IEPE-Link™ -LXRS®

Wireless IEPE Sensor Node

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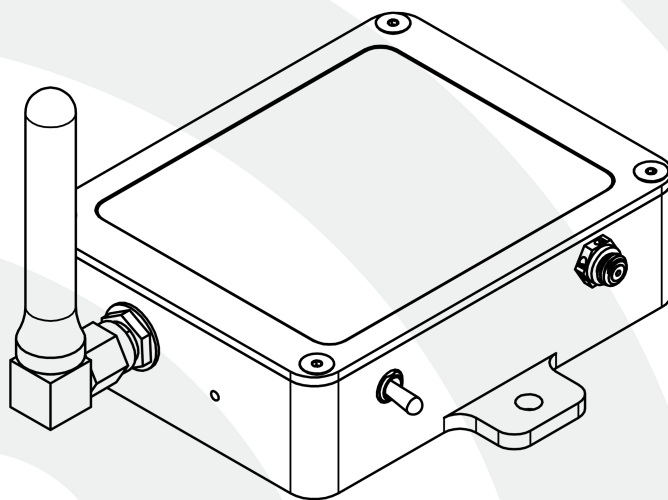
LORD MicroStrain®
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Table of Contents

LORD MicroStrain®
SENSING SYSTEMS

LORD MicroStrain®
SENSING SYSTEMS

LORD MicroStrain®
SENSING SYSTEMS

1.   Wireless Sensor Network Overview

The LORD MicroStrain ® 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 MicroStrain® Lossless Extended Range Synchronized (LXRS®) data communications protocol. Bidirectional 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 standalone data acquisition equipment.
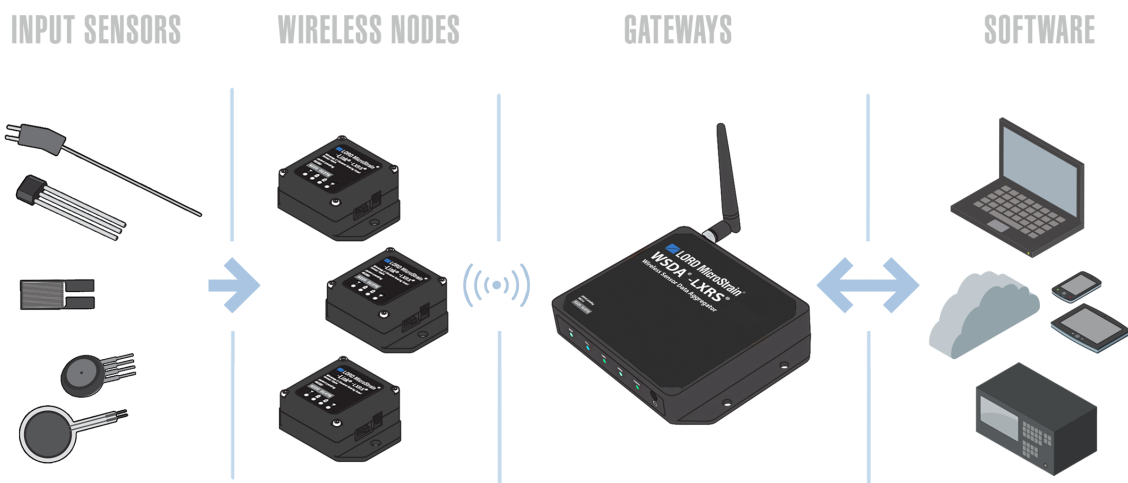
The selection of available nodes allows interface with many types of sensors, including accelerometers, strain gauges, pressure transducers, load cells, torque and vibration sensors, magnetometers, 4 to 20mA sensors, thermocouples, RTD sensors, soil moisture and humidity sensors, inclinometers, and orientation 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 Node Commander® and SensorCloud™ software platforms. Integration to customer systems can be accomplished using OEM versions of the sensor nodes and leveraging the LORD MicroStrain® data communications protocol.

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

2.   Node Overview

The IEPE-Link™ -LXRS® wireless sensor node is a specialty node designed for high speed, high resolution, short duration sampling from Integrated Electronics Piezoelectric (IEPE) type accelerometers. The IEPE-Link™ -LXRS® employs the ultra low noise, small packaging features of conventional IEPE sensors to provide an excellent solution for high sensitivity vibration and shock monitoring applications such as: long-term machine health monitoring; modal, seismic and structural analysis; and flight and product testing.

The IEPE-Link™ -LXRS® accepts inputs from most IEPE sensors using the industry standard 10-32 mini-coaxial connector and 2.3 mA constant current excitation. It features 24-bit resolution with a 109.5 dB dynamic range, 1 kHz to 104 kHz sampling rates and user-selectable frequency filtering. The node uses periodic burst sampling with configurable sample rates, durations, and intervals. Synchronized sampling allows precise coordination with other nodes.

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

Figure 1 - IEPE-Link™ -LXRS® Wireless Sensor Node

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2.1   Components List

IEPE-Link™ -LXRS® 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 56*.
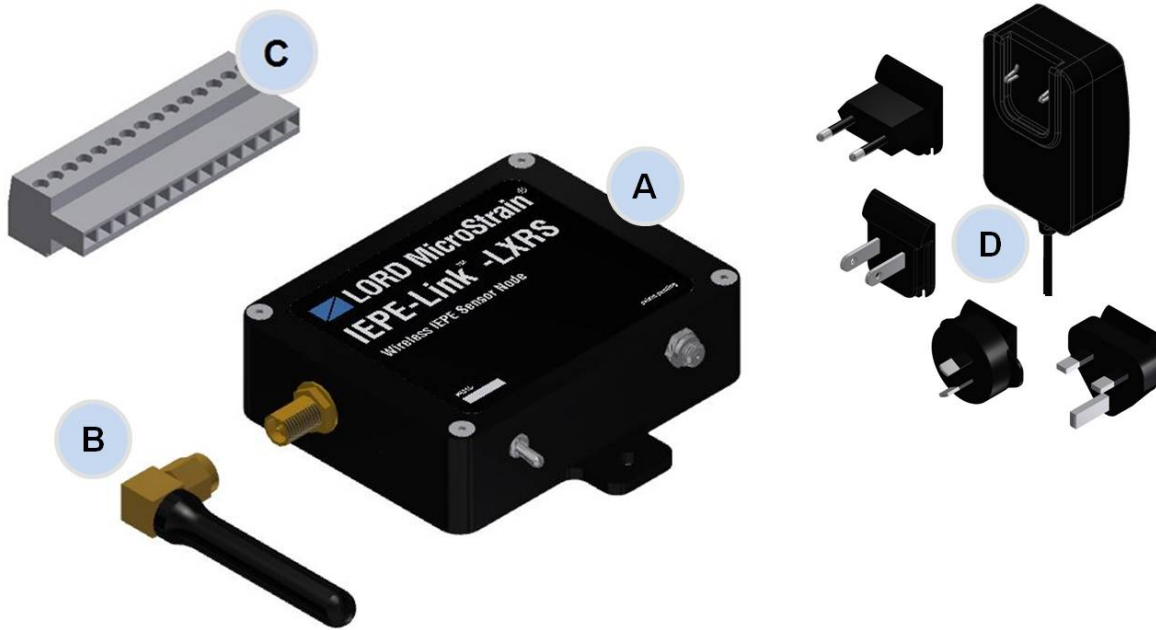
Item	Description	Quantity
A	IEPE-Link™ -LXRS® Wireless Sensor Node	1
B	Right angle antenna	1
C	Removable terminal block	1
D	Power supply and plug adapter kit	1
--	User Manual, Quick Start Guide and Calibration Certificate	1

Table 1 - Components List

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2.2 Interface and Indicators

The IEPE-Link™-LXRS® includes a power input jack for charging the internal battery or externally powering the node, a power on/off switch, an antenna connector for attaching the node antenna, a sensor connector, an auxiliary terminal block for future use, and mounting holes for device installation.

The indicators on the IEPE-Link™-LXRS® include a device status indicator, and a battery charge status indicator. The following table describes basic indicator behavior. During data acquisition, the device status indicator has other sequences (*see Device Status Indicators on page 50*).
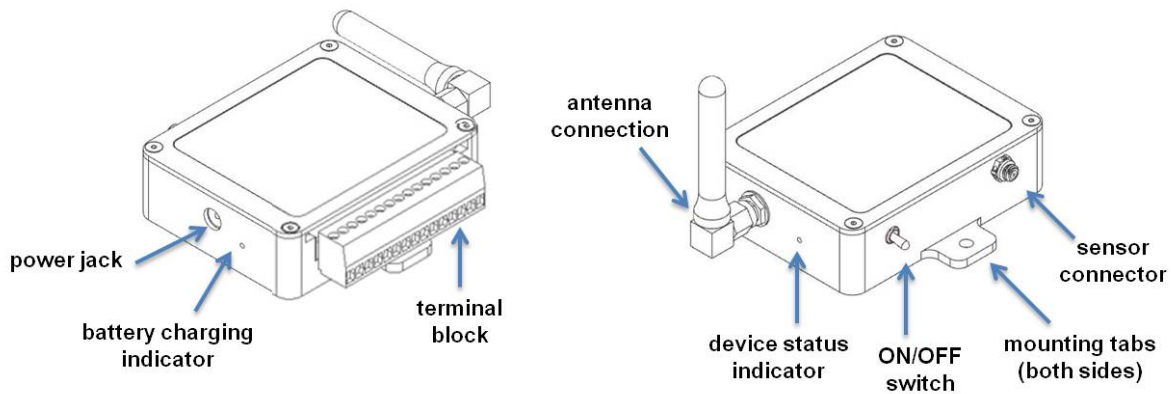
Figure 2 - Interface and Indicators

Indicator	Behavior	Node Status
Battery charge status indicator	OFF	Node battery is not currently being charged
	ON bright red	Node battery is charging
	ON dim red	Battery fault condition. Reset by unplugging power and then plugging node in again
	ON green	Battery is fully charged
Device status indicator	OFF	Node is OFF
	Rapid flashing on start-up	Node is booting up
	1 (slow) pulse per second	Node is idle and waiting for a command

Table 2 - Indicator Behaviors

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SENSING SYSTEMS

2.3 Node Operational Modes

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

Active mode

- Node is sampling at assigned sample rate and duration.
- Status indicator on node blinks green or blue at 1 Hz or at sample rate.

NODE IS SAMPLING

idle or stop command

start sampling command

Idle mode

- Allows node configuration
- Allows toggling between sampling and sleeping modes
- Status indicator on node pulses green 1/second.

NODE IS WAITING FOR A COMMAND

sleep command or inactivity time-out

Idle, stop, or wake command

Sleep mode

- Low power mode
- Checks periodically for an idle command (user-selectable interval)
- Status indicator on node occasionally blinks green (user-selectable interval).

NODE IS CONSERVING POWER

Figure 3 - Node Operational Modes

3. System Operational Overview

<table>
<tr>
<td>⚠️ **WARNING**</td>
<td>The IEPE-Link™ -LXRS® contains an internal, rechargeable Lithium Polymer (Li-Po) battery. For important precautions see Safety Information on page 65.</td>
</tr>
</table>

To acquire sensor data, nodes are used with any LORD MicroStrain® data gateway, such as the WSDA®-Base -10*x*-LXRS® or WSDA®-1500 - LXRS®, and a software interface.

LORD MicroStrain® has two software programs available for data acquisition from the wireless sensor network: SensorCloud™ and Node Commander®. SensorCloud™ is an optional web-based data collection, visualization, analysis, and remote management platform based on cloud computing technology. Node Commander® 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 Node Commander® 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.

NOTE

To maximize operating time, it is recommended that the IEPE-Link™ -LXRS® internal battery be fully charged before installation. If fully discharged, it can take up to 8 hours. For charging instructions *see Charging the Node Battery on page 42*.

LORD MicroStrain®
SENSING SYSTEMS

3.1   Software Installation

To install Node Commander ® Software Suite on the host computer, run the installer executable file and follow the on‑screen prompts. The software is provided with all gateways and is available on the LORD MicroStrain® website (*see References on page 69*).

NOTE

The Node Commander® software includes hardware drivers required for use with USB gateways. Once installed, the software will automatically detect and configure any USB gateways that are plugged into the host computer.

The suite includes the following programs:

- **Node Commander** is used for configuring nodes and acquiring, viewing, and saving data.

- **Live Connect™** is a TCP/IP-to-serial conversion tool that translates the communications between Node Commander and an Ethernet gateway.

- **WSDA® Data Downloader** is used to download acquired data from the flash memory card embedded in an applicable gateway, to a host computer.

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 - LXRS®. Data files can also be easily uploaded. For more information *see Data Handling on page 30*.

Users can also design custom programs with the open source data communications protocol (*see References on page 69*).

LORD MicroStrain®
SENSING SYSTEMS

3.2   System Connections

To acquire sensor data the following components are needed: user-supplied external sensor, a LORD MicroStrain® wireless sensor node, a LORD MicroStrain® data gateway and a local or networked host computer with access to the data acquisition software (such as Node Commander® and SensorCloud™). For a connections overview refer to *Figure 4 - System Connections* .

Nodes will communicate with any LORD MicroStrain® 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® -Base -10x -LXRS® gateway utilizes local serial connections to the host computer, such as RS232 and USB, and interfaces with the Node Commander® software. The WSDA® -1500 - LXRS® gateway utilizes Ethernet communications and can be used with Node Commander® and SensorCloud™, although system configuration is completed using Node Commander®. Gateways with analog outputs can be connected directly to stand-alone data acquisition devices for data collection, however system configuration will still occur through a USB interface to Node Commander®.

Users can also write custom programs by utilizing the LORD MicroStrain® Wireless Sensors Network Software Development Kit (*see References on page 69*).
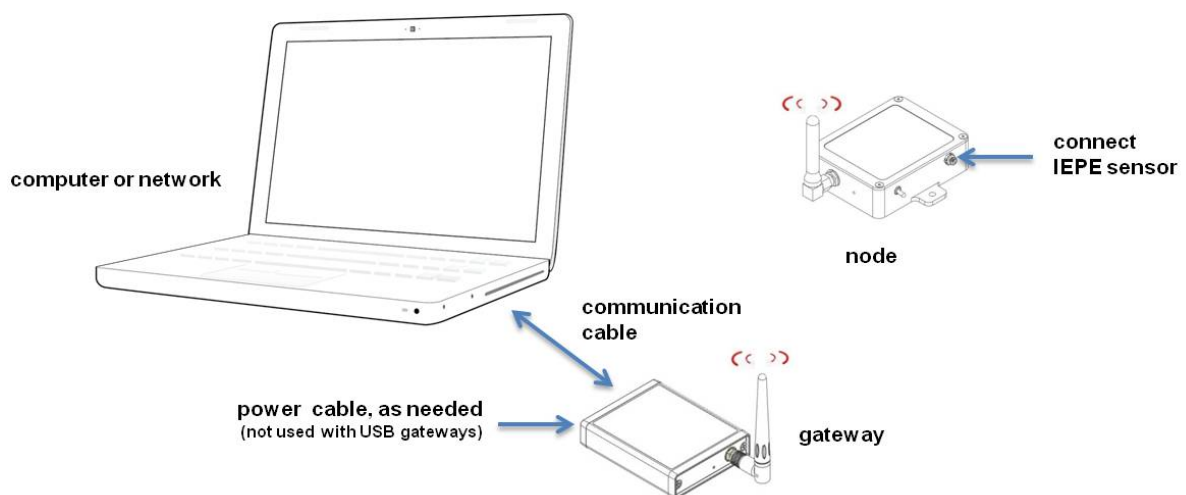
Figure 4 - System Connections

3.3   Gateway USB Communication

The WSDA-Base USB gateway is used as an example in this quick start guide. For information on how to use other gateways, refer to the gateway or Node Commander® user manual (*see References on page 69*).

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

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

2. Open the Node Commander software.

3. The gateway should appear in the Controller window automatically with a communication port assignment (*Figure 5 - USB Gateway Communication*). If it is not automatically discovered, verify the port is active on the host computer, and then remove and re-insert the USB connector.
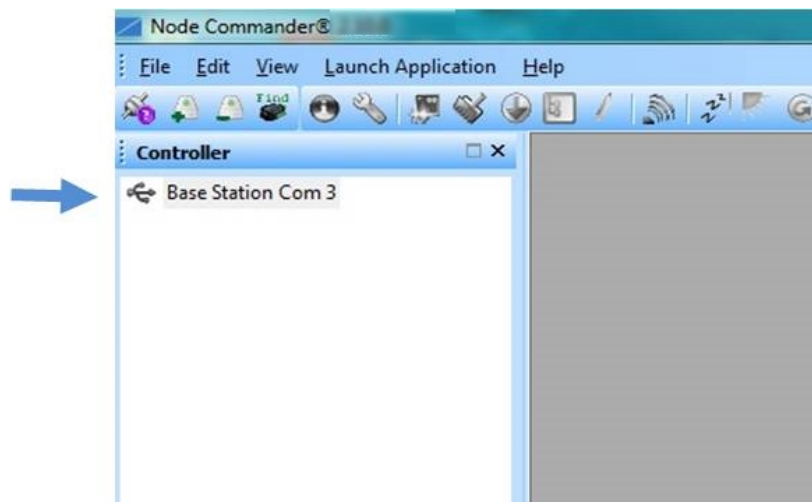
Figure 5 - USB Gateway Communication

3.4   Connect to Nodes

Several methods can be used in Node Commander® to establish communication with the nodes. This quick start section covers the two simplest methods; adding a node by address and by using the node discovery feature.

3.4.1   Adding a Node by Address

Adding a node by address requires the node to be on the same communication frequency as the gateway. The node address and frequency are indicated in the documentation included with the node when it is purchased.

1. To add a node by address, right-click on the gateway name in the Controller window, and select Add Node > Add Single Node (*Figure 6 - Adding a Node by Address*).

2. The node address and frequency are indicated in the documentation included with the node. Enter the node address, and select OK. If the node is not found, a message will appear and provide the option to scan for the node on other frequencies. Alternately, the Node Discovery feature can be used.

Figure 6 - Adding a Node by Address
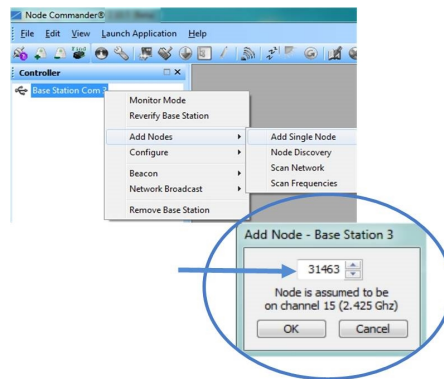
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3.4.2 Using Node Discovery

The Node Discovery feature allows connection between the gateway and node to occur even if they are on different frequencies. To connect to nodes using node discovery, begin by making sure the node is powered off.

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 45*.

---

1. Right-click on the gateway name and select Add Node > Node Discovery (*Figure 7 - Using Node Discovery*).

2. Using the power switch, turn on the node. Within a few seconds, the node will transmit a message with its operating frequency.

3. When the device status indicator on the node ends the rapid flash sequence and begins pulsing at one-second intervals, the node has completed the normal boot-up sequence and is running in idle mode. At this point the node should be listed in the Controller window; scanning can be stopped by selecting the Stop button in the Node Discovery window.

Figure 7 - Using Node Discovery

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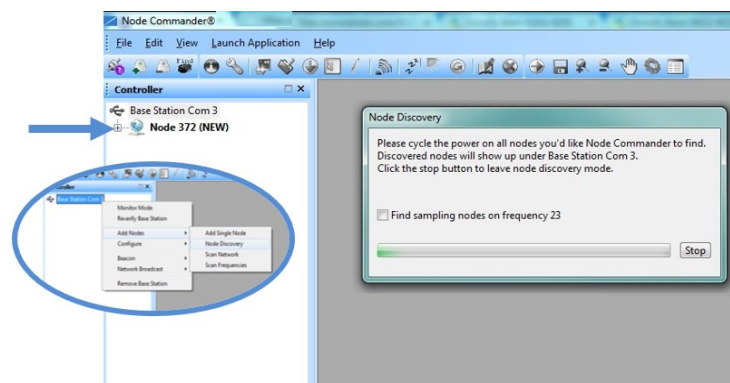
3.5   Channel Configuration

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

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

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

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

    c. **Configure:** The Configure button changes the channel parameters, such as measurement units, gain and offset settings, and calibration values. The channel must be enabled first by selecting the adjacent check box.
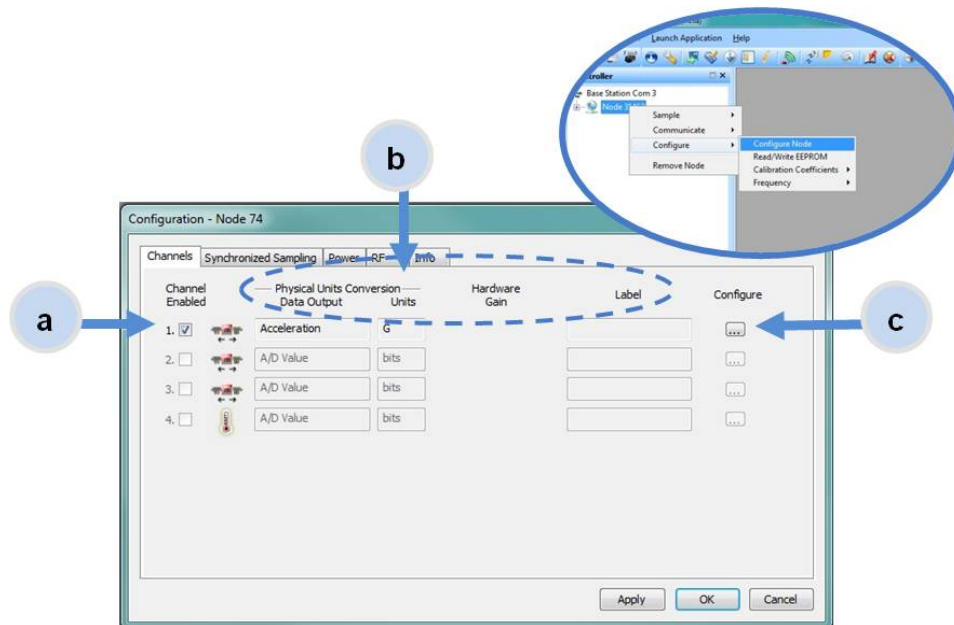
Figure 8 - Node Channels Menu

2. To enter the channel configuration menu, select the Configure button as shown in *Figure 8 - Node Channels Menu*. The channel configuration menu options change depending on the sensor type selected.

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

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

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

   d. **Sensor Slope:** is the sensor sensitivity value used to convert the sensor voltage reading to engineering units. For the IEPE-Link -LXRS this value is provided in the sensor manufacturer calibration data.

   e. **Edit Presets:** allows users to save the conversion values for a particular sensor. This is useful when the node may be used to take measurements from different sensors. When the new sensor is attached, the Edit Preset menu is used to save or select its conversion information.

   f. **Low Pass Filter Cutoff:** This setting determines what sampled readings will be reported based on the frequency of the signal. Any frequency above the selected setting will be omitted. For best performance select a Low Pass Filter Cutoff that is no more than half of the sample rate.

Figure 9 - Channel Setup

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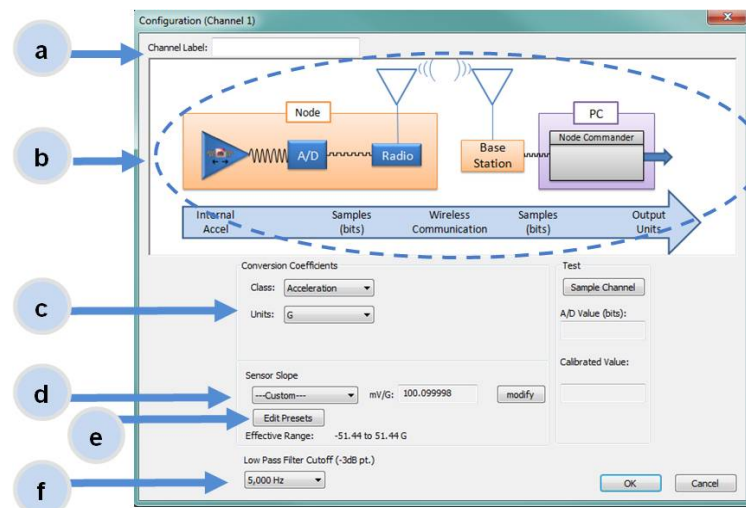
3.5.1 Sensor Conversion Values

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 Node Commander® (*see Sampling Settings on page 22*) and saved in the node memory for the applicable channel.

For the IEPE-Link™ -LXRS® the engineering unit is *g*-force. The conversion value obtained from the sensor manufacturer and is typically referred to as sensitivity in units of mV/*g* (milli-volts of sensor output per g-force it experiences). For example, a sensor with an operating range of +/-50 *g* may have a sensitivity of 99.8 mV/*g*.

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. Calibration accounts for the variations between sensor elements.

The conversion values can be entered in two menus. The channel Configuration menu has more options than the Calibration Coefficients menu, but both are acceptable ways to enter the values and formulas.

Conversion Formula: The conversion formula assumes a linear relationship between the original units (such as A/D bits) and new engineering units (such as *g*-force), 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-

LORD MicroStrain®
SENSING SYSTEMS

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*.

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*. Because IEPE accelerometers are AC coupled there is no offset value.

Effective Range: the effective range is the calculated sensor measurement range in engineering units (EU). The effective range is dependent on the slope, offset and resolution of the node. The effective range is the number of bits per EU unit (slope) multiplied by the total number of bits, minus the offset (if applicable).

3.5.2   Saving Sensor Profiles

The presets feature allows users to save the conversion values for a particular sensor in the configuration menu. This is useful when the node may be used to take measurements from different sensors. When the new sensor is attached, the Edit Preset menu is used to save or select its conversion information (*Figure 10 - Sensor Presets*).

1. Select the Edit Presets button.

2. To add an new node, leave the Select Presets drop down menu at -Add New-.

   a. Name the node in the Title field.

   b. Enter the sensor sensitivity in the mV/g field.

   c. Select the Add Preset to save the configuration.

3. For already saved nodes, select the node title from the Select Presets menu.

4. Select the Close button to exit.

Figure 10 - Sensor Presets
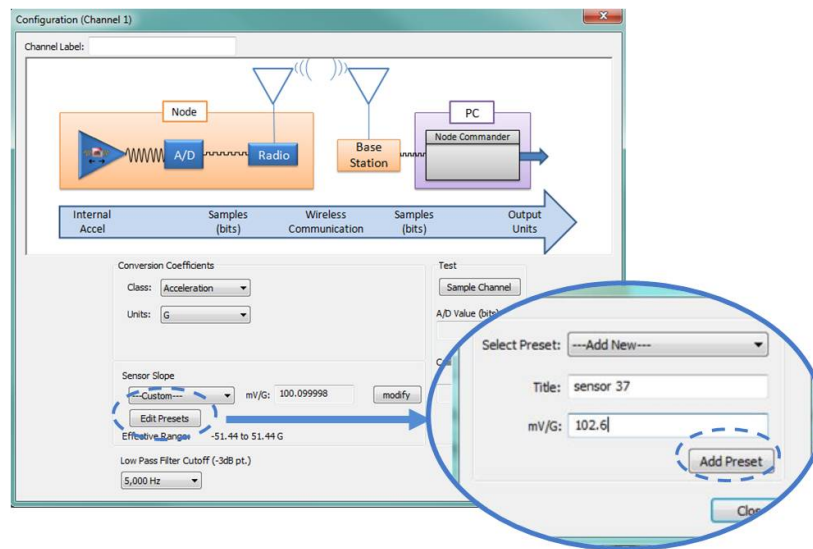
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3.6   Sampling Settings

The IEPE-Link™ -LXRS® utilizes synchronized sampling burst mode for collecting sensor data. Synchronized sampling allows multiple nodes to sample simultaneously. In burst mode samples are taken for a short duration at high sample rates and scheduled to repeat at fixed intervals (*Figure 11 - Synchronized Burst Samples*). Sample rate, burst duration, and time between bursts are user configurable.
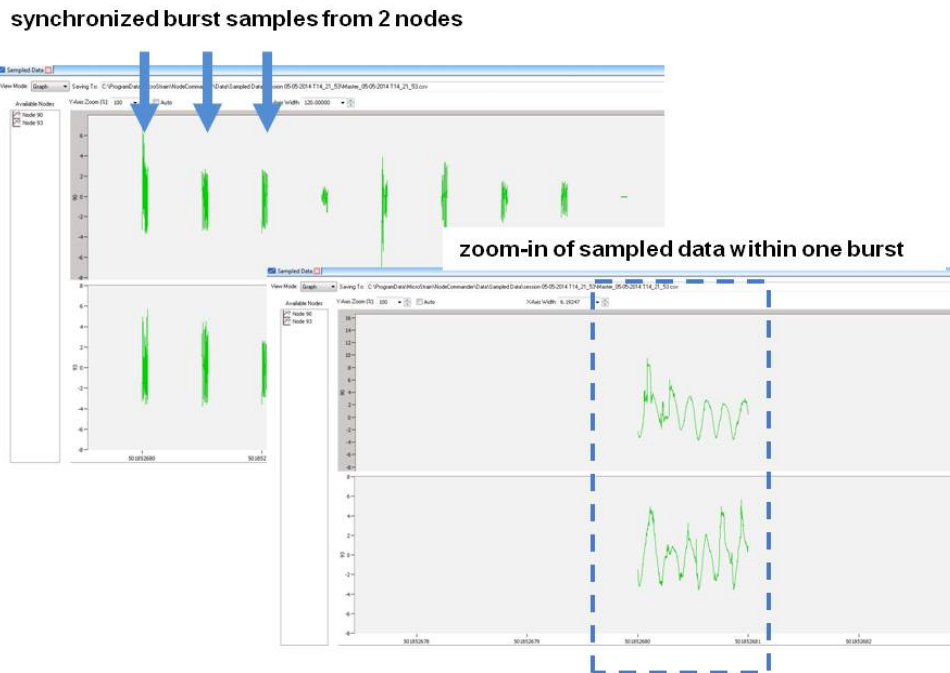
Figure 11 - Synchronized Burst Samples

To adjust synchronized sampling burst settings in Node Commander®, open the node configuration menu by right- clicking on the node name and then selecting Configure > Configure Node > Synchronized Sampling (*Figure 12 - Synchronized Sampling Settings*).

The Synchronized Sampling menu includes a bandwidth calculator. The bandwidth calculator describes what percentage of the system sampling capacity has been reached (*Figure 12 - Synchronized Sampling Settings* - Percent of Total Bandwidth). One node can be configured to consume up to 50% of the system bandwidth. Sampling settings are interactive and automatically limited to stay within the node bandwidth constraint. Adjusting one setting may apply limits to another. Observe the bandwidth calculator while making adjustments to

sampling settings to find the balance of sample rate, burst duration and burst intervals most suitable for the application.
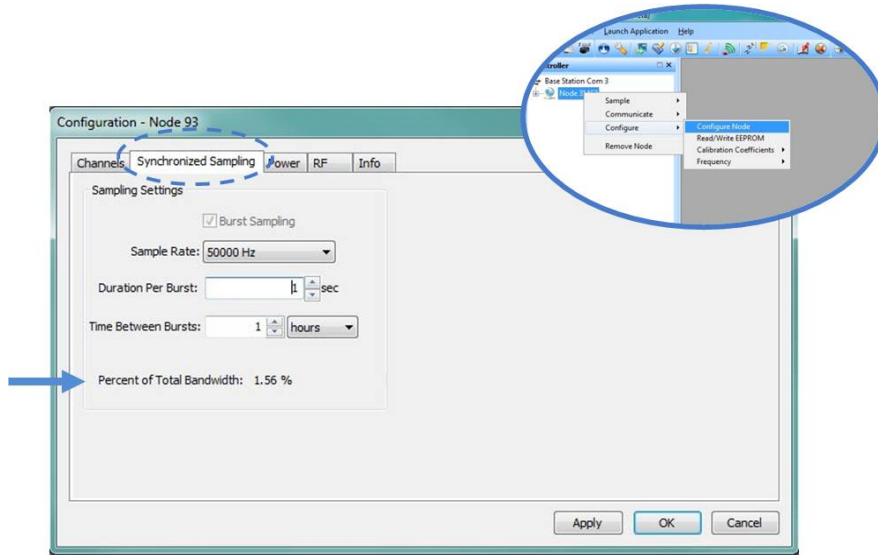
Figure 12 - Synchronized Sampling Settings

The following considerations should be made when determining sampling settings:

- Maximum burst length is determined by sample rate. The higher the sample rate, the shorter the burst lengths can be (*Table 3 - Sample Rate and Burst Duration*).

Sample rate (kHz)	Maximum burst duration (seconds)
1	150
10	15
12.5	12
25	6
50	3
62.5	2.4
78	1.92
104	1.4

Table 3 - Sample Rate and Burst Duration

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SENSING SYSTEMS

- Increasing the sample rate and duration, or decreasing the time between bursts, reduces the system bandwidth and therefore the number of nodes that can be networked to one gateway (*Table 4 - Example of Node Network Limits*).

Sample rate (kHz)	Burst duration (seconds)	Time between samples (minutes)	Maximum number of nodes per gateway
10	5	10	7
10	5	30	31
10	5	60	64
10	5	240	125

Table 4 - Example of Node Network Limits

- Increasing the sample rate and duration, or decreasing the time between bursts, increases the duration the node is in sample or transmit states, and therefore reduces battery life (*see Power Profile on page 63*).

NOTE

In burst mode, it may take many minutes to transmit all of the burst data. Total transmit time depends on the amount of sampled data (based on sample rate and burst duration) and the transmit rate. Transmit rate is automatically set in Node Commander® depending on the time available between samples (more time = slower transmission rates). As the data is received by the gateway it will update in the software, but does not represent real time acquisition.

LORD MicroStrain®
SENSING SYSTEMS

3.7 Data Acquisition

When data acquisition is started, each of the sampling modes has different menu options and views. Some open a settings menu before data acquisition begins and may include a data list view and/or a graph view. The following is an example of Synchronized Sampling (*Figure 13 - Starting a Sampling Session*). For more information about synchronized sampling and using the gateway beacon *see Data Acquisition on page 25*. For more information about other sampling modes, refer to the Node Commander® user manual. (*see References on page 69*).

To start a sampling session, nodes can be selected individually or as a group. When selected as a group, they will all be set to the same sampling mode. Right-click on the nodes and select Sample > Synchronized Sampling.
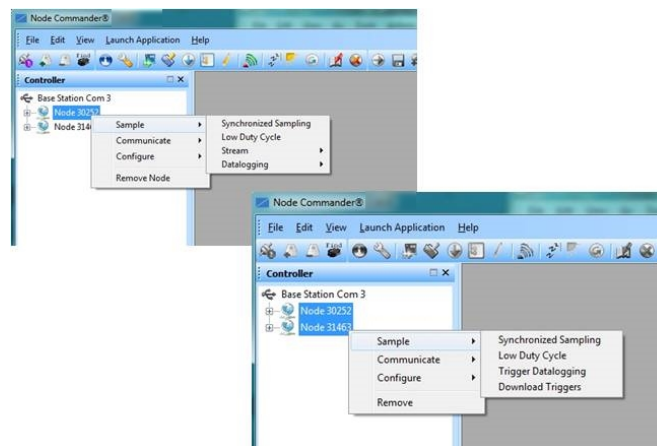
Figure 13 - Starting a Sampling Session

When a synchronized sampling session is started, the sampling menu appears and includes settings to enable optional sampling features, configure nodes, and to specify where the data will be saved. The built-in bandwidth calculator displays the total bandwidth used by the nodes selected for synchronized sampling (*Figure 14 - Synchronized Sampling Menu*).

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

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

LORD MicroStrain®
SENSING SYSTEMS

button opens the node configuration menus to adjust settings as needed and recalculates the node bandwidth. Multiple nodes can be configured together by using the Shift or Ctrl key to select them.

c. **Lossless:** enables the lossless data protocol. The protocol enables buffering and retransmission of data in order to provide 100% data collection success. Using this feature may increase data display latency.
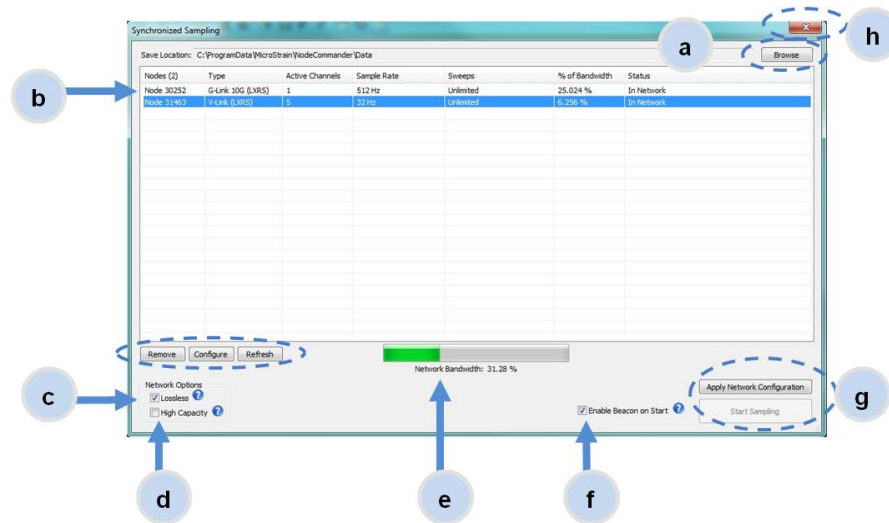
Figure 14 - Synchronized Sampling Menu

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

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

f. **Enable Beacon on Start:** When synchronized sampling is started the nodes wait for the first beacon transmission to initiate sampling. When this option is selected (default), the gateway beacon is enabled and will begin transmitting at a fixed interval when sampling is started. Disabling the beacon on start (unchecking the box) will set the nodes to wait for the beacon, but it does not actually start the beacon when sampling is started. This can be used if there is a need for sampling to be initiated later, or if the beacon is being received from another source than the gateway. Enabling the beacon in this way is the same as enabling the beacon in the gateway menu Refer to the Node Commander® User Manual for more information.

LORD MicroStrain®
SENSING SYSTEMS

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

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

Synchronized sampling features two data views: Grid view and Graph view. Once sampling has started, the data grid view is the default view (*Figure 15 - Synchronized Sampling Data View*).
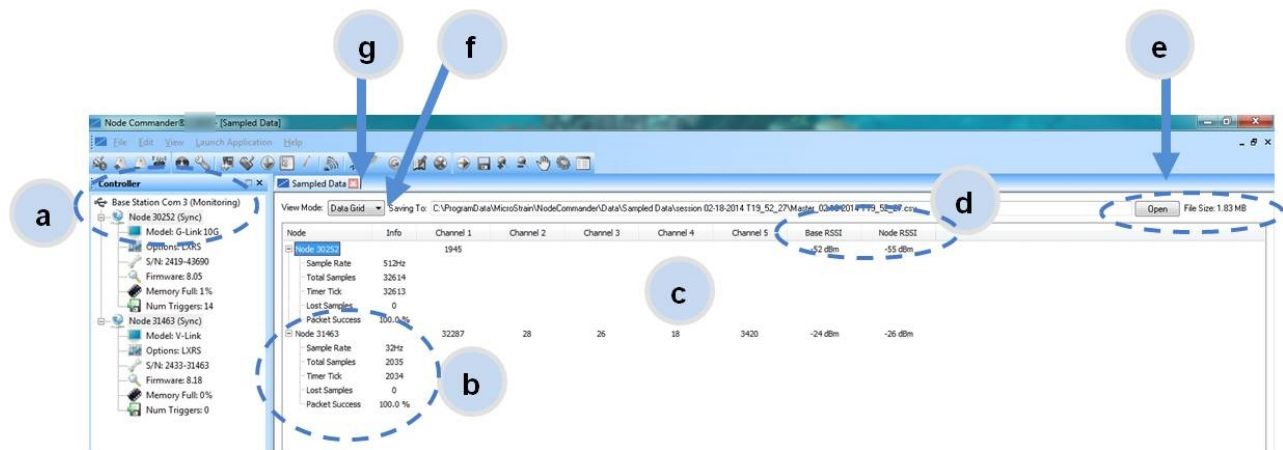
Figure 15 - Synchronized Sampling Data View

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

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

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

d. **Radio strength:** indicates the strength of the communication between the gateway and node. *See Range Test on page 37*.

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

f. **View menu:** Select between Data Grid and Graph views.

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

LORD MicroStrain®
SENSING SYSTEMS

> **NOTE**
>
> When synchronized sampling is set to slower sample rates it may take several seconds after sampling is initiated for the first sample to appear.

Use the view menu to select the Graph view of the data (*see Synchronized Sampling Graph View on page 28*). Click on the node name to view the graph for that node. Click again to hide it.
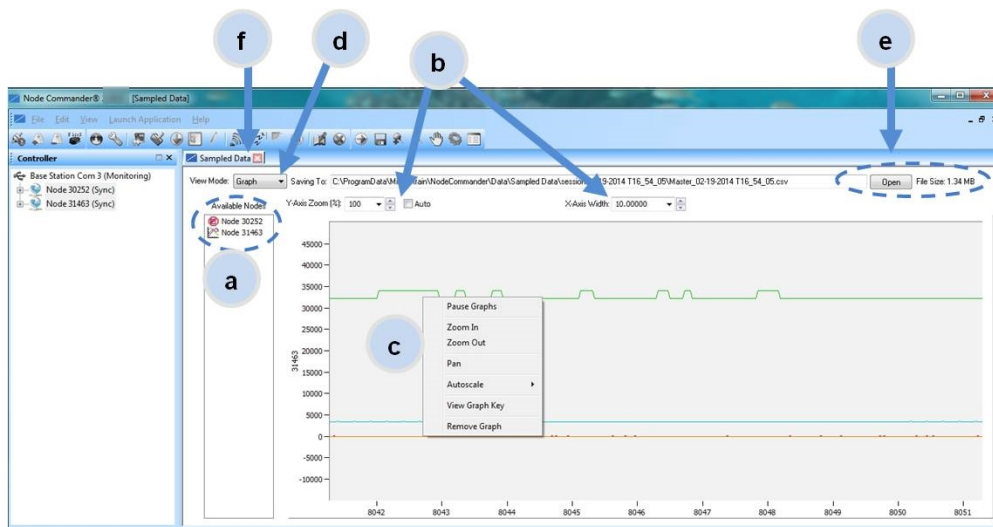
Figure 16 - Synchronized Sampling Graph View

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

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

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

d. **View menu:** Select between Data Grid and Graph views.

LORD MicroStrain®
SENSING SYSTEMS

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

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

NOTE

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

LORD MicroStrain®
SENSING SYSTEMS

3.8   Data Handling

Data acquired through Node Commander® is automatically saved on the host computer (*see Sensor Data Files on page 34*) 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 MicroStrain® sensor products or third-party systems. Basic SensorCloud™ services are available to all users free of charge (*see Connecting to SensorCloud™ on page 31*).
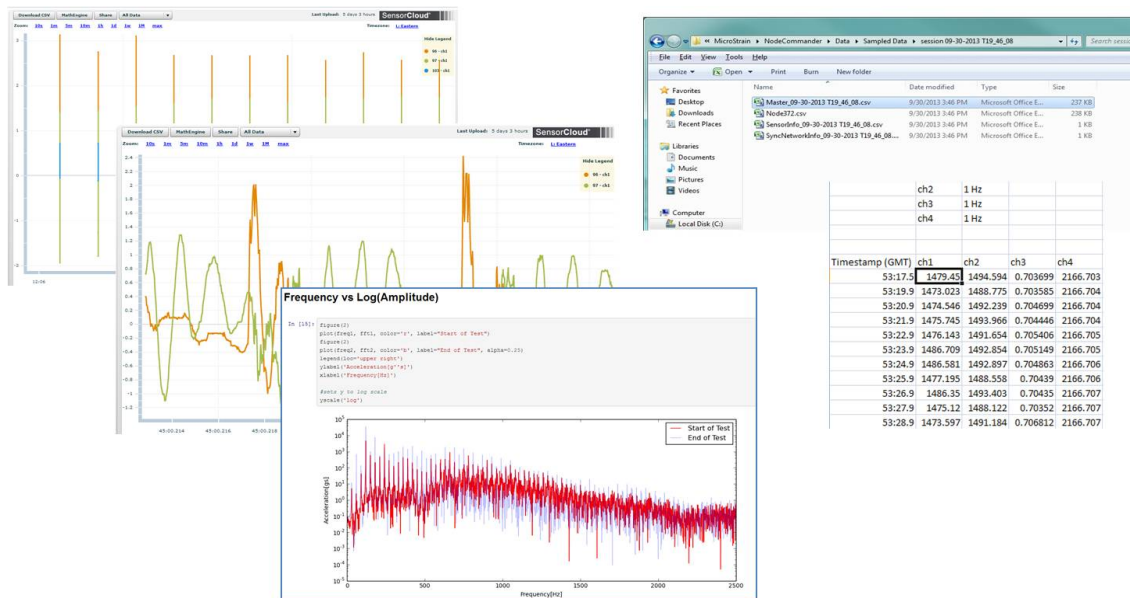
Figure 17 - Data Storage, Display and Processing

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 18 - 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 19 - SensorCloud™ Menu Views*). The Data and Settings views are only available once a device is selected from the device list.

Figure 19 - SensorCloud™ Menu Views

LORD MicroStrain®
SENSING SYSTEMS

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

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

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

 Data - This view is only available after a device is selected. It displays data that is collected from sensor nodes or uploaded from files. Data selections are listed by node channel or a user-defined label, and can be enabled for display in the graph window. The interactive graph 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 20 - SensorCloud™ Data View

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

MathEngine® - is used to analyze sensor data. Functions include the ability to filter out frequencies, smooth out noisy data, perform math operations such as Fast Fourier Transforms

(FFTs), and more (*Figure 21 - MathEngine® View*). MathEngine® interfaces with the SensorCloud graphing view for faster processing. Users can write their own algorithms for custom applications. Refer to the MathEngine® website for more information.

http://sensorcloud.com/mathengine
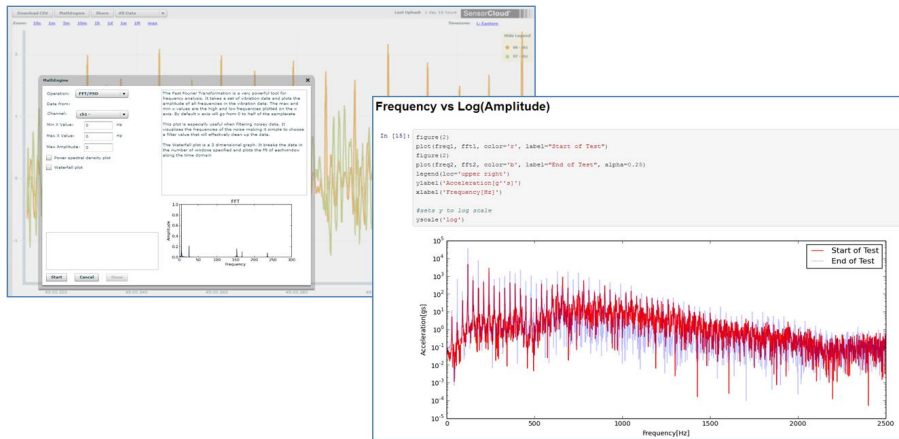
Figure 21 - MathEngine® View
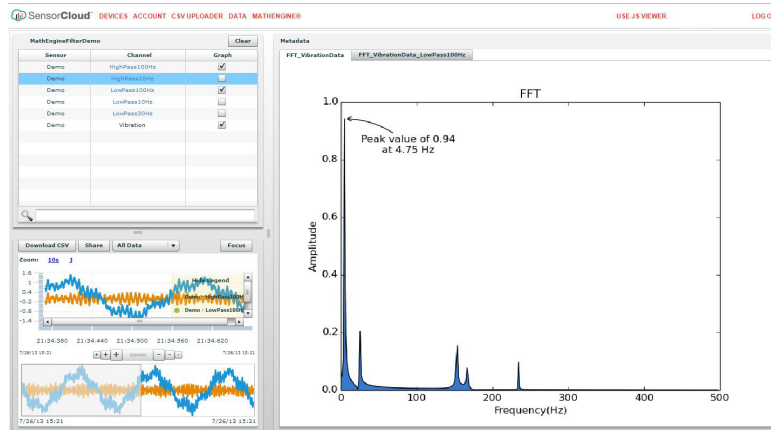
Figure 22 - FFT Graph in SensorCloud™

http://sensorcloud.com

LORD MicroStrain®
SENSING SYSTEMS

3.8.2   Sensor Data Files

Data acquired in Node Commander is stored in .CSV format and can be opened with Microsoft Excel, Quattro Pro, Open Office, or another CSV editors/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 at the beginning of the sampling session (as applicable). 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**
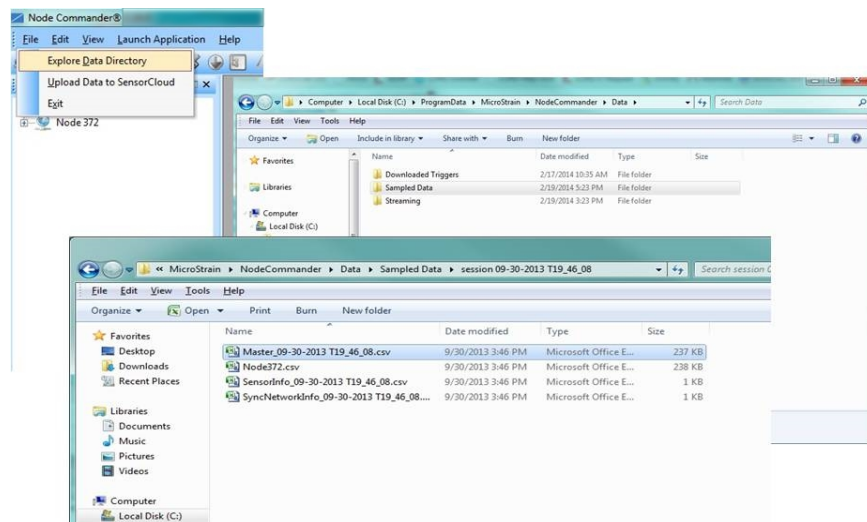
Figure 23 - Exploring Data

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.

LORD MicroStrain®
SENSING SYSTEMS

4.   Node Installation

4.1   Mounting Recommendations

The IEPE-Link™ -LXRS® is rated for indoor use only, unless housed in a ruggedized outdoor enclosure.

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. . For more information *see Optimizing the Radio Link on page 36*.
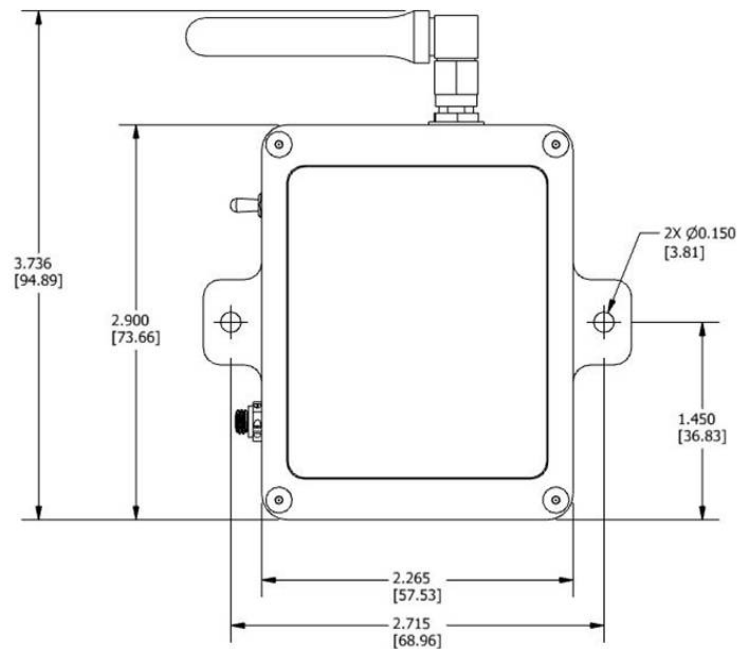
Figure 24 - Mounting the Node

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 IEPE-Link™-LXRS® operates at a 2.4GHz transmission frequency and comes standard with a right-angle, ¼-wave rubber whip antenna with 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 Node Commander® by using the range test feature to quantify the radio signal strength (RSSI) in various scenarios. *See Range Test on page 37* for instructions on using Node Commander® for measuring RSSI. The following are general guidelines for maximizing transmission range:

- **Establish Line of Sight (LOS)** between the node and gateway antennas as best as possible. Try to avoid obstructions between the antennas, such as buildings, terrain, vegetation, or other physical barriers. Increase the mounting height of the node or antenna to allow a clearer LOS path to the gateway. Height above the ground is also important because reflections off of the ground can interfere at the receiver. Generally, the higher above the ground the better.

- **Minimize Radio Frequency Interference (RFI)** such as other equipment antennas, especially those operating in the same frequency range. This includes other nodes. If other antennas are required nearby, mount them at different heights to minimize interference. Additionally, the specific node frequency is selectable within its operational range using the Node 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. If mounting the node on metal or near metal objects in unavoidable, the antenna can be mounted remotely with an antenna cable. The connector on the antenna is male reverse polarity SMA (male RPSMA), so a male-to-female RPSMA cable would be required.

LORD MicroStrain®
SENSING SYSTEMS

4.2.1 Range Test

After establishing communication between node and gateway, use the range test feature in Node Commander® to monitor the signal strength and to optimally position the nodes, gateway, and antennas 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. Right-click on the node header, and select Communicate > Range Test.
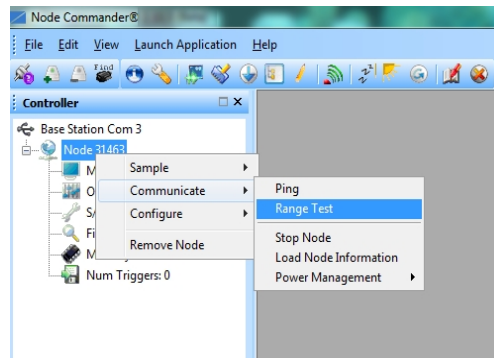
Figure 25 - Range Test Menu

2. The total RSSI range for the node and gateway is -90 to 0dBm. 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.
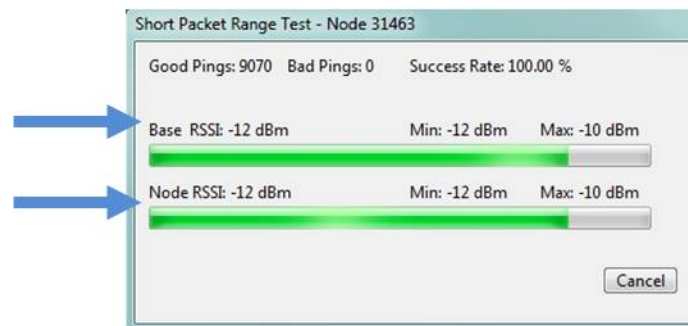
Figure 26 - Range Test Statistics

4.   Connecting Sensors

The IEPE-Link™ -LXRS® sensor connector is a 10-32 coaxial connector, common to many IEPE sensors. There is one female connection port on the device enclosure (*see Interface and Indicators on page 9*).

Cables are available from the IEPE sensor manufacturers and third party coaxial cable assembly providers. For example, Dytran *6010A05* and Pasternack *PE36520*.

LORD MicroStrain®
SENSING SYSTEMS

5. Powering the Node

> ⚠️ **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 65*).

The node can be powered with either the internal battery or an external source. These sources cannot be used simultaneously; there is switch on the node to select which source to use. When the node is manufactured, the switch is set to operate using the internal battery.

External battery holders are also available for the IEPE-Link™ -LXRS® and can be used to extend battery operating capacity and duration. For more information *see Node Accessories on page 57*.

5.1 Selecting the Power Source

> ⚠️ **WARNING**
>
> The IEPE-Link™ -LXRS® contains an internal, rechargeable Lithium Polymer (Li-Po) battery. For important precautions *see Safety Information on page 65*.

> ⚠️ **CAUTION**
>
> The IEPE-Link™ -LXRS® is susceptible to damage and/or disruption of normal operation from Electrostatic Discharge (ESD). For important precautions *see Safety Information on page 65*.

> **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 and the power supply disconnected before servicing.

LORD MicroStrain®
SENSING SYSTEMS

There is user-accessible switch inside of the node to select the power source.

1. Verify the node power switch is in the OFF position and no external power is applied.

2. Remove the node cover screws with a 0.05" hex head wrench.

3. Use a small flat-head screwdriver to push the recessed switch fully to the desired position, as indicated in *Figure 27 - Power Source Selection*. The figure shows the node configured for an external power source.

4. Once the setting is selected, fasten the node cover back in place.
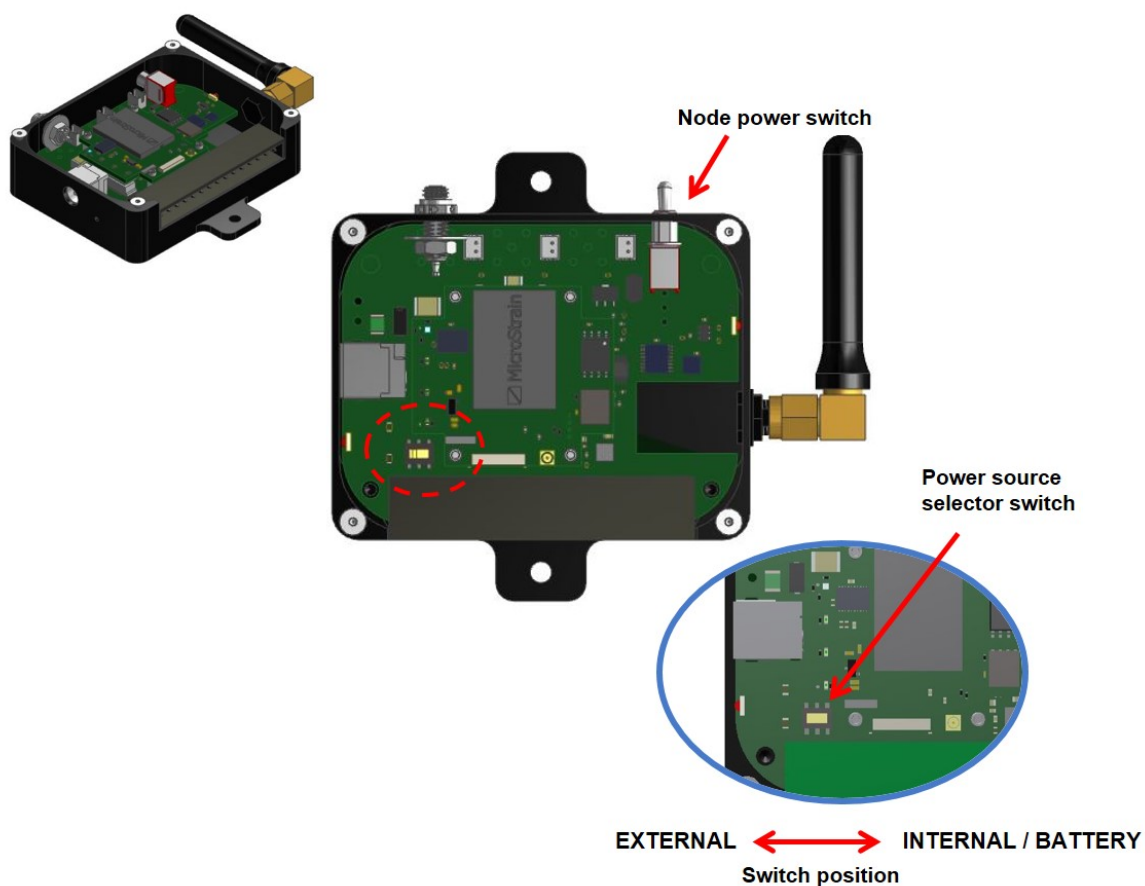
Figure 27 - Power Source Selection

5.2   Using the Internal Node Battery

⚠**WARNING**   The IEPE-Link™ -LXRS® contains an internal, rechargeable Lithium Polymer (Li-Po) battery. For important precautions *see Safety Information on page 65*.

When the internal node switch is set for internal power, the node is powered by a rechargeable, 650 mAH lithium polymer battery. This battery is not user-serviceable. For additional IEPE-Link™ -LXRS® power specifications *see Power Profile on page 63*.

LORD MicroStrain®
SENSING SYSTEMS

5.3   Charging the Node Battery

> **⚠WARNING**
>
> Use only the power supply specified for the node to charge the battery. Using a power supply above the rated voltage could cause personal injury and permanent damage to the node. For important safety considerations *see Safety Information on page 65*.

NOTE

Touching sensors or charging the node battery while acquiring data may induce noise on sensitive sensor signals and is not recommended.

---

1. Turn the node power switch off, and plug the node power supply into the node and then into a 120/240VAC, 50/60Hz AC power source. Use only the power supply specified for the node. Use the supplied power plug adapters, as needed.

2. Verify the charge indicator is red and on brightly, indicating charging. If it is only on dimly a battery fault has occurred. Reset the node by unplugging power and then plugging it back in. The indicator should now turn on brightly. Continue charging until the indicator turns green to indicate a completed charge. Charging takes approximately 6-8 hours from a full depletion.

charge indicator

Figure 28 - Node Charging

LORD MicroStrain®
SENSING SYSTEMS
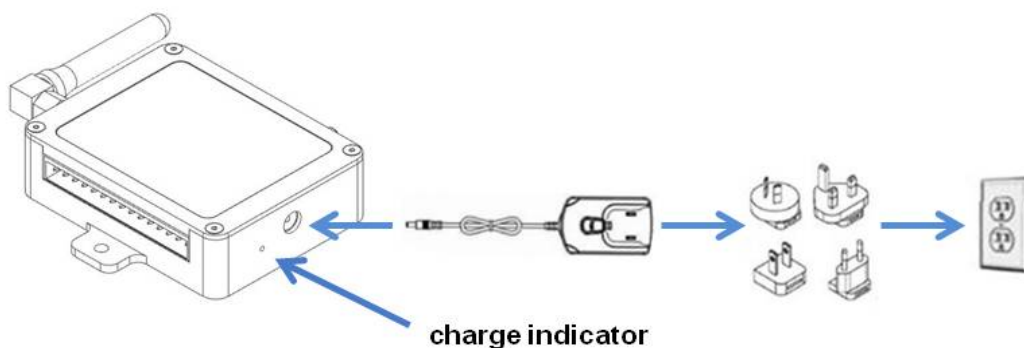
5.4   Connecting an External Power Supply

⚠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 65*).

When the internal node switch is set for external power, the node may be directly powered by the power supply specified for charging the node (or another regulated AC to DC power supply with the appropriate output parameters, *see Operating Specifications on page 61*). It can also be powered by an external battery or other regulated DC supply. The supply must deliver a stable voltage between 3.2 and 9.0 V dc and be capable of sourcing at least 100 mA. External battery holders are available for the IEPE-Link™ -LXRS® (*see Node Accessories on page 57*).

External power is applied through either the power supply jack, or the terminal block connectors. Do not connect both. Observe connection polarities, or the node may be damaged.

terminal block

terminal block number	signal
14	GND
15	Vjck

power jack

power jack pin	signal
center	Vjck
barrel	GND
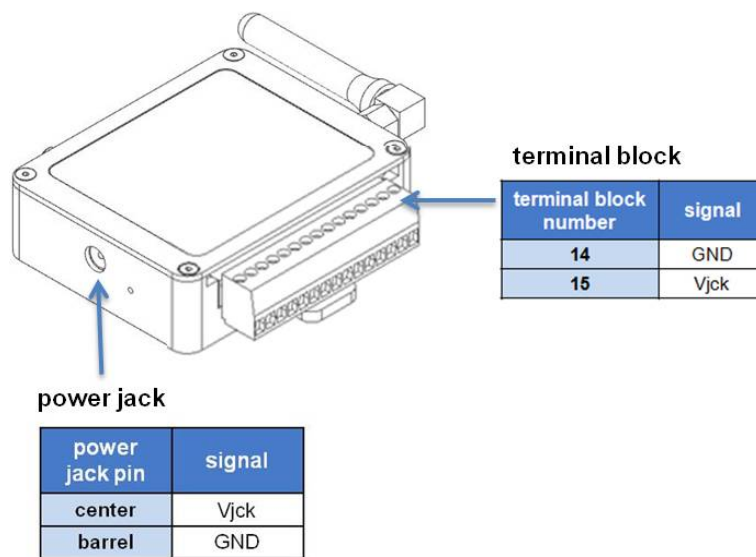
Figure 29 - External Power Connections

LORD MicroStrain®
SENSING SYSTEMS

5.5   Terminal Block Connections

When inserting the 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 faulty connections
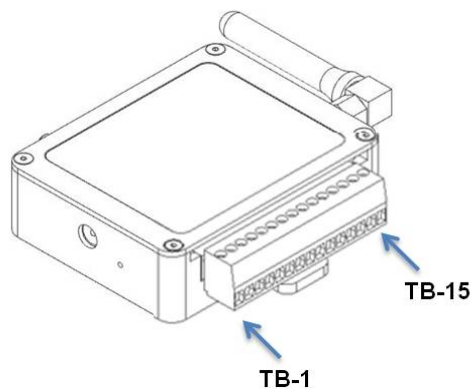
Node Pin Number	Signal
1	(future use)
2	(future use)
3	(future use)
4	(future use)
5	(future use)
6	(future use)
7	(future use)
8	(future use)
9	(future use)
10	(future use)
11	(future use)
12	(future use)
13	(future use)
14	GND
15	Vin

Table 5 - Terminal Block Connections

LORD MicroStrain®
SENSING SYSTEMS

6.   Troubleshooting

6.1   Troubleshooting Guide

1. POWER gateway or node does not turn on, or node does not charge	2. COMMUNICATION no communication to the gateway or node	3. DATA ACQUISITION sensor data is missing or incorrect
1.1 node or gateway power is off	2.1 node or gateway has no power	3.1 no com to node or gateway
1.2 external power off or miswired	2.2 gateway has no com with computer	3.2 sampling settings are incorrect
1.3 wrong power supply or voltage	2.3 node cannot be configured	3.3 sampling has not started
1.4 node internal source select incorrect	2.4 node is out of range	3.4 sensor is not connected correctly
1.5 node battery is dead	2.5 node is not in normal boot mode	3.5 sensor channel not configured correctly
1.6 node battery fault	2.6 node is sampling	3.6 sensor calibration is invalid
1.7 node or gateway is damaged	2.7 node is sleeping	3.7 sensor requires more warm-up time
	2.8 gateway or node is damaged	

LORD MicroStrain®
SENSING SYSTEMS

Problem	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. **1.3 wrong power supply** 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. **1.4 node internal source select switch is incorrect** When the node is manufactured, it is set to internal battery operation, but it can be configured to accept an external source. When set to accommodate an external source, the battery cannot be charged. **1.5 node battery is dead** If the node power source selector is set to internal, and the node will not power on or charge, the node battery may need to be replaced. Contact LORD MicroStrain® Technical Support (*See Technical Support on page 54*). **1.6 node battery fault** If the battery charge indicator on the node is only dimly illuminated when charging is attempted, a battery fault condition has occurred. Unplug power, and then plug it back in. The indicator should turn on brightly, indicating charging. **1.7 node or gateway is damaged** If all power settings and connections have been verified, and the node is still unresponsive, contact LORD MicroStrain ® Technical Support (*See Technical Support on page 54*).

LORD MicroStrain®
SENSING SYSTEMS

Problem	Possible cause and recommended solution
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 Node Commander®) 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 Node Commander® Edit > Preferences menu, under Devices. Once communication has been established, the network configuration can be changed. **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 Node Commander®, 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 37*. The system has been tested to operate with the node and gateway

LORD MicroStrain®
SENSING SYSTEMS

Problem	Possible cause and recommended solution
	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 toggling the node ON/OFF switch rapidly three times, then leaving it in the ON position 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, sample, or sleep. If the node is sampling, it cannot be configured. In Node Commander®, 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, sample, or sleep. If the node is sleeping, it cannot be configured. In Node Commander®, 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 MicroStrain® Technical Support (*See Technical Support on page 54*).
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.

LORD MicroStrain®
SENSING SYSTEMS

Problem	Possible cause and recommended solution
	3.2 sampling settings are incorrect If the sampling mode, rate, or duration are not performing as expected, enter the node configuration menu, and verify the sampling settings.
	3.3 sampling has not started If sampling is occurring, the sampling mode will be displayed next to the node name in Node Commander®. 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 MicroStrain® Technical Support (*See Technical Support on page 54*).
	3.7 sensor requires more warm-up time When taking samples with the IEPE-Link™ -LXRS® the sensor is turned on 15 seconds in advance of sampling to allow the sensor time to warm up and settle. Settling time may vary between sensors and sensor manufacturers. If any performance degradation is observed between sensors, it may be necessary to adjust the warm-up internal. If this is suspected, contact LORD MicroStrain® Technical Support for instructions (*see Technical Support on page 54*).

LORD MicroStrain®
S E N S I N G   S Y S T E M S

6.2   Device Status Indicators

The following is a complete summary of the IEPE-Link™ -LXRS® status indicators.

Indicator	Behavior	Node Status
Battery Charge Status Indicator	OFF	Node battery is not currently being charged
	ON bright red	Node battery is charging
	ON dim red	Battery fault condition, reset by unplugging power and then plugging it back in
	ON green	Battery is fully charged
Device Status Indicator	OFF	Node is OFF or sleeping
	OFF, with occasional flash	Node is sleeping with radio check intervals enabled (default is every 5 seconds)
	Ten rapid flashes green when power is initially applied	Node is booting normally and sending out a status message.
	1 second pulse green	Node is idle
	Continuously ON green	Node is logging or streaming data
	1 Hz pulse green	Node is sampling in low duty cycle
	1 Hz pulse blue	Node is in synchronized sampling mode
	ON bright blue	Node is in synchronized sampling mode and is re-syncing or taking a burst sample
	Pulses for each ping	Node is sending out communication requests (such as in ping command, range test, or EEPROM read/write)
	Four to seven slow pulses when power is initially applied	Fault condition

Table 6 - Device Status Indicators

LORD MicroStrain®
SENSING SYSTEMS

6.3 Updating Node Firmware

Under the recommendation of LORD MicroStrain® Technical Support Engineers, nodes can be upgraded to the latest available firmware to take advantage of new features or correct operating issues. Node Commander® version 2.7.0 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 MicroStrain® website. *See Technical Support on page 54* for contact and website information.

1. Download the LXRS® Firmware Upgrade file from the LORD MicroStrain® 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 Node Commander® , and establish communication between the node and gateway as normal.

4. While holding F1 button on the keyboard, right-click the node name, and a drop-down menu will appear.

Figure 30 - Update Node Firmware

LORD MicroStrain®
SENSING SYSTEMS
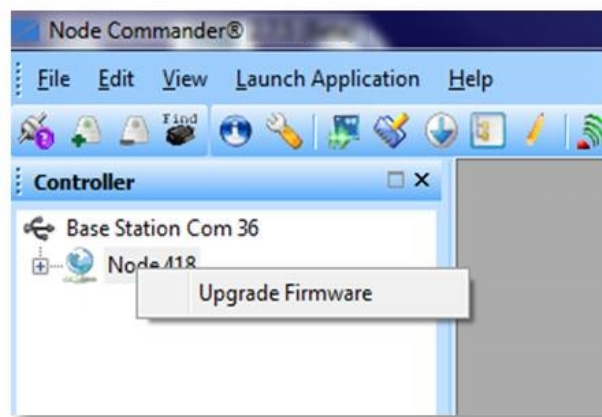
5. Release the F1 key.

6. Click Upgrade Firmware, and the Node Firmware Upgrade window will appear.

7. Click Browse, and navigate to the downloaded .zhex file.

8. Click Write, and the upgrade sequence will begin. When completed, "Upgrade Success" will appear in the Status column.
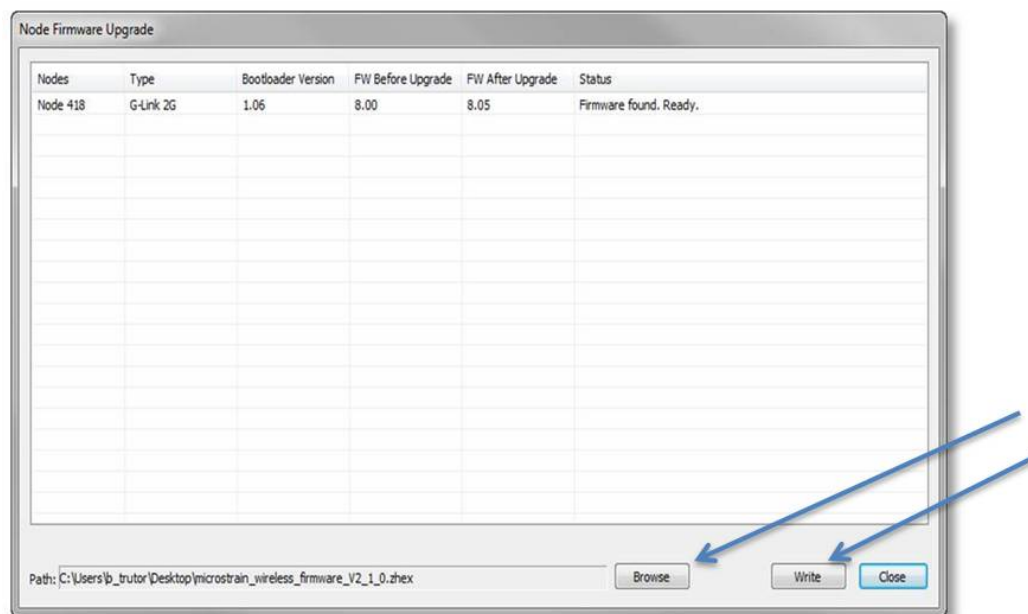
Figure 31 - Upgrade Firmware Window

LORD MicroStrain®
SENSING SYSTEMS

6.4   Repair and Calibration

The IEPE-Link™ -LXRS® is factory calibrated when it is manufactured. No further calibration is required.

General Instructions

In order to return any LORD MicroStrain® product, you must contact LORD MicroStrain® 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 MicroStrain® 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 MicroStrain®.

Warranty Repairs

LORD MicroStrain® 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 MicroStrain® will repair or replace, at its discretion, a defective product if returned to LORD MicroStrain® within the warranty period. This warranty does not extend to any LORD MicroStrain® 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 MicroStrain®.

Non-Warranty Repairs

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

LORD MicroStrain®
SENSING SYSTEMS

6.5   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)

LORD MicroStrain®
SENSING SYSTEMS

7.   Maintenance

There are no user-serviceable parts on the IEPE-Link™ -LXRS®. For device service and repair contact LORD MicroStrain® Technical Support (*see Technical Support on page 54*). Opening the device will void the product warranty.

8.   Parts and Configurations

8.1   Standard Nodes

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

Model Number	Description	LORD MicroStrain® Part Number
IEPE -LXRS	• Signal channel IEPE input	**6316-0010**

LORD MicroStrain®
SENSING SYSTEMS

8.2   Node Accessories

The following parts are available for use with the IEPE-Link™ -LXRS®. For the most current product information refer to the LORD MicroStrain® website or contact the LORD MicroStrain® Sales Department. .

Description	LORD MicroStrain® Part Number
Power supply for IEPE-Link™ -LXRS®	**9011-009**
Power supply plug adapter kit	**9011-0022**
Antenna, 2.4GHz, 1/4 wave whip	**9010-0048**
Replacement terminal blocks	**9008-0272**
D cell battery tray for use with wireless nodes (indoor use)	**6302-0200**
AA cell battery tray for use with wireless nodes (indoor use)	**6302-0300**
Lithium D cell battery 19 Ah capacity	**6302-0000**
Lithium AA cell battery 2 Ah capacity	**6302-0100**

Table 7 - Node Accessories

8.3　Wireless System Equipment

The following system parts are available for use with the IEPE-Link™ -LXRS®. For the most current standard, custom, and OEM product options, refer to the LORD MicroStrain® website or contact the LORD MicroStrain® Sales Department. *See Product Ordering on page 59*.

Model	Description	LORD MicroStrain® Part Number
WSDA-1500-SK	Ethernet Data Gateway Starter Kit	**6314-1501**
--	Node Commander® Software	**6301-0300**
--	SensorCloud™ Software Subscription (contact LORD MicroStrain® Sales)	**--**
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**

Table 8 - Wireless System Equipment

LORD MicroStrain®
SENSING SYSTEMS

8.4   Product Ordering

Products can be ordered directly from the LORD MicroStrain® 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

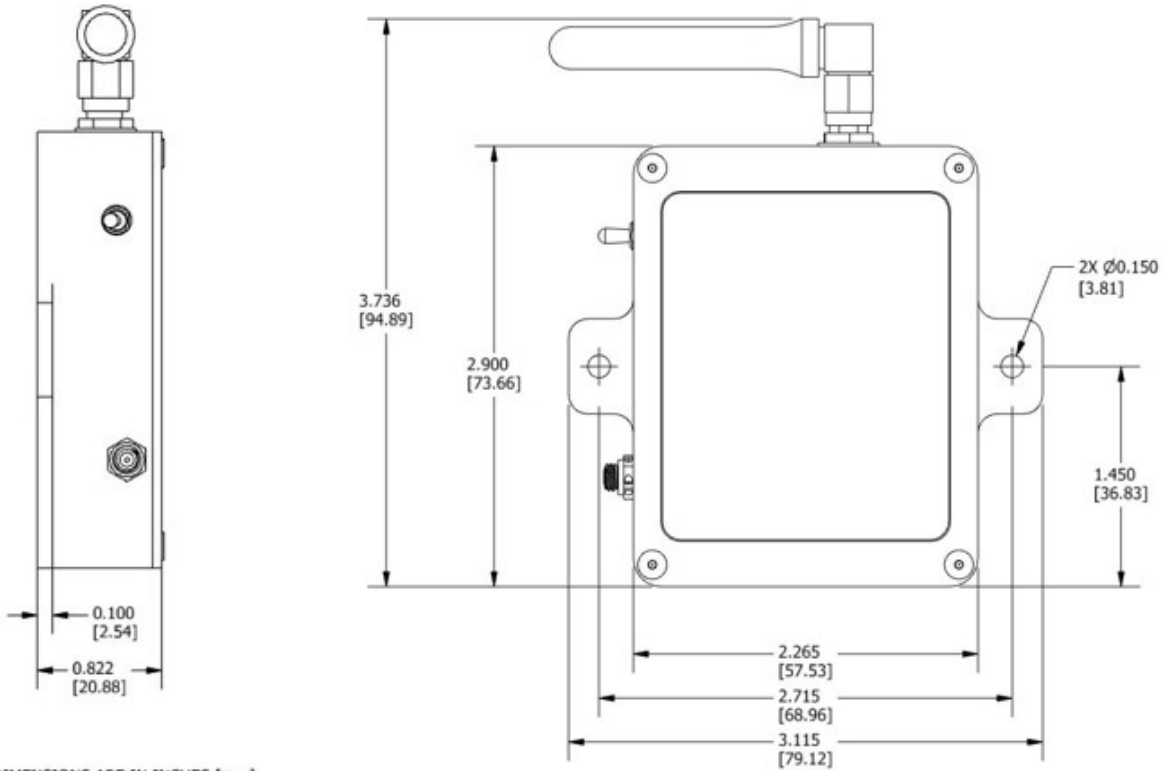**sensing_sales@LORD.com**

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

ALL DIMENSIONS ARE IN INCHES [mm]

Dimensions:	95 mm x 79 mm x 21 mm
Weight:	114 grams
Enclosure Environmental Rating:	General purpose protected

LORD MicroStrain®
SENSING SYSTEMS

9.2 Operating Specifications

Parameter	Specifications
Sensor input channels	**IEPE transducer**, 1 channel
Resolution	24-bit resolution
Dynamic range	109.5 dB dynamic range
Anti-aliasing filter bandwidth	5th order low-pass Butterworth filter with programmable cutoff frequencies from 26 Hz to 33 KHz
Digital finite impulse response (FIR) filter	100 dB in frequency band from 1/2 to 8 times the sample rate
IEPE Transducer Requirements	
Excitation voltage	23 V dc
Excitation current	2.3 mA
Output voltage	± 5 V dc (on 7 to 12 V dc bias)
Sampling	
Sampling modes	Synchronized (periodic burst sampling only)
Sampling rates	**Periodic burst sampling:** 1 kHz to 104 kHz
Maximum burst periods	150 seconds @ 1 kHz; 3 seconds @ 50 kHz; 1.3 seconds @ 104 kHz
Measurable signal bandwidth	1 Hz to 33 kHz
Sample rate stability	±3 ppm
Network capacity	Up to 125 nodes per RF channel (and per gateway) depending on the number of active channels and sampling settings. Refer to the system bandwidth calculator: http://www.microstrain.com/configure-your-system
Synchronization between nodes	± 32 µsec with 10 sec beacon interval (synchronized mode)
Operating Parameters	
Wireless communication range	Outdoor/line-of-sight: 2 km(ideal)*, 800 m (typical)** Indoor/obstructions: 50 m (typical)**
Radio frequency (RF) transceiver carrier	2.405 to 2.470 GHz direct sequence spread spectrum over 14 channels, license-free worldwide, radiated power programmable from 0 dBm (1 mW) to 16 dBm (39 mW); low power option available for use outside the U.S.A.- limited to 10 dBm (10 mW)
RF communication protocol	IEEE 802.15.4
Power source	Internal: 3.7 V dc, 650 mAh rechargeable battery External: 3.2 V dc to 9 V dc
Power consumption	1 burst /10 minutes: 2.9373 mA (10.57 mW), 1 burst/hr: 0.6957 mA (2.50 mW), 1 burst/4 hrs: 0.2875 mA (1.04 mW), 1 burst/24 hrs: 0.1738 mA (0.63 mW) (all sampling @ 10 kHz with 5 second burst duration) See battery life calculator: http://www.microstrain.com/iepe-link-lxrs-battery-life-calculator
Operating temperature	-20 ˚C to +60 ˚C (-40 ˚C to +85˚C available with external battery)
Physical Specifications	
Dimensions	94 mm x 79 mm x 21 mm
Weight	114 grams
Enclosure material	Aluminum
Environmental rating	Indoor use
Integration	
Compatible gateways	All WSDA® base stations and gateways
Compatible sensors	IEPE type sensors that operate within the node input specifications and have an output within ± 5 V dc (custom options available)
Connectors	10-32 coaxial (IEPE input), terminal block (future use)
Software	SensorCloud™, SensorConnect™, Node Commander®,

**LORD MicroStrain®
SENSING SYSTEMS**

Parameter	Specifications
	WSDA® Data Downloader, Live Connect™, Windows XP/Vista/7 compatible
Software development kit (SDK)	Data communications protocol available with EEPROM maps and sample code (OS and computing platform independent) http://www.microstrain.com/wireless/sdk
Regulatory compliance	FCC (U.S.), IC (Canada), ROHS

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

LORD MicroStrain®
SENSING SYSTEMS

9.3   Power Profile

Node power use is highly dependent on the sensor connected and operational parameters such as sample rate, burst duration and time between bursts. Higher sample rates, longer burst durations, and shorter times between bursts equate to shorter battery life. Both the sampling and transmit modes use a lot of power, while the sleep mode is very low (*Table 9 - Node Power Use*). The total amount of power use is largely determined by how long the node stays in sleep mode. The node will automatically go into sleep mode after sampling and transmitting is completed. The more time the node is in sleep state, the more power is conserved. For information on sampling settings *see Sampling Settings on page 22*.

Node state	Current draw	Duration
Sleep	100 uA	variable
Sensor warm-up (before sampling)	~29 mA (will vary between sensors)	15 seconds
Sample	43 mA	<1 to 150 seconds (depending on sample rate)
Transmit	varies with transmission rate	~ 6 seconds

Table 9 - Node Power Use

Below is an example approximation of the power use of a IEPE-Link™ -LXRS® with different burst settings. This chart can be used to approximate internal battery life, and external node power source requirements. A battery life estimation calculator is also available from LORD MicroStrain® Technical Support if more application specific estimations are needed. *See Technical Support on page 54*.

Sample rate (kHz)	Burst duration (seconds)	Time between bursts	Current draw (mA)	Calculated battery life (days)
10	5	10 minutes	2.9373	9
10	5	1 hour	0.6957	39
10	5	4 hours	0.2875	94
10	5	24 hours	0.1738	156

Table 1 - Example IEPE-Link™ -LXRS® Power Use

LORD MicroStrain®
SENSING SYSTEMS

9.4   Radio Specifications

The IEPE-Link™ -LXRS® Wireless Sensor Node employs a 2.4GHz IEEE 802.15.4 compliant radio transceiver for wireless communication. The radio is a direct-sequence spread spectrum radio and can be configured to operate on 14 separate frequencies ranging from 2.405 GHz to 2.470 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 0 dBm (1 mW) to 16 dBm (39 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.

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.

LORD MicroStrain®
SENSING SYSTEMS

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 MicroStrain® 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 Battery Hazards

⚠ WARNING   ⚠ CAUTION   NOTICE

The IEPE-Link™ -LXRS® contains an internal, rechargeable Lithium Polymer battery. Lithium Polymer 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 Polymer 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 MicroStrain ® Technical Support for information on extracting the battery or returning the product for proper recycling and disposal.

LORD MicroStrain®
SENSING SYSTEMS

10.2   User Configurable Power Settings

The IEPE-Link™ -LXRS® Wireless Sensor Node can be powered by either the internal battery or an external source. There is user-accessible switch to select the source. The default setting for this switch is for internal battery operation and charging. *See Selecting the Power Source on page 39*.

Connecting an external power source when the node is set to internal power could result in injury or permanent node damage. For details on how to adjust the switch setting *see Connecting an External Power Supply on page 43*.

- If the node is set to use an external source, and the charging power supply is plugged in, it will power the node from the power supply and not charge the battery. It will continue to use the internal battery.

- If the node is set to internal, and an external power supply other than the one used for charging is plugged in, several things could happen. If it is a power supply that is in the operating range of the charging circuit, it may charge the battery. If it is below the range of the charging circuit, nothing will happen. If the applied voltage is above the range of the charging circuit, damage to the node will likely occur and personal injury may result.

- When under battery operation there is a limit to how much current the node can provide to sensors. If the node is in an over-current condition it will shut off until the cause is removed. Using an external power source for the node or sensor can mitigate this issue.

LORD MicroStrain®
SENSING SYSTEMS

10.3   Power Supply

The IEPE-Link™ -LXRS® Wireless Sensor Node can be powered by an external source.

⚠WARNING **⚠CAUTION** **NOTICE**

Apply only the input voltage range specified for the IEPE-Link™ -LXRS®. 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. For details on how to connect the power supply

10.4   ESD Sensitivity

The IEPE-Link™ -LXRS® is susceptible to damage and/or disruption of normal operation from Electrostatic Discharge (ESD), particularly during data acquisition.

⚠CAUTION **NOTICE**

ESD damage can occur when the device is touched, especially at the device interfaces such as the antenna and connectors. Use proper grounding techniques when handling. If an ESD event occurs, and operation has been interrupted, reset the device by cycling power to it and/or restarting the operational mode in the system software.

LORD MicroStrain®
SENSING SYSTEMS

10.5   Disposal and Recycling

The IEPE‐Link™ ‐LXRS® 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 also have programs for extracting reusable parts for recycling.

11. References

11.1 Reference Information

Many references are available on the LORD MicroStrain® 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
Node Commander® Software User Manual	http://www.microstrain.com/support/docs
SensorCloud™ Overview	http://www.sensorcloud.com/system-overview
MathEngine® Overview	http://www.sensorcloud.com/mathengine
LORD MicroStrain® 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 10 - Related Documents

LORD MicroStrain®
SENSING SYSTEMS

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".

ASTM: The Association of Standards and Testing is a nationally-accepted organization for the testing and calibration of technological devices.

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".

Bits: the digital equivalent of voltage on the node. See 'A/D Value'.

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. Same 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 and 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 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.

Differential (signal): is a method of transmitting electrical signals in which they are paired together as a differential pair and measured with reference to each other only. This method makes the pair less susceptible to electrical noise.

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 antennas are in view of each other with no obstructions.

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

NIST: The National Institute of Standards and Testing is a nationally-accepted organization for testing and calibration of technological devices.

LORD MicroStrain®
SENSING SYSTEMS

Node: The node is the wireless transceiver that the sensor (s) is connected to, 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. Same 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.

PGA: A Programmable Gain Amplifier is an electronic device used to amplify small electrical signals.

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

Read/Write EEPROM: commands transmitted to the node to read or write parameters stored in the node's operating system

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

Resolution: in digital systems, the resolution is the number of bits or values available to represent analog values or information. For example, a 12-bit system has 4,096 bits of resolution and a 16-bit system has 65,536 bits.

LORD MicroStrain®
SENSING SYSTEMS

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

Single Ended: electrical signals that are measured with reference to a system ground

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, a serial data communications protocol

Wheatstone Bridge: an electrical circuit used to measure unknown electrical resistances

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

LORD MicroStrain®
SENSING SYSTEMS