offset coefficient, and it is typically the starting output value of the sensor with no load applied (in the original units). Mathematically, the offset is b in $y = mx + b$.

Anti-Aliasing Filter: A filter applied before the digitization of the analog signal.

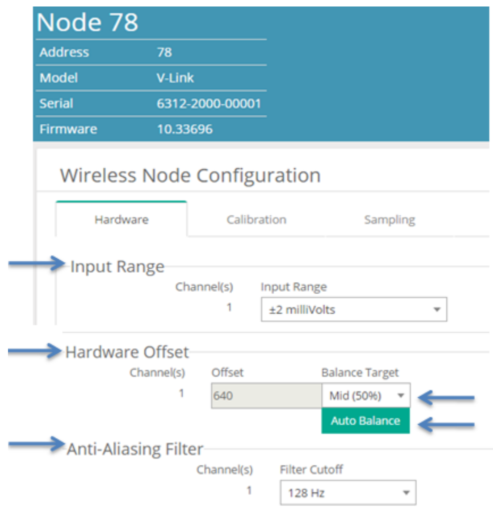


Figure 44 - Advanced Conversion Values Menu

Offset Scale (with Auto Balance): This feature is only available for channels with differential inputs, and assigns the position and value of the no load measurement of the sensor. The offset scale level adjusts the operating window of the sensor measurements in reference to the entire range. For example, in mid scale the sensor no load measurement will be placed in the middle of the range, providing 50% of the range for positive readings and 50% of the range for negative readings. Once the scale level is selected, the Auto Balance procedure is used to assign the actual sensor no-load measurement to the designated scale.

- Low is for positive-going signals (zero at 25% of total range).
- High is for negative-going signals (zero at 75% of total range).
- Midscale is for positive and negative-going signals (zero at 50% of range).

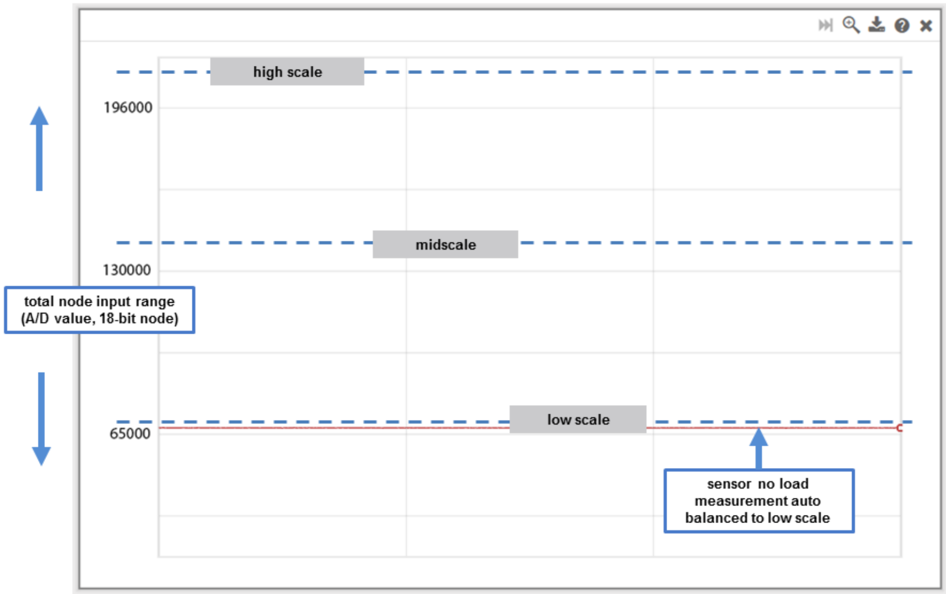


Figure 45 - Offset Scale Setting

6.2.1 Calculating a Linear Slope

A data analysis tool such as Microsoft Excel can be used determine the slope of a linear relationship between sensor output A/D value (bits) and engineering units. This is not a calibration unless a calibrated reference device is used to measure the applied loads. For information and examples for determining calibrations coefficients *see Sensor Calibration on page 50* .

Here is an example, using Excel:

1. Open a blank spreadsheet.
2. Enter the A/D value (bits) measurements and applied load in the desired engineering units in two columns. Enter A/D value in the left column (*x*-axis value) and the applied load in the right (*y*-axis value).
3. From the Insert menu, select Chart > Scatter. Select the preferred format.

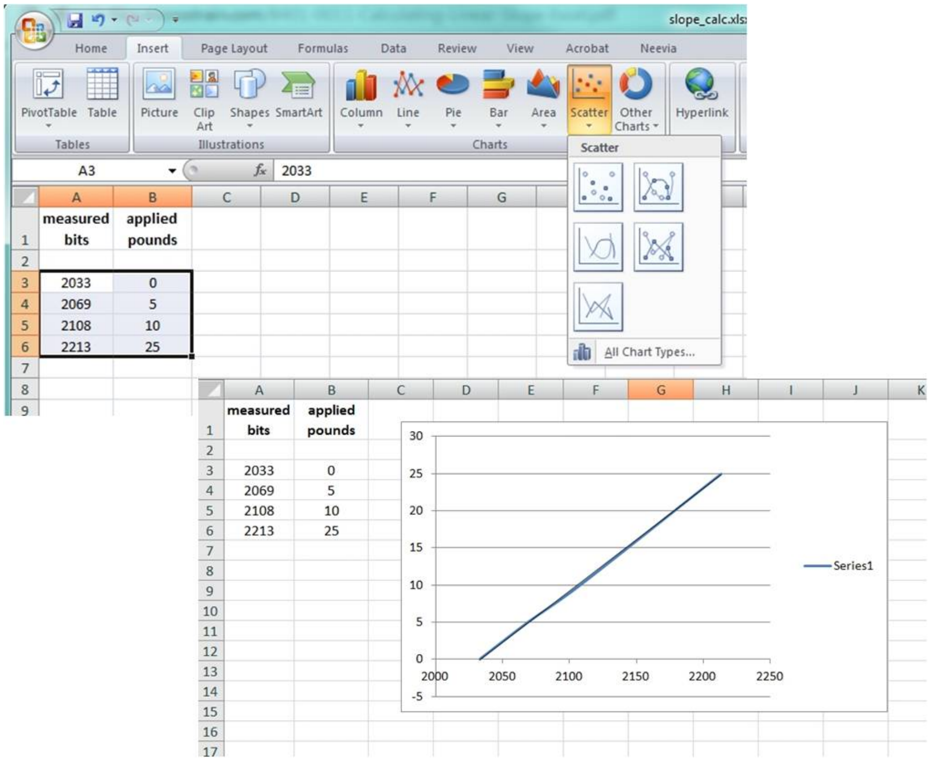


Figure 46 - Generate a Scatter Chart

4. Right-click on the graphed line, and select Add Trendline .
5. Designate the line as Linear, and check the option to Display the Equation on the chart (*Figure 47 - Plot Trendline*).

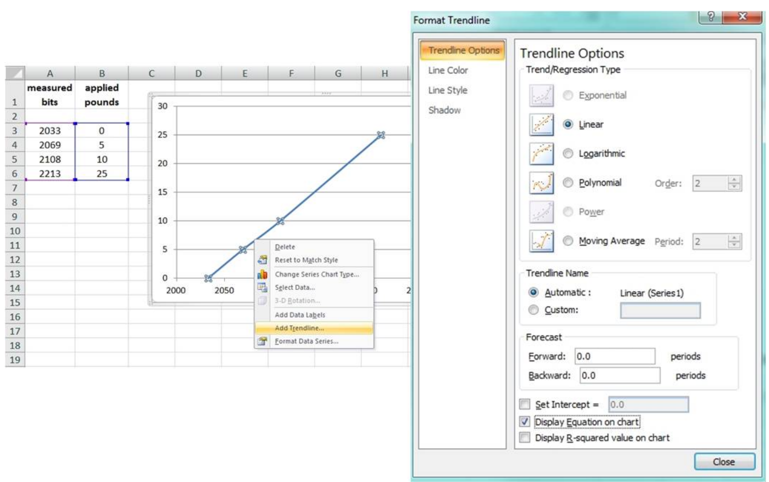


Figure 47 - Plot Trendline

6. The formula of the line is $y=mx+b$, where y is the engineering units at a given point (measurement), m is the slope of the line that represents the linear ratio, x is the A/D value at

a given point, and *b* is the fixed zero load offset of the sensor. Enter the slope and offset as the conversion values for the sensor channel under the applicable engineering units. In this example, enter 0.1338 for the slope and -282.36 for the offset for the units conversion values on the measured channel.

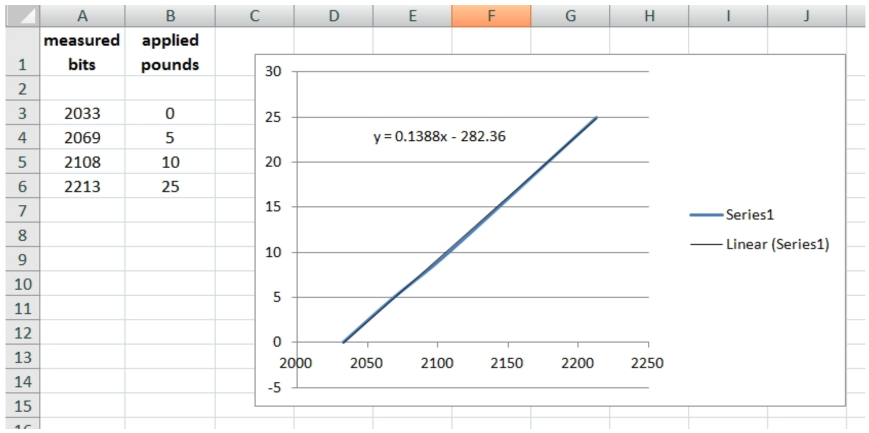


Figure 48 - Slope and Offset Values

6.2.2 Differential Input Gain and Offset

The combination of the gain, offset, and sensor signal cannot exceed the 0 to 5 V dc input of the analog to digital converter within the node.

Resolution: Applying gain to the sensor signal can be used to maximize the measurement resolution. The more of the range that is used, the more digital counts are available to measure the signal, which typically means higher resolution measurements. Limitations to the gain adjustment are the sensor's measurement capabilities and the 0 to 5 V input range of the node. The signal produced after gain is applied to the sensor at full scale must not exceed the input range of the node.

Offset Scale: The scale setting positions the no-load measurement of the connected sensor within the 0 to 5 V range of the node input. The range of A/D counts that corresponds with the 0 to 5 V node input depends on the resolution of the node. An 18-bit node will have a full scale bit range of 262144. A mid-range setting positions the baseline offset in the middle of the range (2.5 V or full scale bits*1/2) and is used for sensors with negative and positive going signals. The low-range setting positions the baseline offset in the bottom quarter range (1.25 V or full scale bits*1/4) and is used for sensors with mostly positive going signals. The high-range setting positions the baseline offset in the top quarter of the range (3.75 V or full scale bits *3/4) and is used for mostly negative going signals.

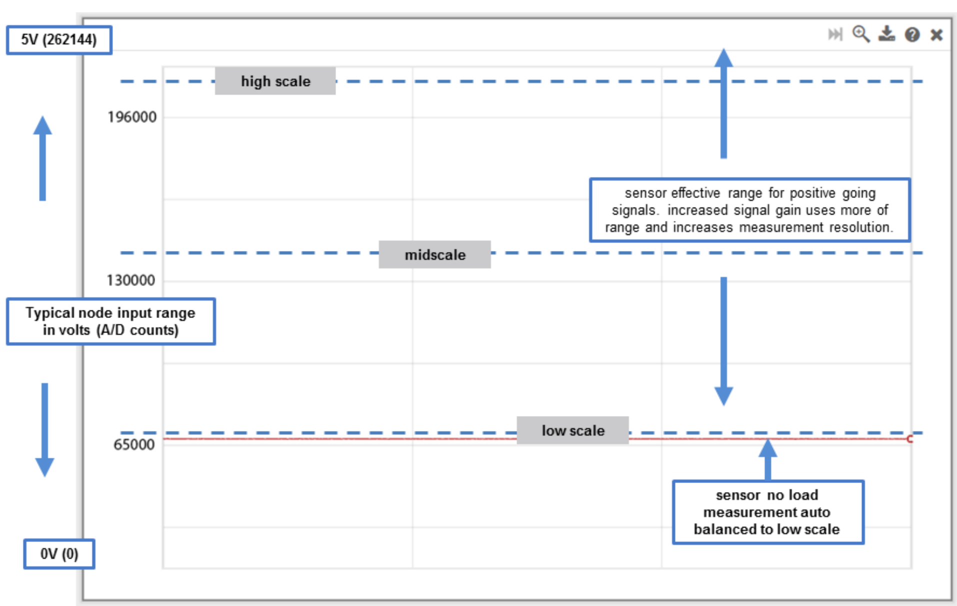


Figure 49 - Differential Input Resolution and Offset (18-bit Node)

Table 1 - Differential Gain Values

This table lists the gain settings available on the V-Link-200 differential input channels. The scaled input range is the approximate signal range of a sensor that would work with that gain, without considering the offset setting.

Gain	Scaled input range
16	+/- 156 mV
32	+/- 78.1 mV
64	+/- 39.0 mV
128	+/- 19.5 mV
256	+/- 9.76 mV
512	+/- 4.88 mV
1024	+/- 2.44 mV
2048	+/- 1.22 mV

Table 8 - Differential Gain Values

Coefficients for Conversion to Volts:

Slope = 5.12 / (2 ^ 18 * gain)

Offset = -(5.0 / (2 * gain)) (assuming balance to mid-scale is perfect)

7. Powering the Node

The node can be powered with either the internal battery or an external source within the 7.5 to 36 V dc range.

⚠WARNING	The V-Link-200 contains internal, non-rechargeable lithium batteries. When replacing batteries, use only the batteries specified for the node. Do not disassemble, short circuit, crush, puncture, or otherwise misuse the battery. Do not attempt to recharge the batteries. Do not expose to water. Disposal is subject to federal and local laws. For important precautions see Safety Information on page 94.

⚠WARNING	Apply only the input voltage range specified for the node in the polarity indicated. Failure to do so could result in personal injury and permanent damage to the node (see Safety Information on page 94).

⚠CAUTION	The V-Link-200 is susceptible to damage and/or disruption of normal operation from Electrostatic Discharge (ESD). For important precautions see Safety Information on page 94.

NOTICE	The electronics within the node are sensitive to moisture and static. Do not touch the internal circuitry or expose to liquids. Verify the node power switch is OFF before servicing.

7.1 Using the Internal Node Battery

⚠WARNING	The V-Link-200 contains internal, non-rechargeable lithium batteries. When replacing batteries, use only the batteries specified for the node. Do not disassemble, short circuit, crush, puncture, or otherwise misuse the battery. Do not attempt to recharge the batteries. Do not expose to water. Disposal is subject to federal and local laws. For important precautions *see Safety Information on page 94*.

The node is powered by four non-rechargeable, replaceable 3.6 V dc, 2.4 Ah, AA lithium batteries. If the node will not power, the batteries may need to be replaced. For more information on replacing the batteries *See Replacing Batteries on page 94*.

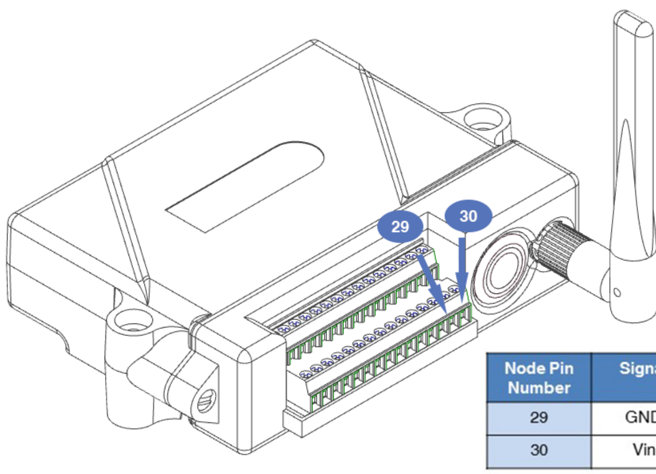
Node battery life is highly dependent on the type of sensor connected, as well as operational parameters such as sample mode and rate. More active channels and higher sample rates equate to decreased battery life.

7.2 Connecting an External Power Supply

> **⚠WARNING**
>
> Apply only the input voltage range specified for the node in the polarity indicated. Failure to do so could result in personal injury and permanent damage to the node (*see Safety Information on page 94*).

The node may be directly powered by a regulated AC to DC power supply with the appropriate output parameters, *see Operating Specifications on page 90*). It can also be powered by an external battery or other regulated DC supply. The supply must deliver a stable voltage between 7.5 to 36 V dc and be capable of sourcing at least 100 mA.

External power is applied through the terminal block connector. Observe connection polarities, or the node may be damaged.

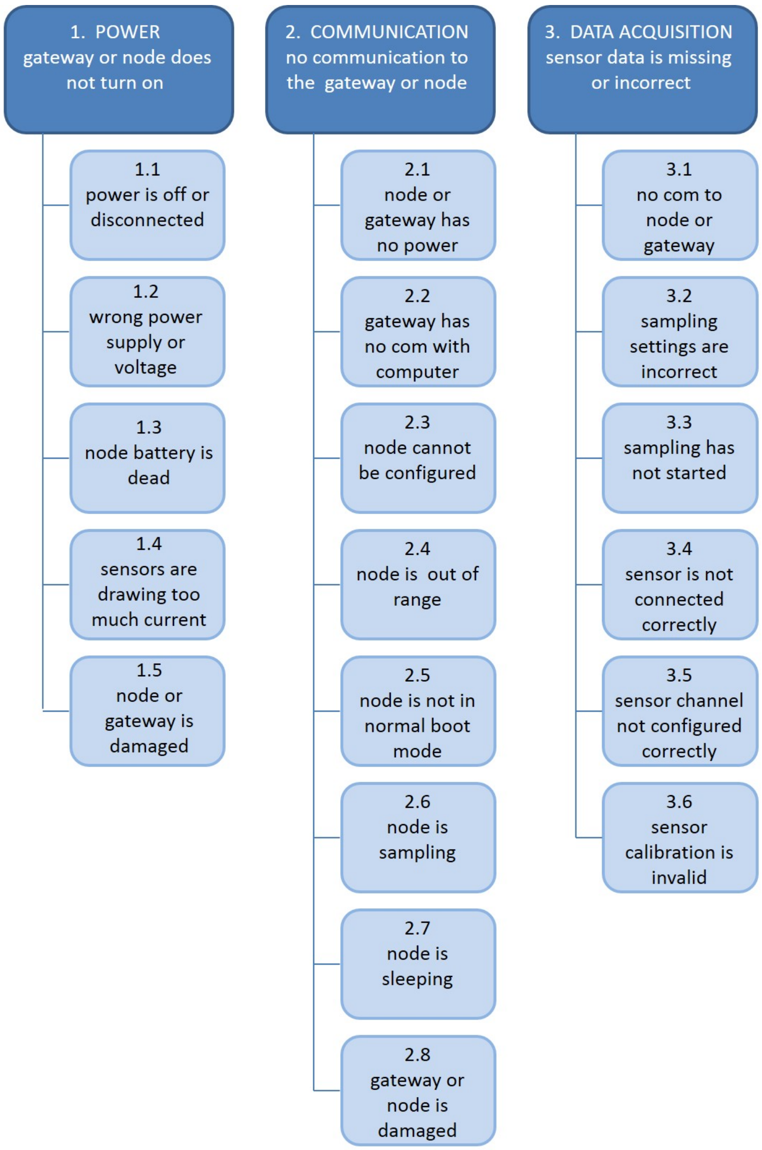


Node Pin Number	Signal
29	GND
30	Vin

Figure 50 - External Power Connection

8. Troubleshooting

8.1 Troubleshooting Guide



	Possible cause and recommended solution
1. POWER gateway or node does not turn on	**1.1 node or gateway power is off** The status indicator LED on the device may be off. Turn the device on, and the status indicator LED should illuminate.
	1.2 external power is off or miswired Verify the device power source is connected correctly and powered on.
	1. wrong power supply or voltage Using a power supply other than the one specified for the device (or an external supply that is outside of the device operating range) could result in permanent damage to the device or cause it to not work properly.
	1. node battery is dead If the node will not power on, the node battery may need to be replaced.
	1. 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 wrong.
	1. 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 (*See Technical Support on page 82*).
2. COMMUNICATION no communication to the gateway or node	**2.1 node or gateway has no power** Verify the node and gateway have power applied and that applicable 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. • For serial gateways, verify that the COM port setting. • For USB gateways, verify that the drivers are installed on the computer (included with SensorConnect) and that the software has had sufficient time to detect it. • For Ethernet gateways, use Live Connect to verify communications on a DHCP network. Check that the extended timeouts are enabled in the SensorConnectEdit > Preferences menu, under Devices. Once communication has been established, the network configuration can be changed.

	Possible cause and recommended solution
	2.3 node cannot be configured Observe the node status indicator LED to determine the device's state: boot, idle, sample, or sleep. If the node is sampling or sleeping, it cannot be configured. In SensorConnect, execute the Stop Node command to put the node in idle state, allowing configuration to occur. If the user inactivity timeout is set very low, the configuration menu will have to be entered quickly, before the timeout occurs, 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. For range test and installation recommendations *See Range Test on page 33*. 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 status indicator shows the node booting 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 Observe the node status indicator LED to determine the device's state: boot, idle, active, or sleep. If the node is sampling, it cannot be configured. In SensorConnect, execute the Stop Node command to put the node in idle state, allowing configuration to occur.
	2.7 node is sleeping Observe the node status indicator LED to determine what state it is: boot, idle, active, or sleep. If the node is sleeping, it cannot be configured. In SensorConnect, execute the Stop Node 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 (*See Technical Support on page 82*).
3. DATA ACQUISITION **sensor data is missing or incorrect**	**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.
	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

	Possible cause and recommended solution
	sampling settings.
	3.3 sampling has not started If sampling is occurring, the sampling mode will be displayed 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.
	3.4 sensor is not connected correctly Verify sensors connections and wiring. For non-standard connections contact LORD Sensing Technical Support (*See Technical Support on page 82*).
	3. sensor channel not configured correctly Verify that the sensor is configured on the correct channel and has been enabled for data acquisition.
	3. sensor calibration is invalid In the channel configuration settings, verify that the calibration . Verify that the sensor channel units are selected correctly. Verify that all parameters were written to the node channel.

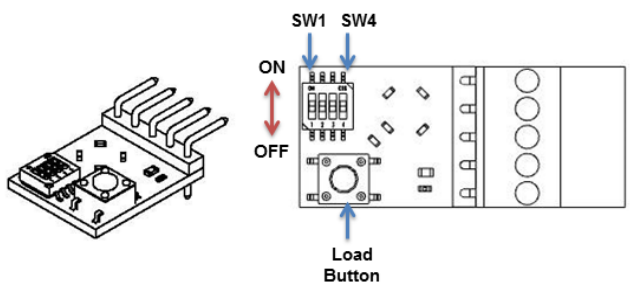
8.2 Using the Node Tester Board

The node tester board is used to verify node and network functions before sensors are connected, or for diagnostic purposes. The node tester board is used only on differential input channels, and provides a fixed load so system functions can be verified including basic operations not related to the sensor, such as communication and sampling. A fixed load is applied to the differential input by pressing the load button.

There are various impedance value node tester boards available, depending on the node it is being used with. *See Parts and Configurations on page 84* for configuration options and part numbers. Each is configurable to emulate full, half and quarter bridge strain gauges. *Table 9 - Tester Board Configuration* describes the strain gauge load settings available. This setting must match the type of node channel that is being tested. For example if the node is a quarter-bridge node, the setting on the tester board must be the same. The configuration chart is also printed on the underside of the board.

NOTE

The switches may come with a protective film covering them. Simply peel the film off to access the switches.



Configuration	SW 1 position	SW 2 position	SW 3 position	SW 4 position
Full Bridge	ON	ON	ON	OFF
Half Bridge	OFF	OFF	ON	OFF
Quarter Bridge	OFF	OFF	OFF	ON

Table 9 - Tester Board Configuration

The following steps describe an example of how to use the tester board to sequence through the primary functions of the node and the wireless system. If the results indicated in the final steps are achieved, the system is fully operational for measuring a full bridge strain gauge. Other scenarios can be tested as needed.

1. Set the jumpers for Full Bridge operation, using a small flat head screw driver to fully push the switch into the desired position.

2. Verify the node is powered off and unplugged.

3. Plug the node tester board into the node Channel 1 position.

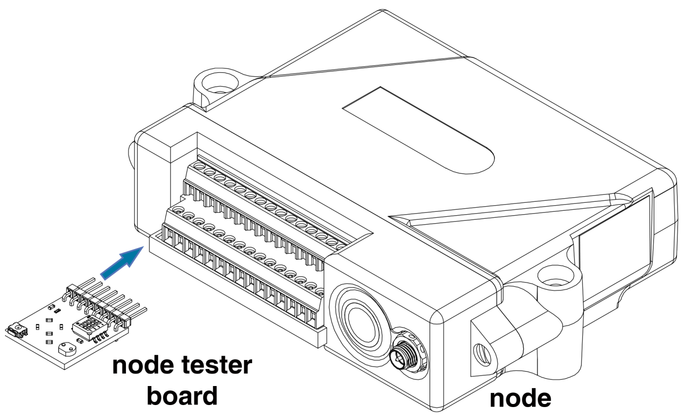


Figure 51 - Node Tester Board Installation

4. If not already completed, set up the Wireless Sensor Network equipment and install the SensorConnect software. *See System Operational Overview on page 14*.

5. Launch the SensorConnect software, and establish communications with the gateway and node.

6. Select Hardware > Input Range for channel 1, select +/-2 mV from the drop down menu.

7. Under Hardware Offset, select Balance Target for channel 1, select Mid (50%) from the drop down menu.

8. Select Auto-Balance. When auto-balance is complete, a blue information window will indicate the balance result.

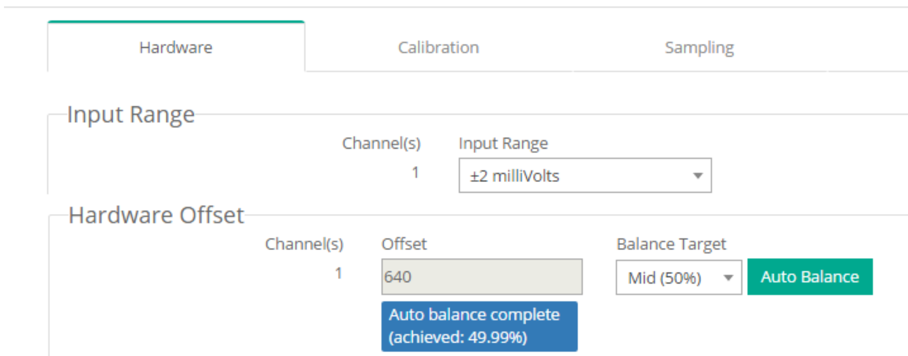


Figure 52 - Auto-Balance

9. Select Calibration.

10. Select Microstrain from the Unit drop down menu, select the Shunt Cal button enabled on the right.

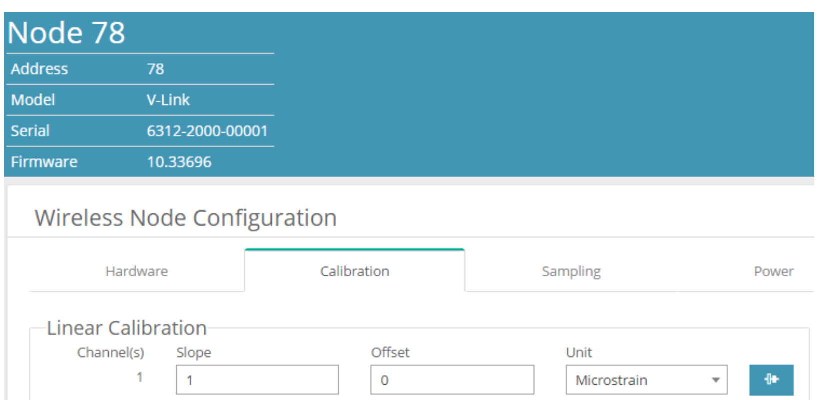


Figure 53 - Node Configuration Menu

11. Use the following settings:
    a. **Calibration Mode:** Internal
    b. **Number of Active Gauges:** 4
    c. **Gauge Factor:** 2
    d. **Gauge Resistance:** 1000
    e. **Shunt Resistance:** 499000
12. Select Start Shunt Cal for Slope and Offset calibrations.
13. Select Accept Calibration.

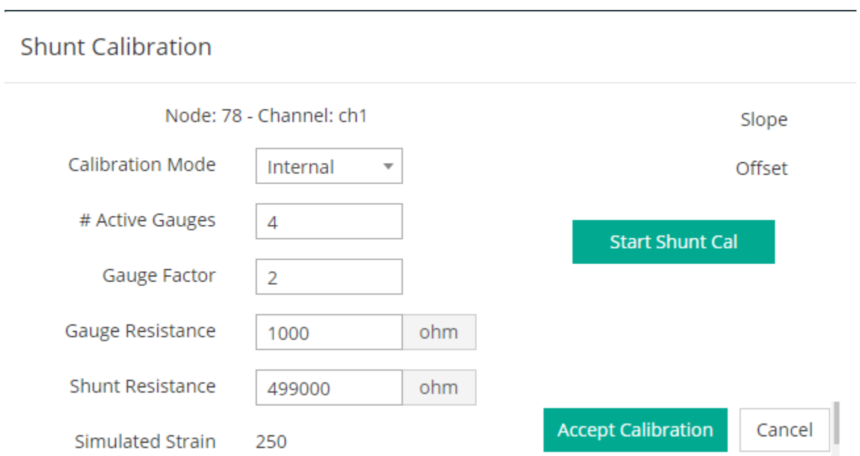


Figure 54 - Channel Settings

14. When the calibration is complete, the Wireless Node Configuration window will appear.
15. Select Apply Configuration to write to node memory.
16. In the Wireless Node Configuration window, select the Node heading and then select Sampling.

17. From the Wireless Network menu, select the drop down menu for channel 1 under Sampling > uncheck Continuous streaming, and check For to select a duration of +/- 10 seconds using the arrows to the right of the box, or by typing the number 10 in the box. (the system will auto set to 10.15625).

18. Select Apply and Start Network.

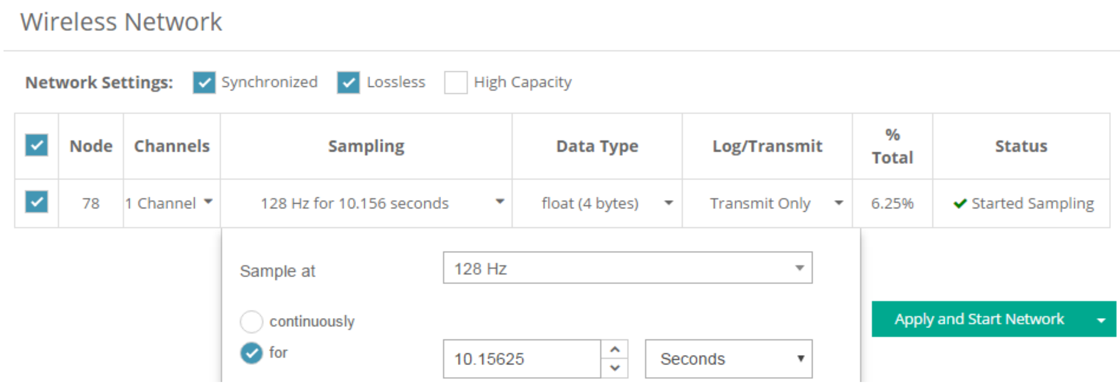


Figure 55 - Node Sampling Menu

19. As soon as Apply and Start Network is selected, the node will start collecting data for a duration of +/-10 seconds. During that time, press and release the load button on the node tester board to shunt the resistive load on and off. Verify the result is as shown in the figure below. The pulse value should equal tester board ohm value. Testing is complete.

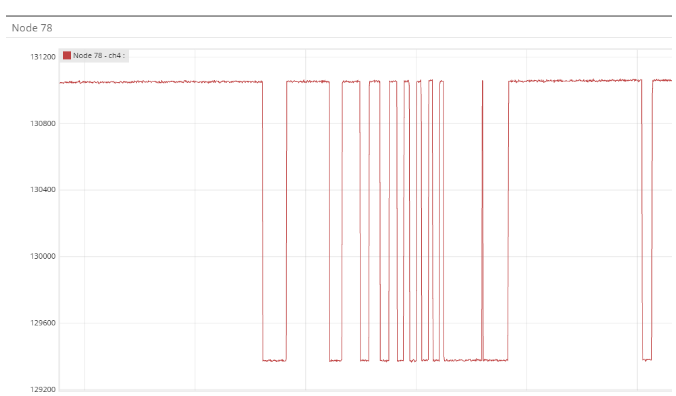


Figure 56 - Node Tester Output Stream

8.3 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. *See Technical Support on page 82* for contact and website information.

1. Download the Firmware Upgrade file from the LORD Sensing website.
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

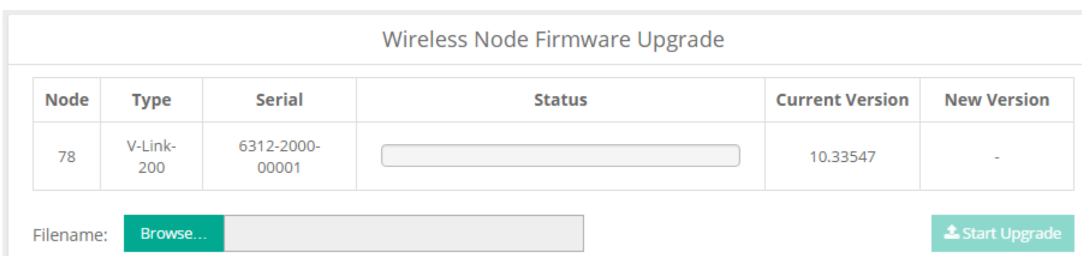


Figure 57 - Update Node Firmware

8.4 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 number (RMA). 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 provide the LORD Sensing model number and serial number as well as your name, organization, shipping address, telephone number, and email. Normal turn-around 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 which have been subject to misuse, alteration, neglect, accident, incorrect wiring, mis-programming, or use in violation of operating instructions furnished by us. 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.

8.5 Technical Support

There are many resources for product support found on the LORD MicroStrain® 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
Fax: 802-863-4093

SKYPE: microstrain.wireless.support

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

8. Maintenance

The replaceable batteries are the only user serviceable parts in the V-Link-200. For instructions on how to change the batteries, *See Replacing Batteries on page 94*).

For other service or repair needs contact LORD Sensing Technical Support (*see Technical Support on page 82*).

8. Parts and Configurations

8.6 Standard Nodes

For the most current product information, custom, and OEM options not listed below, refer to the LORD Sensing website or contact the LORD Sensing Sales Department.

Model Number	Description	LORD Sensing Part Number
V-Link-200	• Four differential channels • Four single ended channels • Internal temperature sensor	6312-2000

Configuration Options (Required for use. Specify at time of order)

- **Full-bridge configuration** on one or more differential channels.
- **120Ω, 350Ω or 1000Ω half-bridge** completion on one or more differential channels.
- **120Ω, 350Ω or 1000Ω quarter-bridge** completion on one or more differential channels.
- **High g-force** option. Node operates in gravitational forces in excess of 550 g.

8.7 Node Accessories

The following parts are available for use with the V-Link-200. For the most current product information, custom, and OEM options not listed below, refer to the LORD Sensing website or contact the LORD Sensing Sales Department. *See Product Ordering on page 88*.

Description	LORD Sensing Part Number
120Ω node tester board	
350Ω node tester board	6313-9000
1000Ω node tester board	6313-8000
Lithium AA cell battery 2.4 Ah capacity	9021-0034
Standard whip antenna (FCC compliant)	9010-0048

Table 10 - Node Accessories

8.8 Recommended Sensors

Many sensors can be used with the V-Link-200. The following sensors are supported for use with the V-Link-200 and are available from LORD . For help with other sensor applications, *see Technical Support on page 82*.

Model	Description	LORD Sensing Part Number
ACCEL TRIAX-50	Triaxial Accelerometer, +/-50g	6402-0320
ACCEL-TRIAX-100	Triaxial Accelerometer, +/-100g	6402-0120
ACCEL-TRIAX-200	Triaxial Accelerometer, +/-200g	6402-0220
ACCEL-TRIAX-500	Triaxial Accelerometer, +/-500g	6402-0420

Table 11 - LORD Sensing Sensors

8.9 Wireless System Equipment

The following system parts are available for use with the V-Link-200. For the most current standard, custom, and OEM product options, refer to the LORD Sensing website or contact the LORD Sensing Sales Department. *See Product Ordering on page 88*.

Model	Description	LORD Sensing Part Number
WSDA-1500-SK	Ethernet Data Gateway Starter Kit	6314-1501
--	SensorConnect Software	--
WSDA-BASE-104-SK	USB Gateway Starter Kit	6307-1041
WSDA-BASE-102-SK	RS232 Gateway Starter Kit.	6307-1021
WSDA-BASE-101-SK	Analog Gateway Starter Kit	6307-1011
--	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

Table 12 - Wireless System Equipment

8.10 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

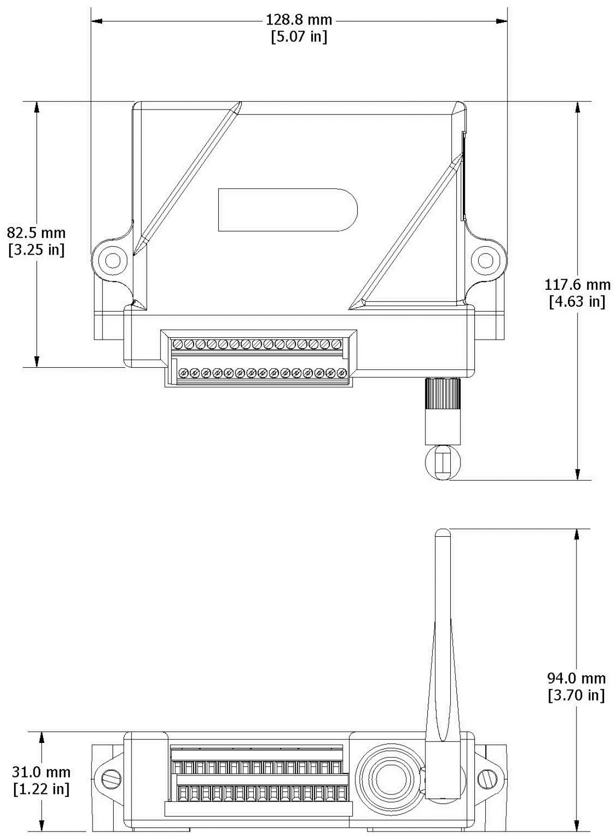
sensing_sales@LORD.com

Phone: 802-862-6629
Fax: 802-863-4093

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

9. Specifications

9.1 Physical Specifications



Dimensions:	128.8 mm x 82.5 mm x 31.0 mm
Weight:	283 grams (with batteries), 217 (without batteries)
Enclosure Environmental Rating:	General purpose indoor (IP67/NEMA4X rated enclosure available)

9.2 Operating Specifications

Parameter	Specifications
General	
Sensor input channels	**Differential analog,** 4 channels **Single-ended analog,** 4 channels
Integrated sensors	**Internal temperature,** 1 channel
Data storage capacity	16 M Bytes (5+ million data points)
Analog Input Channels	
Selectable measurement ranges	Differential: ± 1.22 mV dc to 156 mV dc Single-ended: ±2.56 V dc, ±5.12 V dc, ±10.24 V dc, 0 to 5.12 V dc, 0 to 10.24 V dc
Single-ended input impedance	1 Mohm
Input bandwidth	DC-4000 Hz (-3 dB cutoff)
ADC Resolution	18 bit
Accuracy	± 0.1 % full scale typical
Noise	± 0.02 % full scale
Temperature stability	< 0.1 % full scale over temperature range
Anti-aliasing filter	Differential Inputs Only: user-set 128 Hz to 4 kHz, Sallen-Key Single-ended Inputs: -3 dB at 15 kHz, Two-pole
Bridge excitation voltage	+4.096 V dc (150 mA max)
Measurement gain and offset	16 to 2048, user-set in software on differential channels
Integrated Temperature Channel	
Measurement range	-40 °C to 85 °C
Accuracy	±1 °C (at 25 °C) typical
Resolution	0.1 °C
Sampling	
Sampling modes	Synchronized, low duty cycle, datalogging, event-triggered
Sampling rates	**Continuous sampling:** 1 sample/hour to 4 KHz ***** **Periodic burst sampling:** 32 Hz to 8 KHz *****
Sample rate stability	±5 ppm
Network capacity	Up to 127 nodes per RF channel depending on settings. See: http://www.microstrain.com/configure-your-system
Synchronization between nodes	± 50 µsec
Operating Parameters	
Wireless communication range	Outdoor/line-of-sight: 1.5 km(ideal), 800 m (typical)****** Indoor/obstructions: 250 m (typical)******
Radio frequency (RF) transceiver carrier	2.405 to 2.470 GHz spread spectrum over 14 channels, power settings from 4 dBm (2.5 mW) to 16 dBm (39 mW)
Radio frequency (RF) channel allocation	2.40 to 2.483 GHz spread spectrum with 14 distinct channels
RF communication protocol	IEEE 802.15.4, FSK/GMSK
RF transmit power	User-set from 0 dBm to 20 dBm. Power output restricted regionally to operate within legal requirements
RF receive sensitivity	-99.4 dBm
RF transmission rate	250 kbps
Power source	Internal: Four replaceable 3.6 V dc, 2.4 Ah Lithium batteries External: +7.5 to 36.0 V dc
Operating temperature	-40 °C to + 85 °C
Acceleration limit	100 g
Physical Specifications	
Dimensions	129 mm x 82.5 mm x 31 mm
Weight	283 grams (with batteries), 217 grams (without batteries)
Environmental rating	Indoor use (IP67 faceplate available)
Enclosure material	Molded polycarbonate
Integration	
Mounting	Bolt down or DIN-rail mount
Compatible gateways	All WSDA 101 base stations and gateways
Compatible sensors	Differential analog sensors, -10 to +10 V dc analog sensors
Connectors	Screw terminal block (M4 circular connectors on IP67 faceplate)

Parameter	Specifications
Shunt calibration	Internal shunt calibration resistor 499 KΩ, differential channels
Software	SensorCloud, SensorConnect, Windows 7 (or newer)
Software development kit (SDK)	Open-source MicroStrain Communications Library (MSCL) with sample code available in C++, Python, and .NET formats http://www.microstrain.com/software/mscl
Regulatory compliance	FCC (U.S.), IC (Canada), MIC (Japan), CE (European Union), ROHS

*** Divide maximum rate by number of active channels ** Line of sight with antenna at 3 meters**

***Measured with antennas elevated, no obstructions, and no RF interferers.**
****Actual range varies with conditions such as obstructions, RF interference, antenna height & orientation.**

9.3 Radio Specifications

The V-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 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 24. For all newly manufactured nodes, the default setting is 2.425 GHz (channel 15).

For standard models, radiated transmit power is programmable from 4 dBm (2.5 mW) to 16 dBm (40 mW). A low-transmit power option is available (for use in Europe and elsewhere) and is limited to 10 dBm (10 mW).

The radio complies with FCC Part 15 (USA) and IC (Canada) regulations. The radio is license-free worldwide. Using antennas and transmission equipment other than what is provided may void FCC compliance.

FCC ID: XJQMSLINK0004

V-Link-200

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference and (2) this device must accept any interference received, including interference that may cause undesired operation. Changes or modifications, including antenna changes not expressly approved by the LORD CORPORATION could void the user's authority to operate the equipment.

NOTE

- The gateway can automatically manage nodes operating on different frequencies by using the Node Discovery feature in Node Commander. 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.

10. 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. Throughout the manual, ANSI Z535 standard safety symbols are used to indicate a process or component that requires cautionary measures.

10.1 Replacing Batteries

1. Remove the screws on both sides of the face plate to open the V-Link-200.

2. Replace the four 3.6 V dc, 2.4 Ah lithium AA batteries, observing the correct polarity orientation. The positive polarities are indicated on the batteries and the node by a "+" symbol.

3. Reassemble.

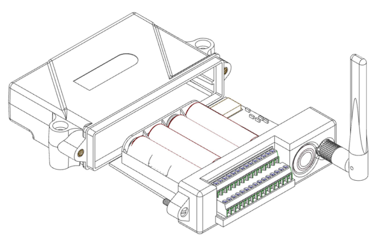


Figure 58 - Replace Batteries

10.2 Battery Hazards

⚠WARNING ⚠CAUTION NOTICE

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

Lithium 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.

10.3 Power Supply

The V-Link-200 Wireless Sensor Node can be powered by an external source.

⚠WARNING ⚠CAUTION NOTICE

Apply only the input voltage range specified for the V-Link-200. Connect to a power source that is near the device, is accessible, and adheres to all national wiring standards. Compliance with wiring standards is assumed in the installation of the power source and includes protection against excessive currents, short circuits, and ground faults. Failure to do so could result in personal injury and permanent damage to the device.

10.4 Disposal and Recycling

⚠WARNING ⚠CAUTION NOTICE

The V-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.

11. References

11.1 Reference Information

Many references are available on the LORD Sensing website including product user manuals, technical notes, and quick start guides. These documents are continuously updated, and new applications are added. They may provide more accurate information than printed or file copies.

Document	Where to find it
Online Wireless Network Calculator	http://www.microstrain.com/configure-your-system
SensorCloud Overview	http://www.sensorcloud.com/system-overview
MathEngine® Overview	http://www.sensorcloud.com/mathengine
LORD Sensing Wireless Sensors Network Software Development Kit	http://www.microstrain.com/wireless/sdk
Product Datasheets	http://www.microstrain.com/wireless/sensors
Product Manuals and Technical Notes	http://www.microstrain.com/support/docs
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

Table 13 - Related Documents

LORD SENSING MicroStrain

11.2 Glossary

These terms are in common use throughout the manual:

A/D Value: the digital representation of the 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. Also referred to as "bits".

Base Station: The base station is the transceiver that attaches to the host computer and provides communication between the software and the node(s). It is also referred to as a gateway.

Burst Sampling: a mode of operation in which the node is sampled for a fixed window of time (burst) and then repeats that window at set intervals. The burst duration and time between bursts is configurable. Also referred to as periodic burst sampling.

Calibration: to standardize a measurement by determining the deviation standard and applying a correction (or calibration) factor

Configuration: a general term applied to the node indicating how it is set up for data acquisition. It includes settings such as sampling mode/rate, number of active channels, channel measurement settings, offsets, hardware gain, and calibration values.

Continuous Sampling: a mode of operation in which the node is sampled continuously until stopped or sampled continuously for a fixed amount of time

Coordinated Universal Time (UTC): the primary time standard for world clocks and time. It is similar to Greenwich Mean Time (GMT).

Cycle Power: a command transmitted to the node to reboot it either through a hardware or software switch

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 node or remotely on the host computer

DHCP (network): Dynamic Host Configuration Protocol is the standardized networking protocol used on Internet Protocol (IP) networks, which automatically configures devices that are attached to it by assigning and configuring the device IP address.

EMI: Electromagnetic Interference is an inductive or radiated disturbance that can create signal degradation on electrical signals, including loss of data.

ESD: Electrostatic Discharge is the sudden flow of electricity that can occur between two charged objects of different potential that come in contact or in close proximity of each other. Static electricity is a common source of ESD.

Event-Based Sampling: a mode of operation in which the node sampling is started when a sensor measurement value (threshold) is achieved

Firmware: the code that is programmed onto a microcontroller or similar device in an embedded system. It includes device operation commands, conditions, memory allocation, and many other tasks.

Gateway: The gateway is a transceiver that attaches to the host computer and provides communication between the software and the node(s). It is also known as a base station.

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

LED: Light Emitting Diode is an indicator light that is used in electronic equipment.

LOS (Line of Sight): is used in radio communications to describe the ideal condition between transmitting and receiving antennas in a radio network. As stated it means the antennae are in view of each other with no obstructions.

LXRS: Lossless Extended Range Synchronized is the proprietary LORD Sensing data communications protocol used in the wireless sensor network.

Node: The node is the wireless transceiver to which the sensor (s) is connected, providing communication with the gateway. The G-Link® -LXRS®, V-Link® -LXRS®, and SG-Link® -LXRS® are examples of nodes manufactured by LORD MicroStrain®.

Node Tester Board: The node tester board is a device designed by LORD MicroStrain® that can be plugged into nodes to test their functionality.

Offset: When describing a mathematically-linear relationship, the offset is the value where the line that represents the relationship in a graph crosses the *y*-axis. The equation of a straight line is: $y = mx+b$, where x is the x-axis coordinate, y is the y-axis coordinate, m is the slope and b is the offset.

Oversampling: In signal processing, oversampling is a technique used to achieve increased signal resolution and better noise immunity by recording readings at a higher frequency than the output of the device being measured. In analog-to-digital conversion, the higher the oversampling rate, the better the recreated analog signal.

Packet: unit of sampled data

Periodic Burst Sampling: a mode of operation in which the node is sampled for a fixed window of time (burst) and then repeats that window at set intervals. The burst duration and time between bursts is configurable. Also referred to as burst sampling.

Ping: a byte transmitted by the gateway to the node. The node responds by echoing the byte, indicating communication exists between the node and gateway.

Range Test: a continuous string of pings used to validate communication between the gateway and the node over distance and obstruction

Real Time Clock (RTC): a computer clock that keeps track of the current time

RFI: Radio Frequency Interference is a disturbance in an electrical circuit due to electromagnetic induction or radiation.

RSSI: Received Signal Strength Indication is a measurement of the transmission power in a radio signal. It is measured in decibels with reference to 1 milliWatt (dBm).

RS232: a serial data communications protocol

Sensor: a device that physically or chemically reacts to environmental forces and conditions, producing a predictable electrical signal

Sleep: a command transmitted to the node to put it into sleep configuration

Sampling: the process of taking measurements from a sensor or device

Sampling Mode: the type of sampling that is being utilized, such as event-triggered, continuous, or periodic. The nodes have several sampling modes that employ these types of sampling.

Sampling Rate: the frequency of sampling

Slope: When describing a mathematically linear relationship, the slope is the steepness of the line that represents that relationship on a graph. The equation of a straight line is: $y = mx+b$, where x is the x-axis coordinate, y is the y-axis coordinate, m is the slope, and b is the offset.

Streaming: Streaming is a sampling mode in which all active channels (and the sensors attached to them) are measured, and the acquired data is transmitted to the gateway and software. The data is not written to non-volatile memory during streaming. Streaming can either be finite (have a user defined start and end time) or continuous (continued until the power is cycled on the node).

Synchronized Sampling: a sampling mode that automatically coordinates all incoming node data to a particular gateway. This mode is designed to ensure data arrival and sequence.

Transmission rate: the number of data packets per transmission window, measured in seconds. Depending on the sampling mode and settings it will be between 1 and 64 packets/second.

Transmission window: the time allowed for one data transmission at the automatically determined transmission rate

USB: Universal Serial Bus is a serial data communications protocol

WSN: Wireless Sensor Network describes a distribution of sensors and data acquisition equipment that autonomously monitors environmental characteristics, such as temperature, pressure, and strain.