LORD USER MANUAL

Node Commander® Software Suite

Wireless Sensor Network Data Acquistion and Utility Software

Node Commander® 2.14.0
Live Connect™ 2.1.3
WSDA® Data Downloader 1.0.2

LORD MicroStrain®
SENSING SYSTEMS

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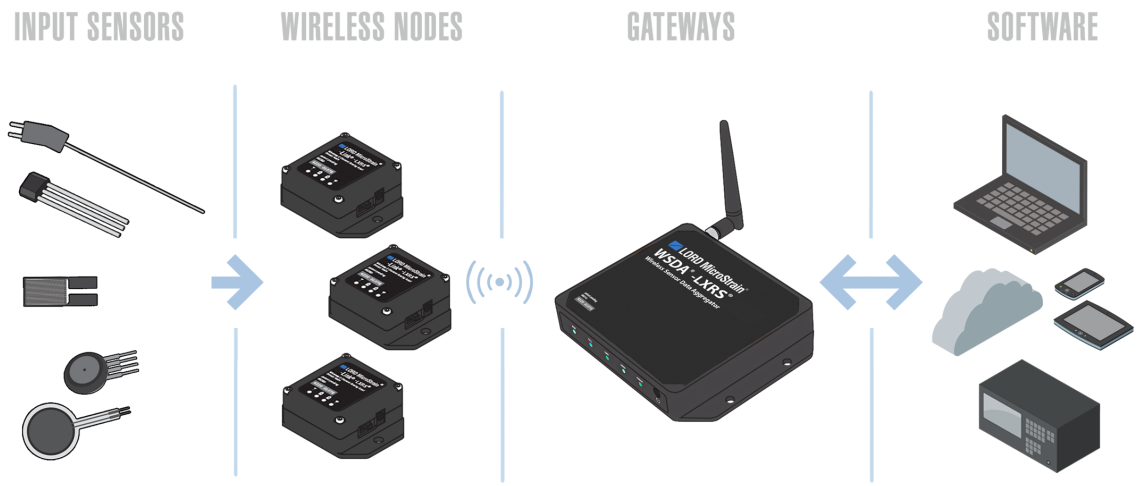
1. Wireless Sensor Network Overview

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. Software Overview

Node Commander® is a full featured data acquisition tool designed for use with the LORD MicroStrain® Wireless Sensor Network. Node Commander® is included with all gateway devices and is used for gateway and node configuration, and data collection tasks. It includes settings for node and gateway communications, power management, sensor type and output parameters, sensor sampling rates and modes, and data handling and storage. There are also interactive features that aid in field installation, such as node discovery, transmission range tests, sensor calibration routines, and near real time sensor data display. Node Commander® manages configuration and data collection of multiple gateways and nodes simultaneously, including synchronized sampling modes.

Node Commander® is designed for use with all LORD MicroStrain® gateways and nodes, and runs on most Windows® platforms. Included with all Node Commander® distributions is an auxiliary program called Live Connect™. Live Connect™ is used to translate between the Node Commander® serial protocol and the TCP/IP protocol used for Ethernet gateways. Another auxiliary program, WSDA® Data Downloader is included for uploading data saved in the WSDA® -1500 - LXRS® gateway on-board memory.

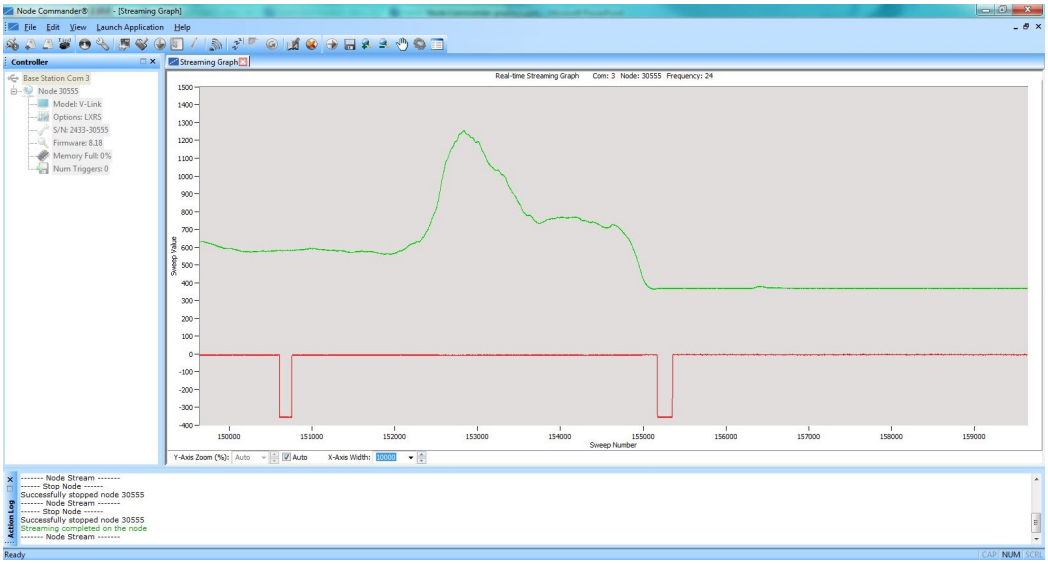


Figure 1 - Node Commander® Software

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2.1 Navigation and Views

The Node Commander® user interface includes a status bar, an icon toolbar, a header row of drop down menus, device menus, and three main information windows, as shown in *Figure 2 - User Interface*. When the software is first launched, only the Controller and Action Log windows are shown. The Sampling windows appear only when sampling is initiated and vary depending on the type of sampling being performed. The device menus are accessible only when the devices, such as gateways and nodes, are connected and communicating with Node Commander®. They are accessed by right clicking on the device name in the Controller window.

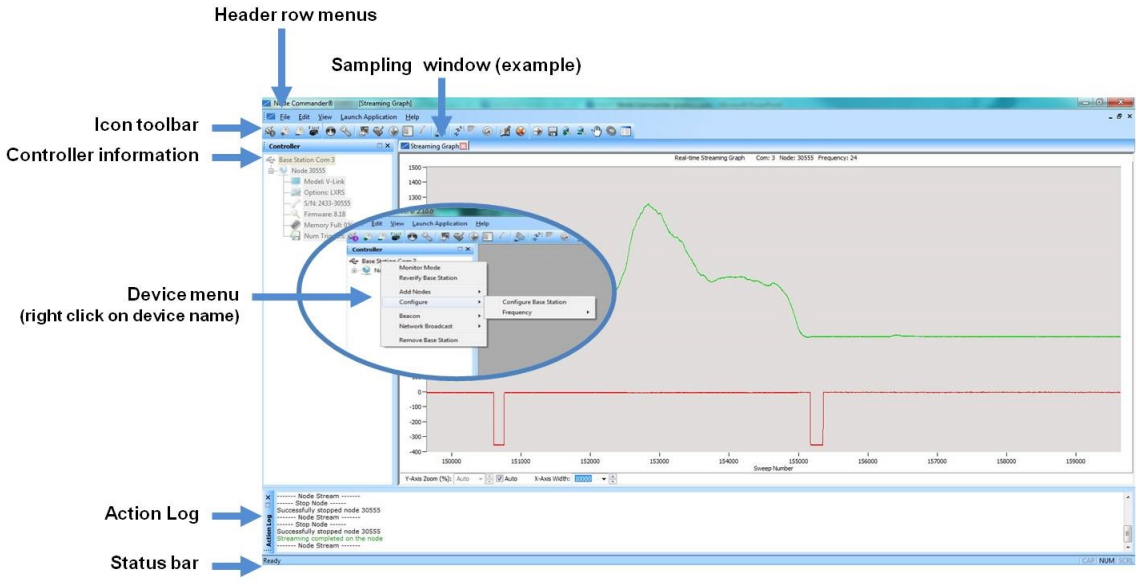

Figure 2 - User Interface

Windows can be repositioned by selecting the window header bar and dragging and dropping it in the desired location. Outline guides will appear when the item is dragged to a new position. Windows can also be closed or minimized with the icons in the upper right corners or with the header row View menu. The header row can be repositioned in the same way but not closed.

In all menus only the commands that are currently available are selectable. They are shown in color and will appear highlighted when hovered over. Some icons and selections will display feature or device details as well. Features that are not available will be gray. Available commands are dependent on what devices are connected and what tasks the software and system are currently executing.

- **CONTROLLER INFORMATION WINDOW** – The Controller information window displays a list of all attached, or previously attached, devices. The devices are organized in a hierarchical tree and display the gateways and corresponding node names and addresses. Additional node information can be viewed by selecting the "+" symbol next to the node name. Inactive devices can be removed from the list through the device menu.

- **HEADER ROW MENUS** - includes the program level commands in Node Commander® , such as file management and view settings.

- **DEVICE MENUS** – such as the gateway and node menus are accessed by right clicking on the device name in the Controller window. All actions available for the particular device can be found in its menu and will vary between device types. Settings will only be applied to the selected device.

- **ICON TOOLBAR** – provides quick access to the most common commands.

- **ACTION LOG** – displays command execution information, including errors. For example, the action log will display confirmation of device verification and an error if it cannot be verified when requested. Information about configuration, testing, and sampling tasks are also displayed after commands are executed. Refer to the log to determine the current status of the system.

- **STATUS BAR** – displays the Node Commander® program status. This menu can be hidden using the header row View menu.

- **SAMPLING WINDOW** – displays the data being acquired from actively sampling node. The sampling window is only displayed when sampling has been activated, and the display varies depending on the sampling mode. Some modes include a graph view and a data view, while others include only one.

NOTE

Available menu and configurations options in Node Commander® are dependent on the devices connected. This manual provides information on all possible menus. Refer to the device manual and specifications to determine what menus and options are applicable.

2.2 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 130*).

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. For more information *see Data Handling on page 23*.

2.3 Software Preferences

The Preferences menu is used to configure basic software operational features such as the default data directory, disk space allocation for data, and device and graphing preferences.

NOTE

To avoid filling the computer memory in high sample rate or data intensive applications, use the Minimum Disk Space Required to Collect Data setting to limit the total file space allocation. Once the limit is reached data will no longer be saved on the computer, however, the nodes may continue to sample and transmit data. In synchronized sampling mode the beacon will be turned off and (depending on configuration) will either go into sleep mode or continue to sample without synchronization. In low duty cycle sampling the node will continue to sample.

To access the menu, click on the Edit header and select Preferences.

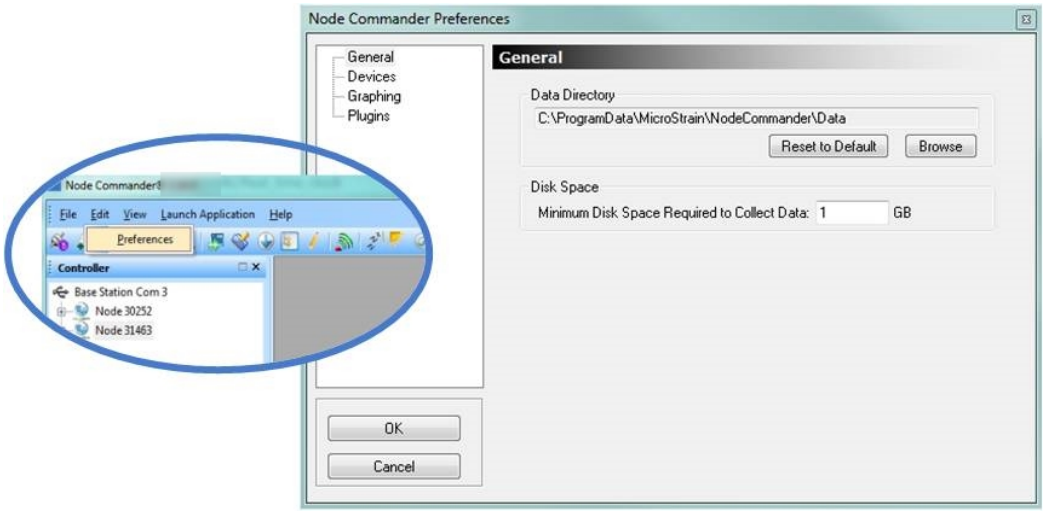

Figure 3 - Software Preferences

3. System Operational Overview

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.

3.1 System Connections

To acquire sensor data the following components are needed: a LORD MicroStrain® data gateway and a local or networked host computer with access to the data acquisition software. For a connections overview refer to *Figure 4 - System Connections*.

The sensor, node, gateway, and software selection are application-dependent, but the basic interfaces are the same. The WSDA® -Base -10*x* -LXRS® gateway utilizes local serial connections to the host computer, such as RS232 and USB, and interfaces with the Node Commander® software. 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 130*).

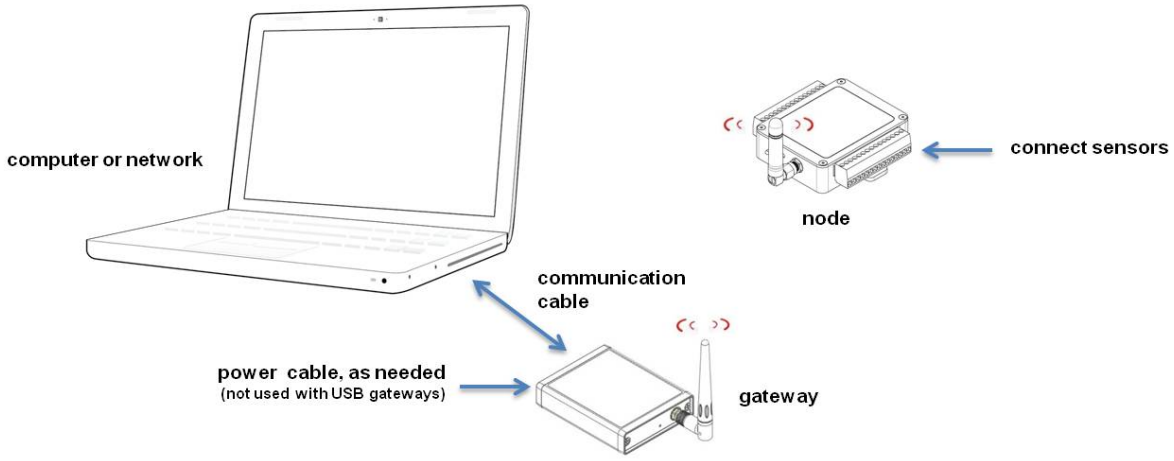

Figure 4 - System Connections

3.2 Gateway USB Communication

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.

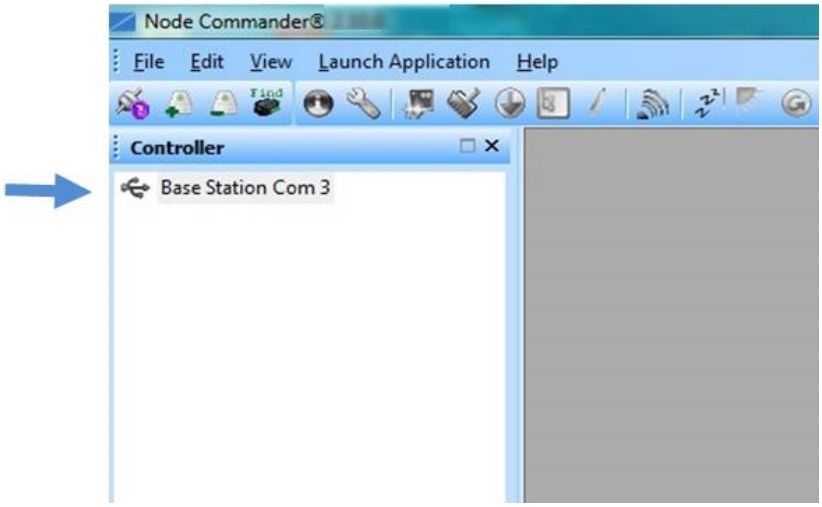

Figure 5 - USB Gateway Communication

3.3 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.

3.3.1 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.

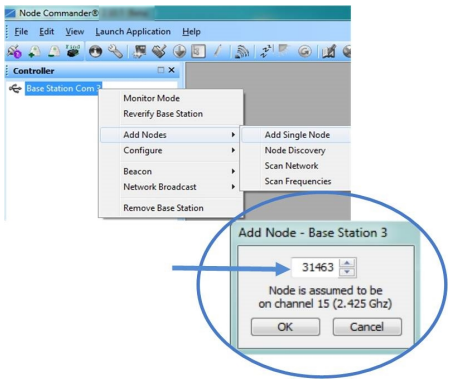

Figure 6 - Adding a Node by Address

3.3.2 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 118*.

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.

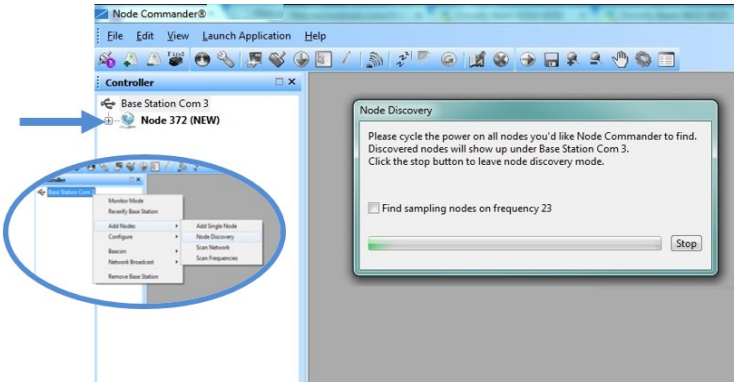

Figure 7 - Using Node Discovery

3.4 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. In the following example (*Figure 8 - Node Channels Menu*): a1) analog differential channel icon, a2) analog single ended channel icon, and a3) temperature channel icon.

    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.

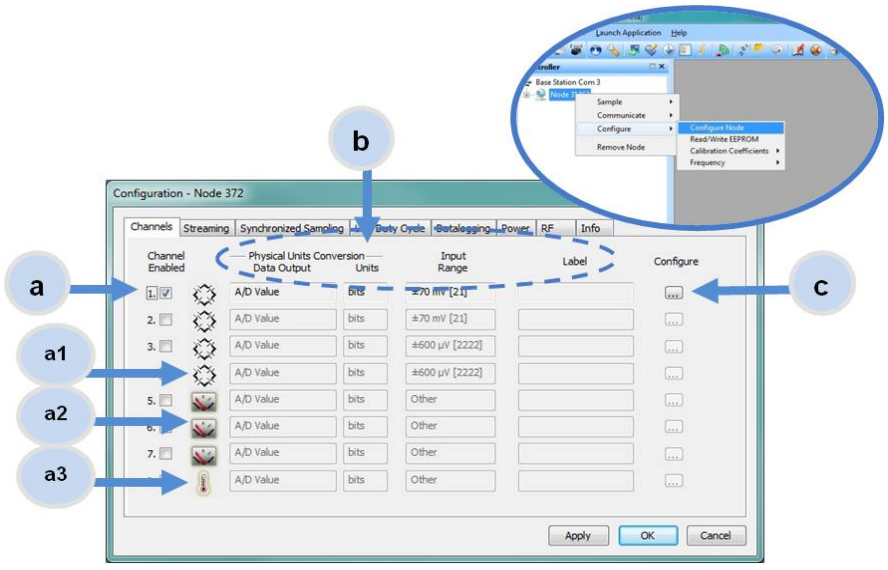

Figure 8 - Node Channels Menu

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2. To enter the channel configuration menu, select the Configure button as shown in *Figure 8 - Node Channels Menu*.

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

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

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

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

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

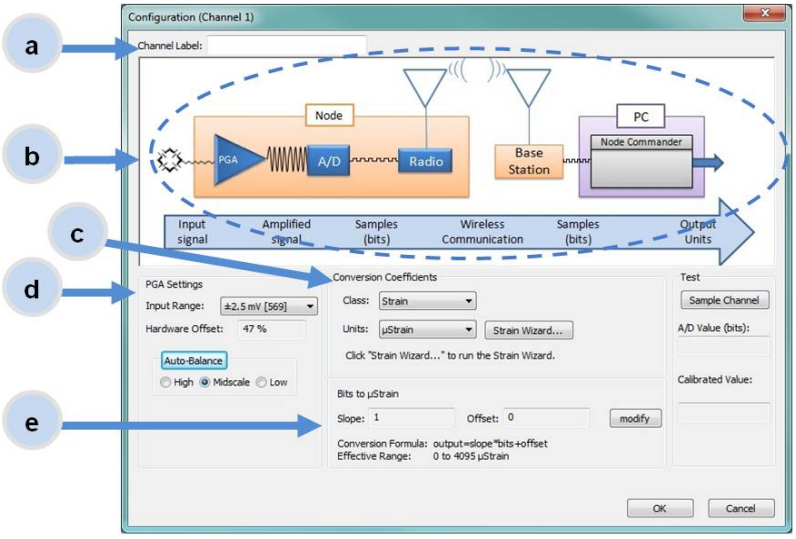

Figure 9 - Channel Setup

3.5 Sampling Settings

Sampling settings are accessed through the Configure Node menu. There is a tab for each sampling mode available for the particular node (*Figure 10 - Sample Settings Menu*).Depending on the type of node, up to four sampling modes are available: Synchronized Sampling, Low Duty Cycle, Streaming, and Datalogging. Some modes have user-configurable settings for sample rate, sample duration, and datalogging. Other settings are automatic, depending on number of active channels and other variables. For more information on sampling modes, refer to the Node Commander user manual (*see References on page 130*).

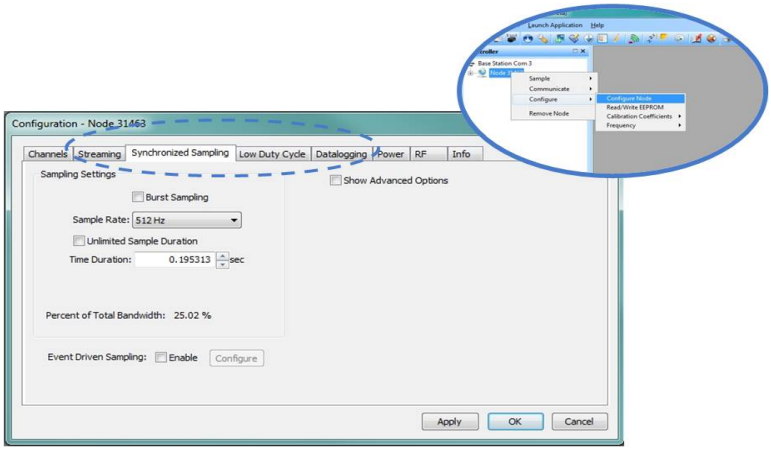

Figure 10 - Sample Settings Menu

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

- Use a sample rate at least twice the value of the target measurement frequency. This is the minimum sample rate required to produce an accurate digital representation of the measured signal. The higher the sample rate, the more accurate the digital representation.
- Using the minimum required sample rate will increase battery life and minimize the allocated network bandwidth.
- Using periodic burst sampling in place of continuous sampling will increase battery life, and the longer the sample interval, the more power and network bandwidth will be saved.

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

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

3.6 Data Acquisition

NOTE

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

When data acquisition is started, each of the sampling modes has different menu options and views. Some have a settings menu that opens 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 11 - Node Sampling Settings*).

1. Right-click on the node (or nodes) name and then select Sample > Synchronized Sampling.
2. In the Synchronized Sampling window select the destination folder for the data in the Save Location field.
3. Select Apply Network Configuration, and then select Start Sampling.

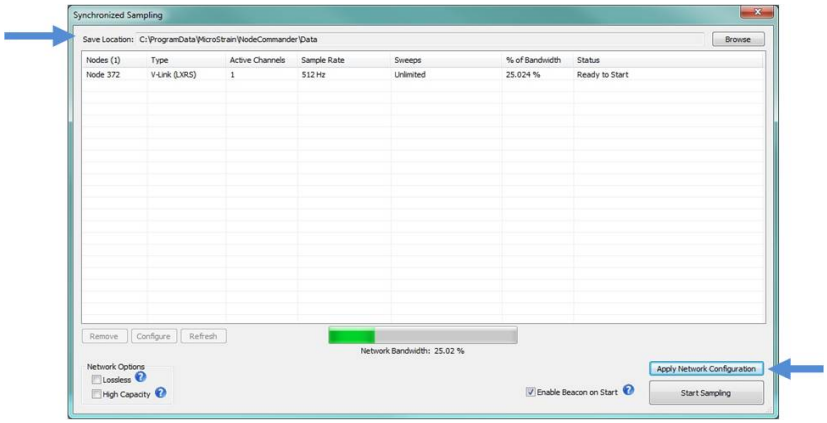

Figure 11 - Node Sampling Settings

4. Close the Synchronized Sampling window by clicking the window X in the upper right. The Sampled Data window is behind it. The default view is the Data Grid view. Use the "+" symbol next to the node heading to view the data statistics. Sampled data will appear in this window.

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.

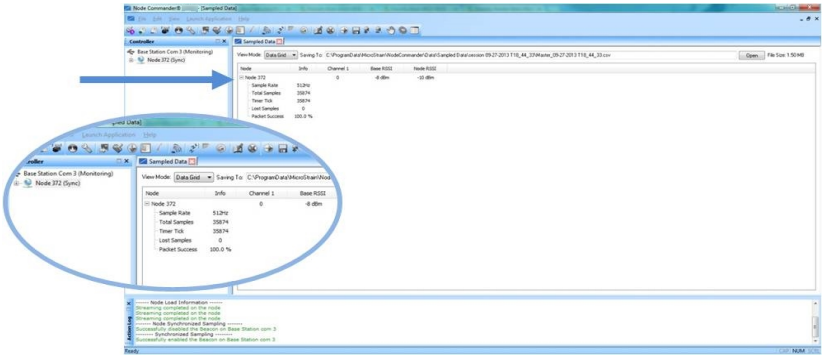

Figure 12 - Sampling Data Grid View

5. Select Graph from the View Mode field, and then click on the node name to view a graphical representation of the data.
6. To end sampling, close the Sampled Data window by clicking the X on the window tab, and select Exit > Stop Nodes.

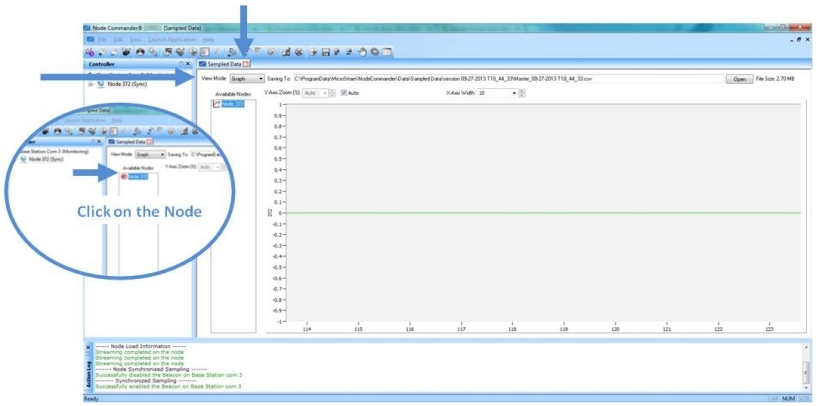

Figure 13 - Sampling Data Graph View

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3.7 Data Handling

Data acquired through Node Commander® is automatically saved on the host computer (*see Sensor Data Files on page 117*) 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 24*).

Figure 14 - Data Storage, Display and Processing

3.7.1 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/

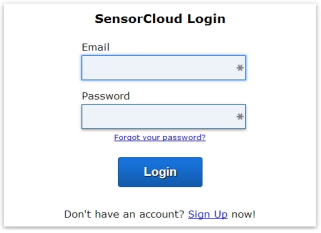

Figure 15 - SensorCloud™ Log-in or Register

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

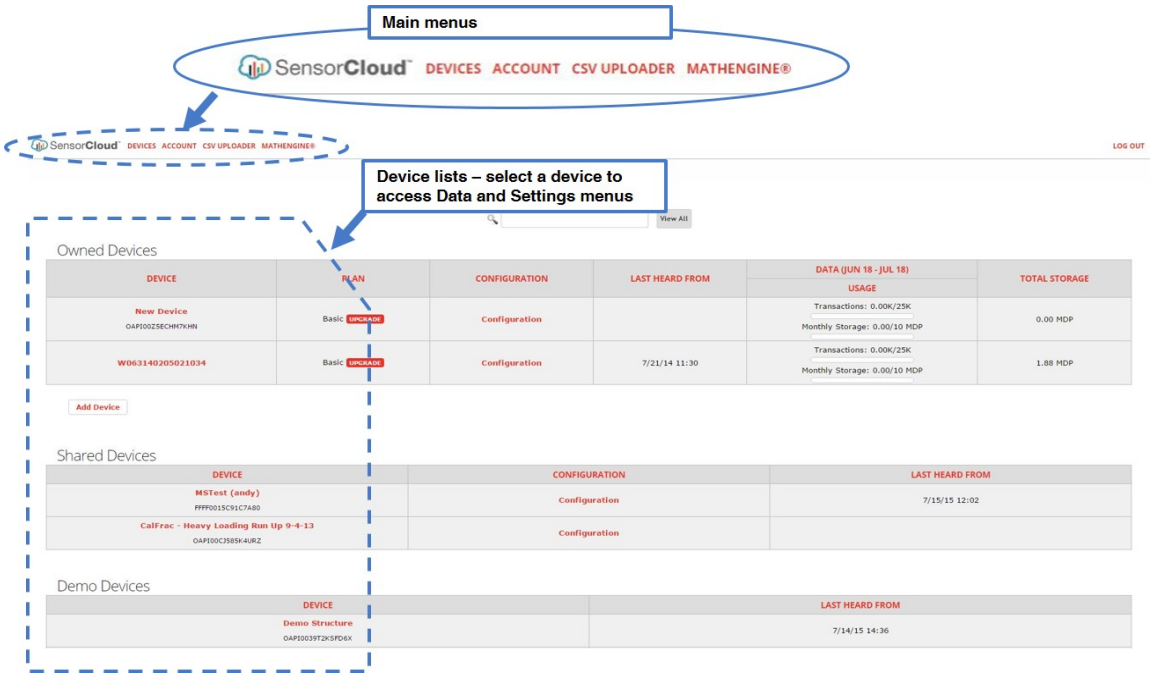

Figure 16 - SensorCloud™ Menu Views

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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 17 - 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 18 - 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

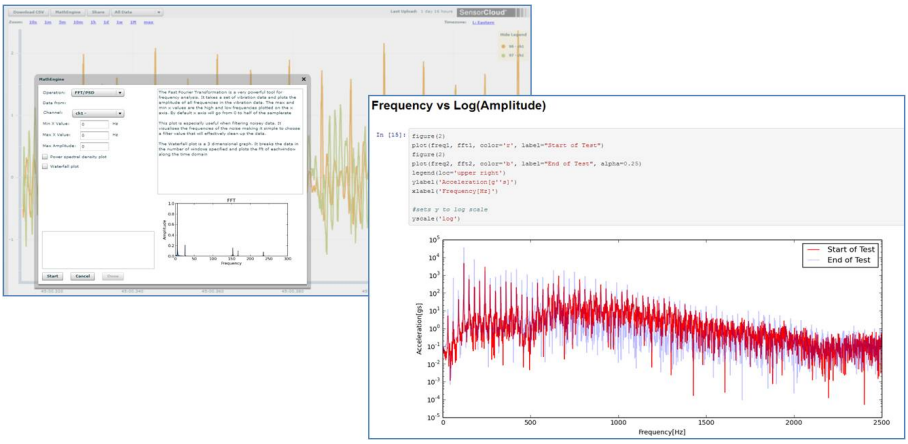

Figure 18 - MathEngine® View

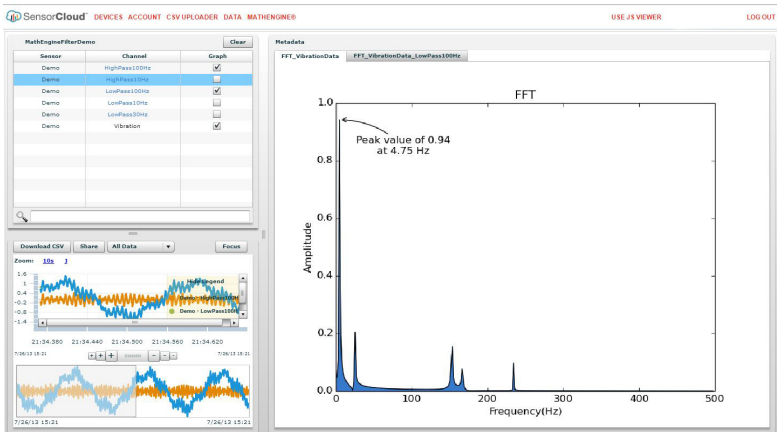

Figure 19 - FFT Graph in SensorCloud™

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

http://sensorcloud.com

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3.7.2 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**

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

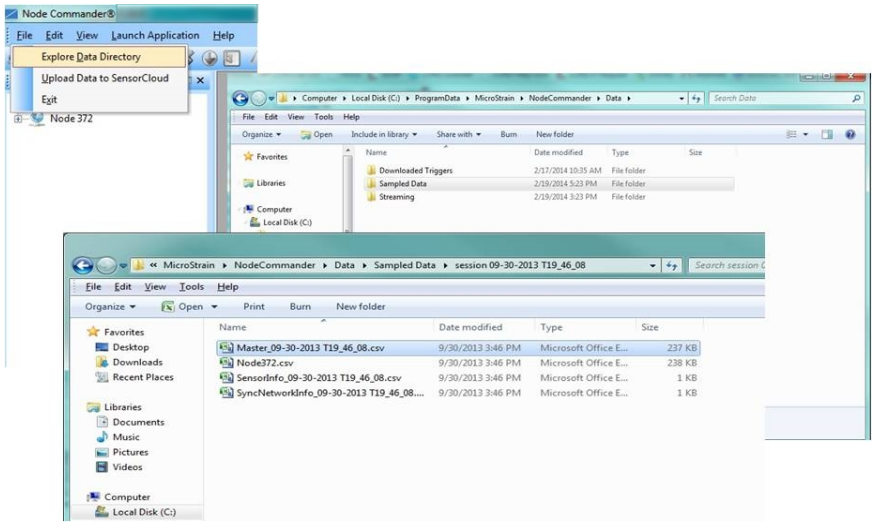

Figure 20 - Exploring Data

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. Gateway Communication

When a gateway is communicating with the host computer in Node Commander® it will appear on a list in the Controller window with a name that includes the communications port for which it is configured and an icon symbolizing the type of communication interface.

Node Commander® remembers gateways and nodes that have been communicated with previously. They will appear on the list when the software is started, however the name and icon will be grayed out if the device is not currently communicating. To remove a gateway that is no longer used, select Remove Base Station from the gateway menu.

Right clicking on the gateway name will produce a list of menu options available for the gateway . *Figure 21 - Gateway Communication* shows a USB gateway that is communicating on ComPort 3, with the corresponding menu and a serial gateway that is not connected.

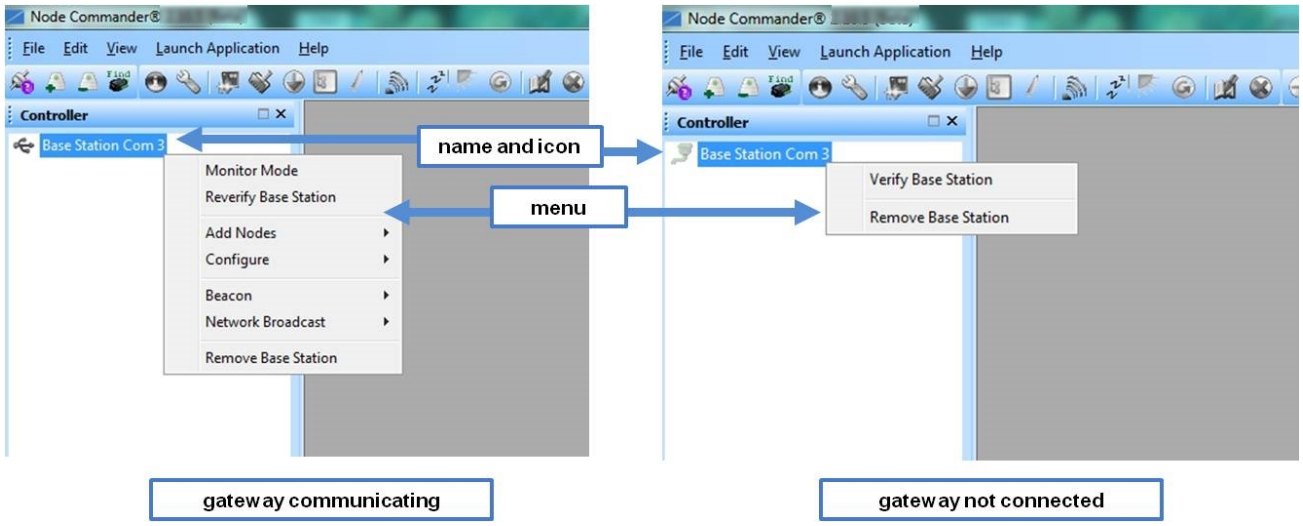

Figure 21 - Gateway Communication

Some gateways will reconnect automatically when plugged into the host computer, while others must be prompted to look for attached devices. To re-establish communication with a gateway on the list, select Verify Base Station from the gateway menu. The Action Log window will display a report on the success of the command.

To establish communication with a new device, or if the Verify Base Station command is unsuccessful, refer to the following section that corresponds with the gateway communication appropriate for the model of gateway being used.

4.1 Gateway Serial Communication

1. See *See System Connections on page 14*. Make all hardware connections and power on the gateway. Verify the gateway status indicator shows that it is on.

> **NOTE**
>
> If using a serial gateway and the computer does not have a serial port, a USB to RS232 converter may be used. Install the converter drivers, as directed by the manufacturer, and set the converter to match the gateway port settings.

1. Open the Node Commander® software

2. Right click anywhere in the Controller window, and select either Scan or Add Com Port from the menu.
    1. Scan Com Ports will attempt to find the connected device automatically, and is useful if the port number is not known. Refer to the Action Log window to monitor the scan progress.
    2. Add Com Ports can be used to assign the port number the gateway is attached to. For information on communication port numbers and settings in Windows®, *see Communications Ports in Windows® on page 123*. If the name and icon are grayed out, the gateway has been added but is not yet communicating.

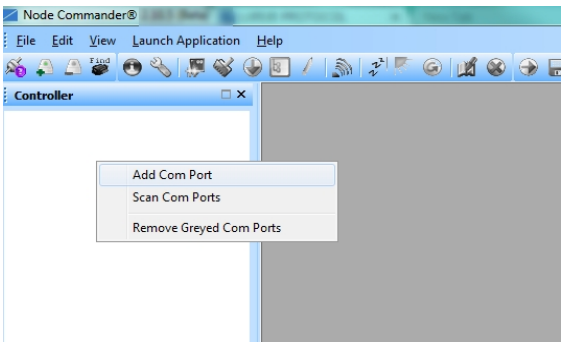

Figure 22 - Scan or Add Com Port

3. If using the Add Com Ports option, select the port that the gateway is connected to, and then click OK.

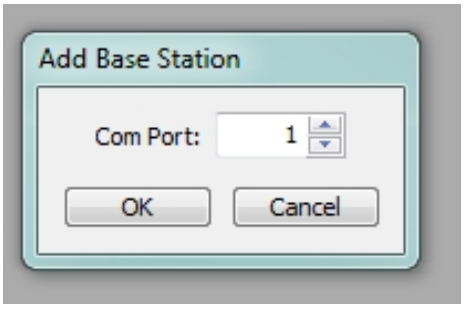

Figure 23 - Select Com Port

4. The gateway will now appear in the Controller window.

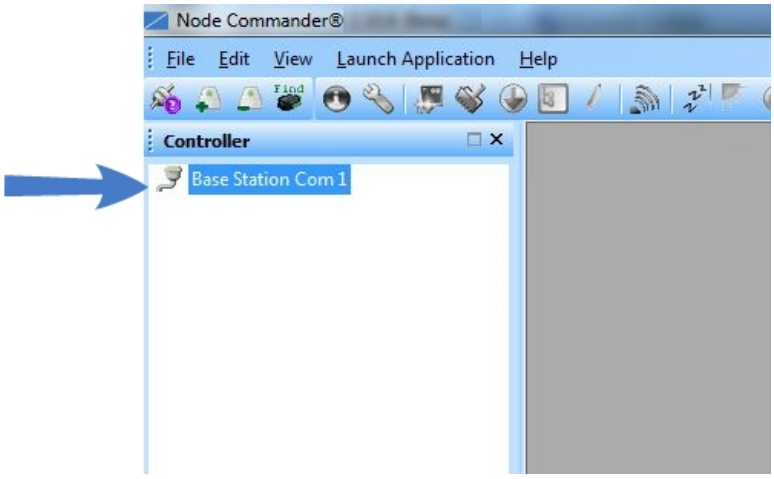

Figure 24 - Serial Gateway Communication

4.2 Gateway USB Communication

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 25 - 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.

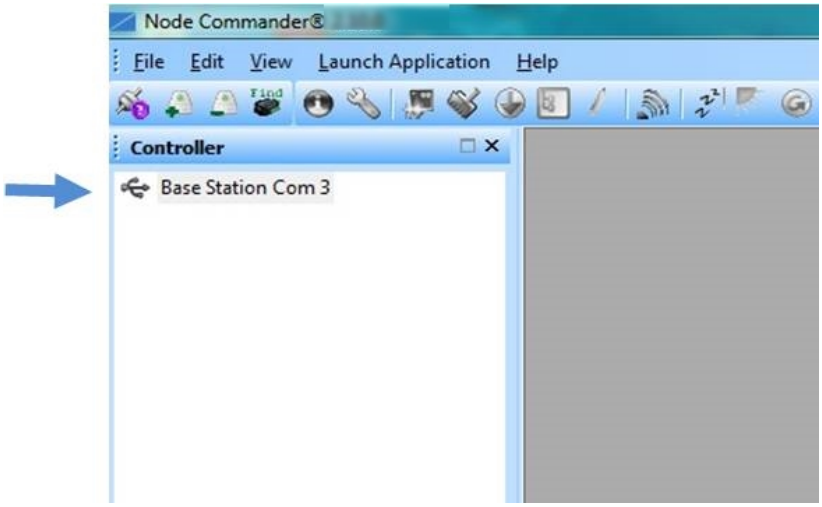

Figure 25 - USB Gateway Communication

4.3 Gateway Ethernet Communications

NOTE

The default configuration of Ethernet gateways is for DHCP network connectivity. In order to change the gateway communication settings initial connection to a DHCP enabled network is required. Refer to the gateway user manual for additional information (*see Reference Information on page 130*).

The gateway can be configured for the following Ethernet communication schemes:

- Automatically, through a DHCP-enabled local or wide area network.
- By assigning the gateway a static IP address and connecting it directly to a host computer.
- By assigning the gateway a static IP address and connecting it to a similarly configured network.
- By connecting remotely through the SensorCloud™ web interface .

4.3.1 Connecting to a DHCP Network with Live Connect™

The following steps describe how to establish communication with the Node Commander® Software using Live Connect™.

1. Connect the host computer and gateway to the DHCP network and apply power to the gateway. Verify the gateway status indicator shows that it is on and has completed the boot up process.
2. Open Live Connect™. The gateway will be detected automatically but depending on the network, it may take 2 to 3 minutes. Once detected, the gateway will appear on the list of discovered devices and can be identified by its serial number in the Device Name column (*Figure 26 - Live Connect™ Interface*).
3. When the gateway appears on the list, highlight it and click the Connect button. The Status column will indicate when communication has been established, and if so, the Port column will display the communications port. All active gateways on the network will be displayed, and can be connected to in this manner.

NOTE

Once communication has been established, the gateway settings can be adjusted through the gateway Control Panel. Access Control Panel by highlighting the gateway and selecting the View button in Live Connect™.

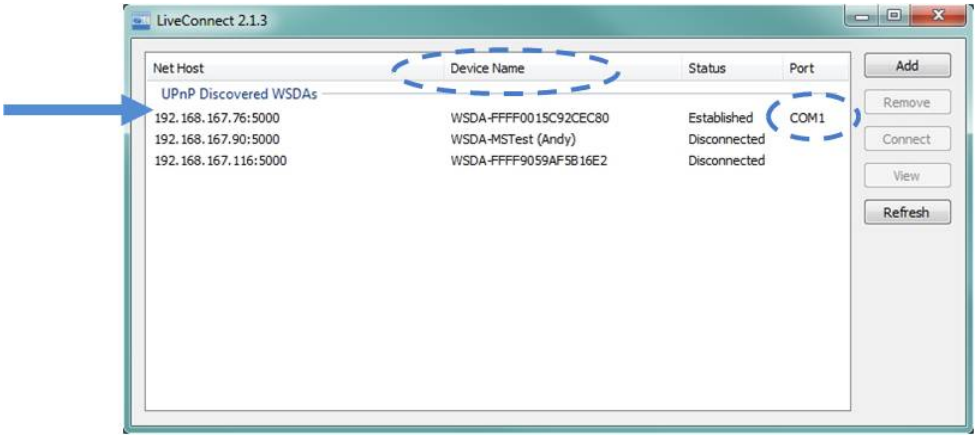

Figure 26 - Live Connect™ Interface

4. Open Node Commander®.
5. The gateway will appear in the Controller window automatically with a communication port assignment.

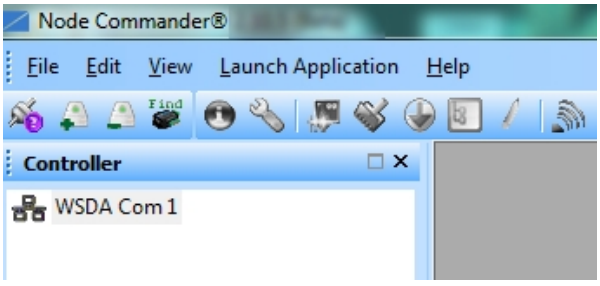

Figure 27 - Ethernet Gateway Communication

4.4 Verify Gateway Communication

The Verify and Reverify Base Station commands can be used to check the communication status of the gateway to the host computer. The Verify command is available in the gateway menu if no communication has been previously established. The Reverify command is in the gateway menu if communication has already be established, and it is used to check the current status. Right-click on the gateway name, and select the command. The Action Log will report the results of the gateway query.

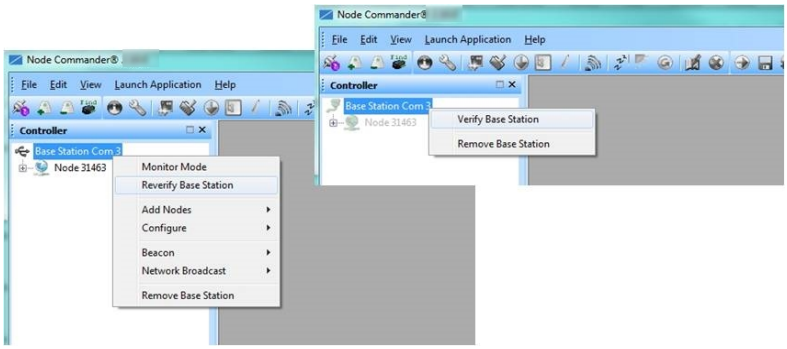

Figure 28 - Verify Gateway Communication

4.5 Gateway Communication Timeout

Node Commander® will attempt to establish communication with the gateway for the amount of time set as the communication timeout; the default setting is 20 milliseconds. If communication cannot be established, try adjusting this value for a longer timeout. Right-click on the gateway name, and select Configure > Configure Timeout. Adjust the value, and then select the Test Value button to test the communication to the gateway (*Figure 29 - Communication Timeout*). This feature can also be used if communication to the node is intermittent.

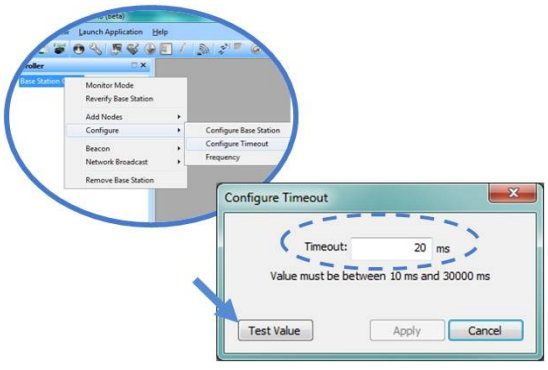

Figure 29 - Communication Timeout

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4.6 Removing a Gateway

To remove a gateway that is no longer used, right-click on the gateway name in the Controller window, and select Remove Base Station from the gateway menu .

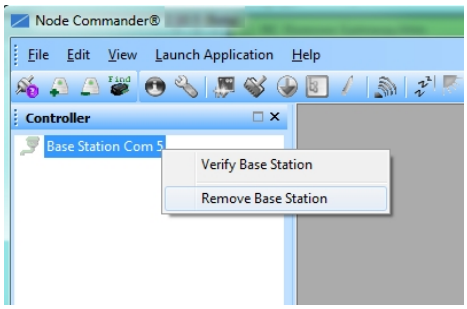

Figure 30 - Removing Gateways

5. Gateway Settings

5.1 Gateway Information

Gateway information (such as the model type, serial number, radio type, operating frequency, current communications port, and firmware revision) is found in the gateway Information window. Right-click on the gateway name and select Configure > Configure Base Station.

There is also a Label field to give the gateway a unique name, which is useful when there are multiple gateways in the system. Gateway transmit power can also be selected in this window. For additional information *see Transmit Power on page 38*.

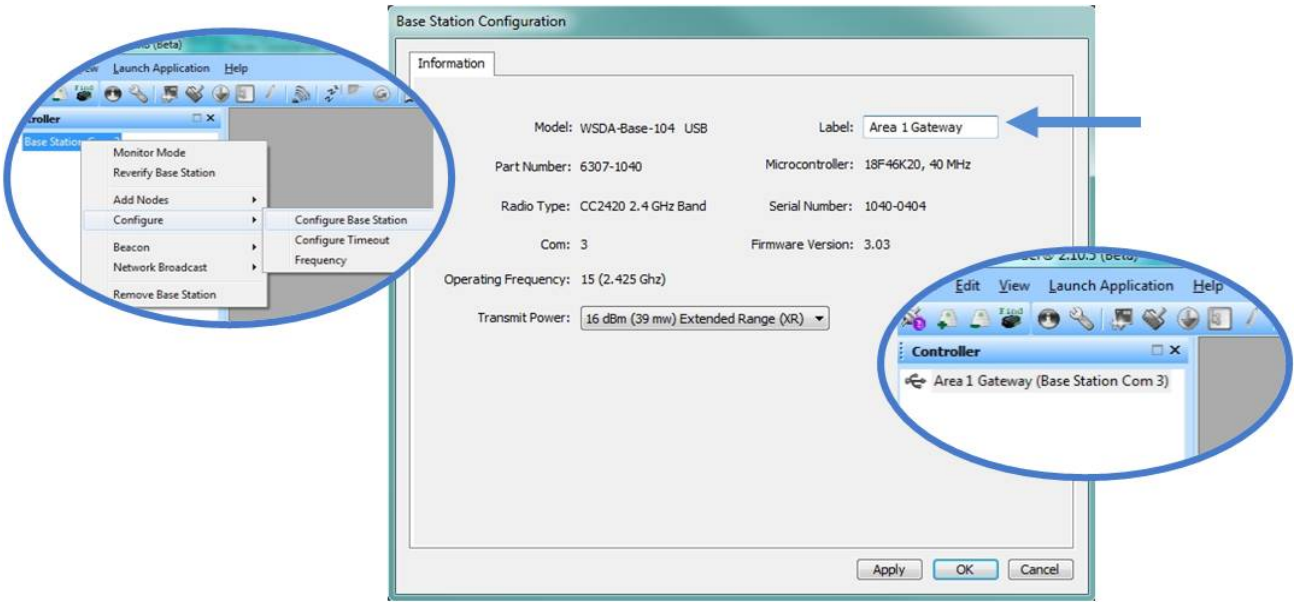

Figure 31 - Gateway Information and Name

5.2 Transmit Frequency

The transmit frequency of the wireless sensor network refers to the communication link between the gateway and the node. There are 14 available frequency channels between 2.405 and 2.470 GHz.

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.

The frequency setting for the gateway can be changed from the Configure menu.

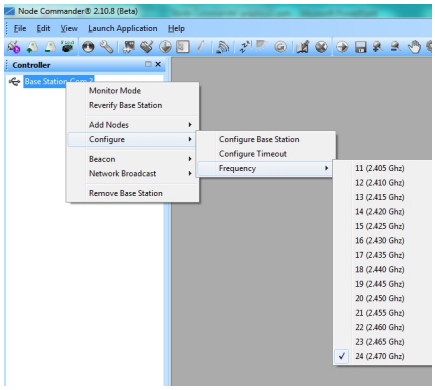

Figure 32 - Gateway Frequency

5.3 Transmit Power

The transmit power level may require adjustment if power consumption is a concern or in regions where there are transmit power restrictions. Lowering the power output reduces power consumption, but it also reduces the wireless communication range between the gateways and nodes.

NOTE

Actual range is highly dependent of how the nodes and gateways are installed and the conditions in the surrounding environment (*see Range Test on page 56*).

Setting	Power Output	Maximum Range
Extended	16 dBm (39mW)	2 km
Standard	10dBm (10mW)	1 km
Low	0dBm (1mW)	70 m

Table 1 - Transmit Power Settings

The transmit power setting for the gateway is found in the gateway Configure Base Station menu.

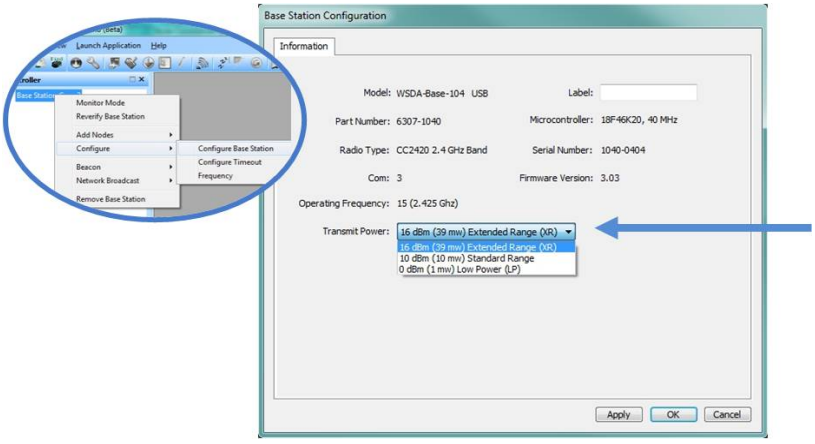

Figure 33 - Transmit Power Setting

5.4 Setting the Serial Baud Rate

⚠CAUTION

Changing the RS232 gateway baud rate may make it inoperable.

- The RS232 gateway is set to communicate at a 115,200 baud rate when it is manufactured. For most computer serial ports, 115,200 baud is the maximum supported rate. On these computers, if the gateway is set to 921,600 baud it will no longer be able to communicate with the computer. To restore, the gateway will need to be connected to a (non-standard) high speed port, or the returned to the factory for reconfiguration.
- The RS232 gateway does not support Synchronized Sampling unless it is set to 921,600 baud and used with a high speed serial port.

1. Open Node Commander® and establish communication with the gateway (*see Gateway Serial Communication on page 29*).

2. Right click on the gateway name header and select Configure and adjust the Baud Rate as needed.

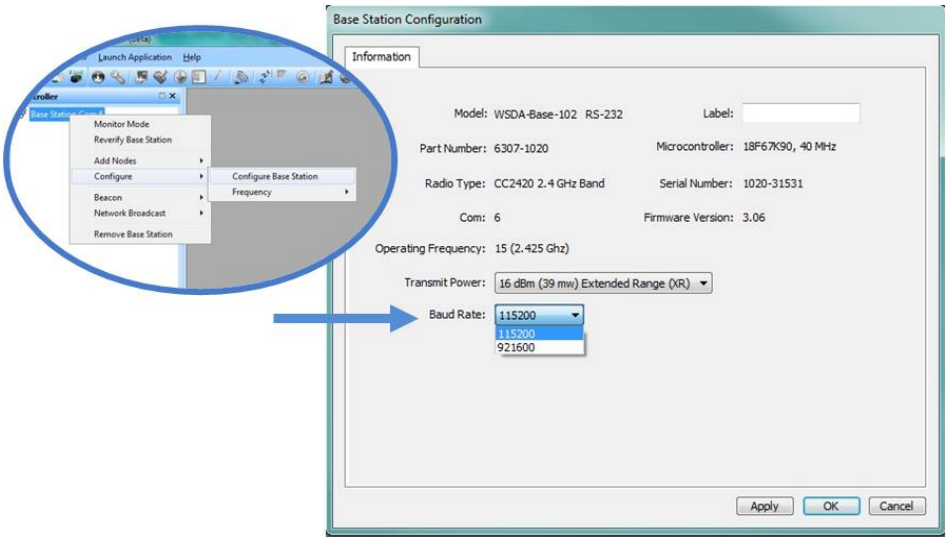

Figure 34 - Setting the Baud Rate

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5.5 Analog Gateway Configuration

In addition to normal digital communications, such as serial and Ethernet, analog gateways have eight channels of configurable outputs that recreate selected sensor input channels of connected nodes. The analog gateway channels are mapped to a node sensor channel through the Node Commander® Configure Node menu.

This menu window is accessed by right clicking on the node heading in the Controller window and selecting Configure > Configure Node. The Analog Pairing menu is used to assign node channels to analog gateway outputs by entering the node address and channel number. Channels can be assigned from multiple nodes. Further configuration options, such as enabling a no signal timeout and selecting signal processing modes, are available in this menu. Refer to the gateway user manual for more information.

Analog gateways have two programmable buttons located on the front of the device. The function of these buttons can be assigned or disabled in the Buttons menu, and include power and sampling options.

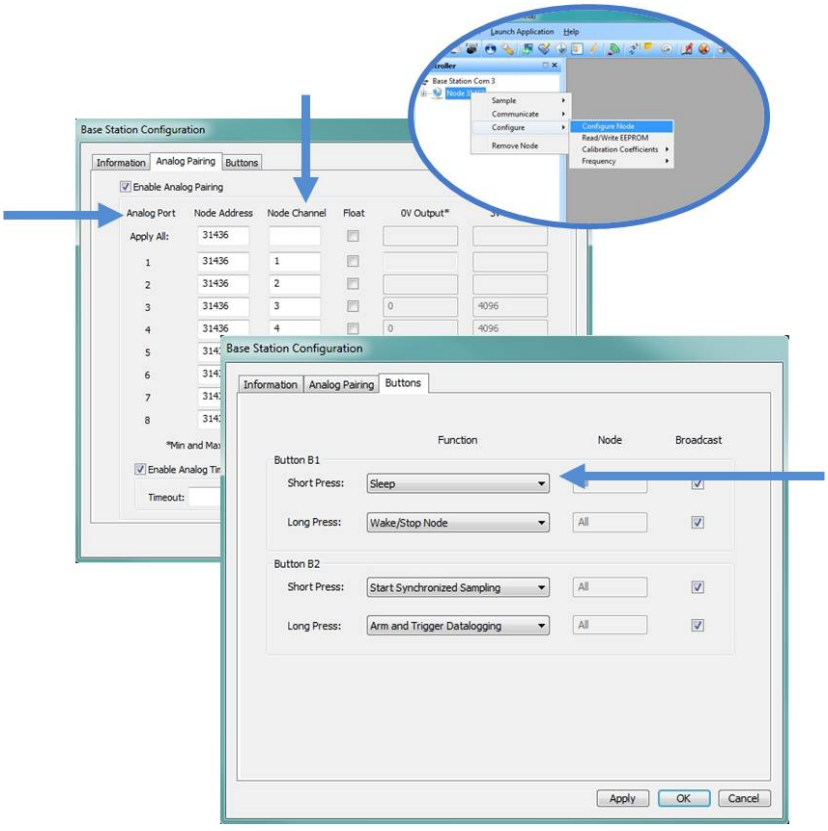

Figure 35 - Analog Gateway Configuration

6. Node Communication

The node has three communication states; **Active, Idle** and **Sleep** (*see Node Operational Modes on page 43*). Node configuration is only possible when the node is in the idle state. If it is configured for a normal boot mode, the node will enter idle state once the boot-up sequence is complete. The node can also be configured to boot-up in sample or sleep mode. This can be accomplished in a few different ways. For example, the node may be configured to boot-up and then start sampling continuously. In that scenario the node will never go into the idle state so configuration of the node is not possible until a stop command is executed to end the sampling. In other boot modes, the node will boot up, sample, and then go into idle state (at which point configuration can occur). The sample duration on these boot up sequences is determined by the sampling settings. Newly manufactured nodes are configured for normal boot mode. *See Node Boot Modes on page 59* for more information about setting and overriding boot modes.

NOTE

Nodes and gateways have status indicator lights that flash in different patterns to describe what mode they are currently in, or activity that is occurring. Refer to the device user manual for details.

The boot mode also determines the state the node will go into after the user-configurable timeout interval has occurred (*see Node Power Management on page 52*). For example, when the node is in the normal boot mode, it will go into the sleep state after the timeout interval has passed. This is useful for power conservation, however, to put it back in idle state for configuration, the node stop or wake command must be executed.

NOTE

If the node has been inactive for longer than the user timeout period, or if the node has entered sleep or sample modes for any reason, execute a stop node command in order to perform configuration tasks.

When a node is communicating with the gateway it will appear in the Controller window on a list under the host gateway. The listing includes the node name and serial number. Additional node information can be viewed by selecting the "+" symbol.

Node Commander® remembers nodes, and gateways, that have been communicated with previously. They will appear on the list when the software is started, however, may not actually be communicating with the gateway. Select the "+" symbol next to the node name to verify the connection. An error will appear if it is not. To reconnect with a previously connected node *see Reestablishing Communication on page 48*.

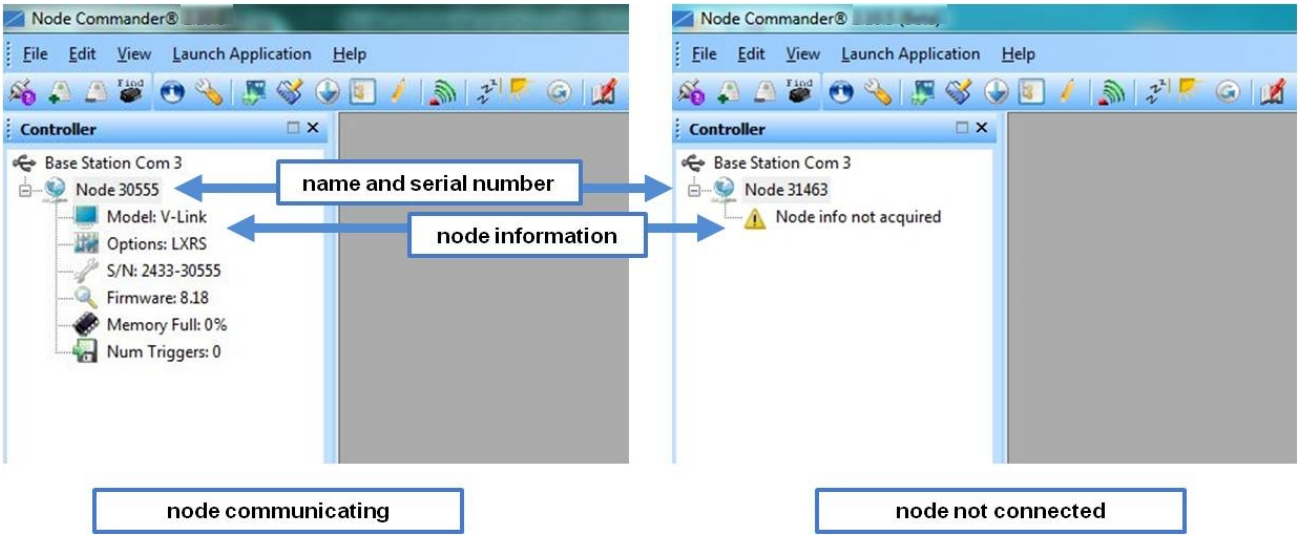

Figure 36 - Node Communication

There are several methods to establish communication with a new device.

1. Automatically with the Node Discovery feature (*see Connect to Nodes on page 44*).
2. Manually by entering the node address (*see Manually Adding Nodes on page 46*).
3. By scanning a range of node addresses (*see Scanning for Nodes by Address on page 47*).

In normal boot mode, the node will power on, send a status message and then enter idle state to wait for a command. Automatic node discovery only occurs in the status message phase of the boot up. If the node is already in idle state, or in any other state, node discovery will not work. Using other methods of establishing communication with the node, such as adding the node manually, works only after boot up is complete and the node is in the idle state.

6.1 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.

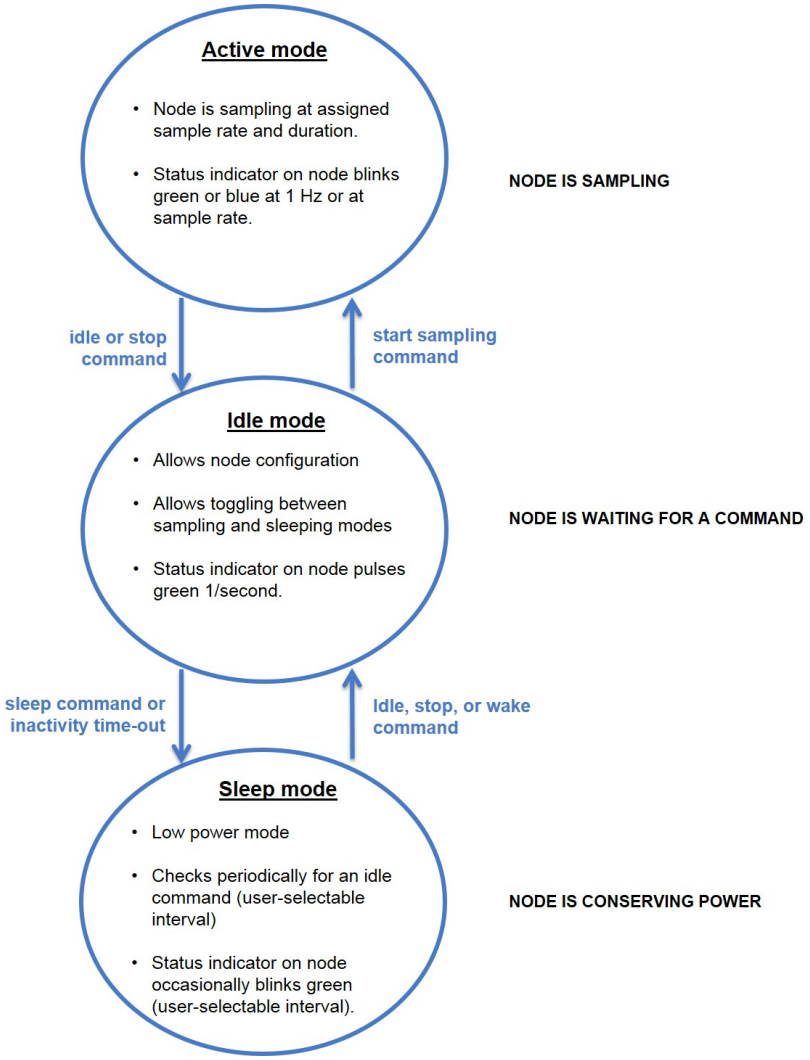

Figure 37 - Node Operational Modes

6.2 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.

6.2.1 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 38 - 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.

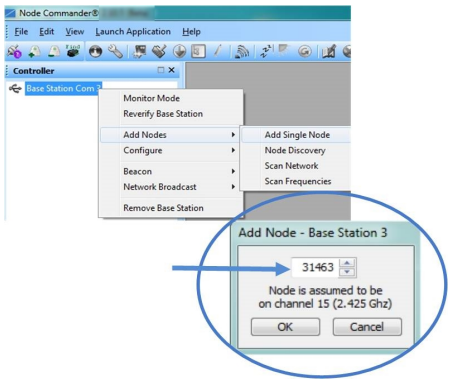

Figure 38 - Adding a Node by Address

6.2.2 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 118*.

1. Right-click on the gateway name and select Add Node > Node Discovery (*Figure 39 - 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.

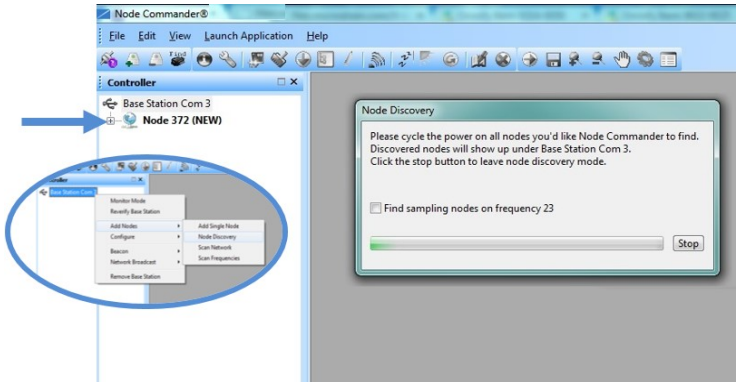

Figure 39 - Using Node Discovery

6.2.3 Manually Adding Nodes

Nodes can be manually added if the node address is known. The address is indicated on the functional test or calibration document included with the node when it is purchased. The gateway will search for the node on the frequency it is currently set to. If the node is on a different frequency, the gateway frequency must be changed in order for the manual addition of the node to be successful. *See Transmit Frequency on page 37* for instructions on how to set the gateway frequency.

1. Make the hardware connections and establish communications with the gateway.

2. Power on the node.

3. Right click on the gateway name in the Controller window and select Add Single Node.

4. Enter the node address and select OK. If the node is not found an error message will appear and provide the option to scan for the node on other frequencies.

5. If the node is found, verify communication by expanding the node information list with the "+" symbol beside the node heading. If the information list appears, communication has been established.

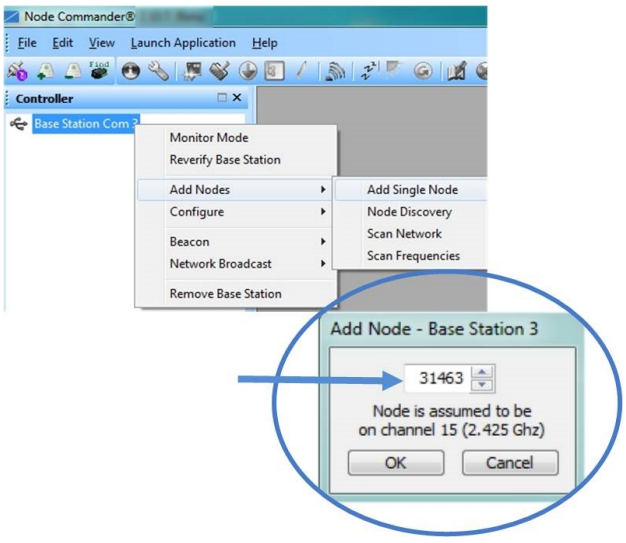

Figure 40 - Adding a Node by Address

6.2.4 Scanning for Nodes by Address

Nodes can found by scanning an address range. The gateway will search for nodes on the frequency it is currently set to. If the node is on a different frequency, the gateway frequency must be changed in order for the scan to be successful. *See Transmit Frequency on page 37* for instructions on how to set the gateway frequency.

1. Make the hardware connections and establish communications with the gateway.
2. Power on the node.
3. Right click on the gateway name in the Controller window and select Scan Network.
4. Enter the node address range. The wider the range, the longer the scan will take.
5. Select OK.
6. If the node is found, verify communication by expanding the node information list with the "+" symbol beside the node heading. If the information list appears, communication has been established.

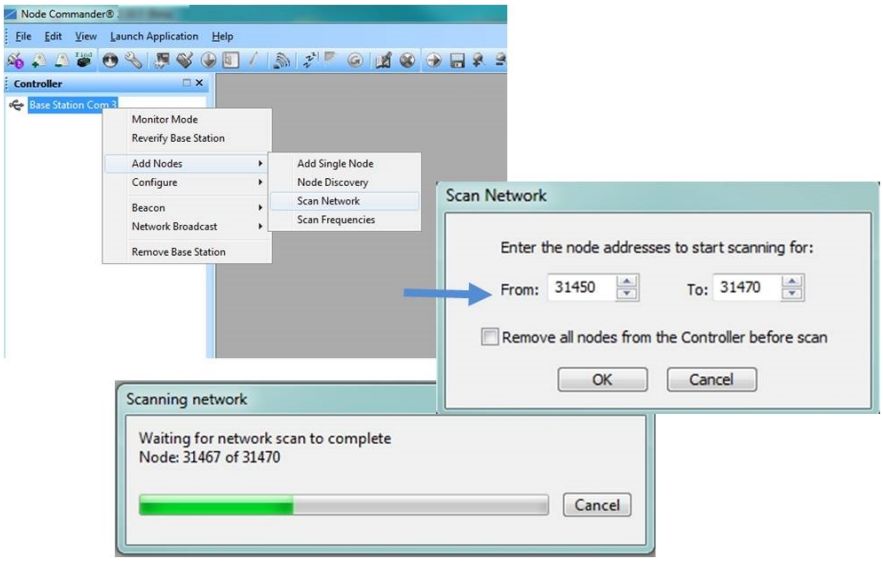

Figure 41 - Scanning Addresses

6.3 Verifying Node Communication

Use the Ping command to verify communication with a node at any time. Right click on the node name in the Controller window and select Communicate > Ping from the node menu. The Action Log window will report if the Ping was successful or not. A successful ping means the node is communicating with the gateway.

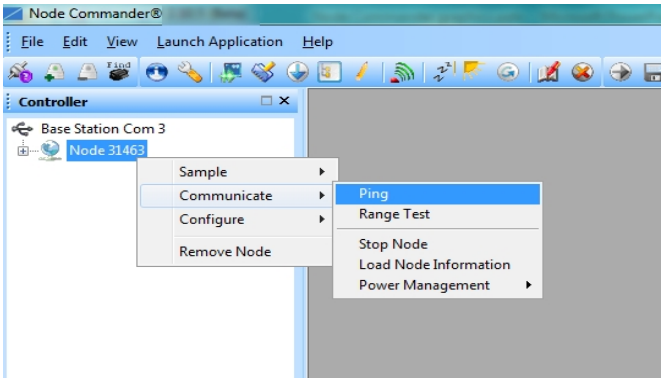

Figure 42 - Test Node Communication

6.4 Reestablishing Communication

Node configuration cannot occur when the node is sampling or sleeping. The Stop Node command is used to end whatever activity the node is currently performing, put the node into idle mode, and allow configuration. It can be use to exit sampling modes, such as sampling on boot up, and to interrupt other routines, such when the node is in sleep mode. To execute a Stop Node command, right click on the node name in the Controller window, and select Communicate > Stop Node from the node menu. After the node has been stopped, node menus, such as Configure, will become accessible.

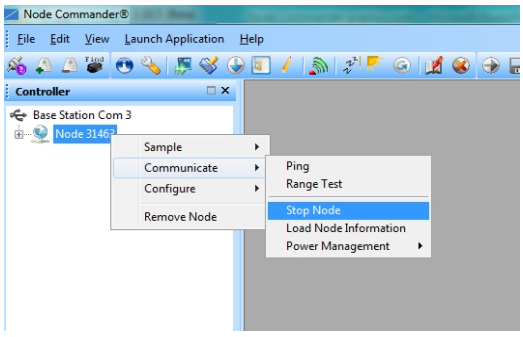

Figure 43 - End Node Activity to Reestablish Communication

6.5 Network Broadcast

The network broadcast feature is used to send the same command at the same time to multiple nodes connected to the same gateway. Nodes must be on the same transmission frequency (channel) as the gateway to receive broadcast commands. Network broadcast functions include communications, sampling, and configuration commands.

Network broadcast commands are found in the gateway menu. Right click on the gateway name, and select Network Broadcast. Then select the desired category and command.

Sample

- Synchronized Sampling Start
- Low Duty Cycle Start
- Armed Datalogging
- Trigger Datalogging Session
- Erase

Communicate

- Ping
- Stop Node
- Wake Node
- Sleep
- Cycle Power

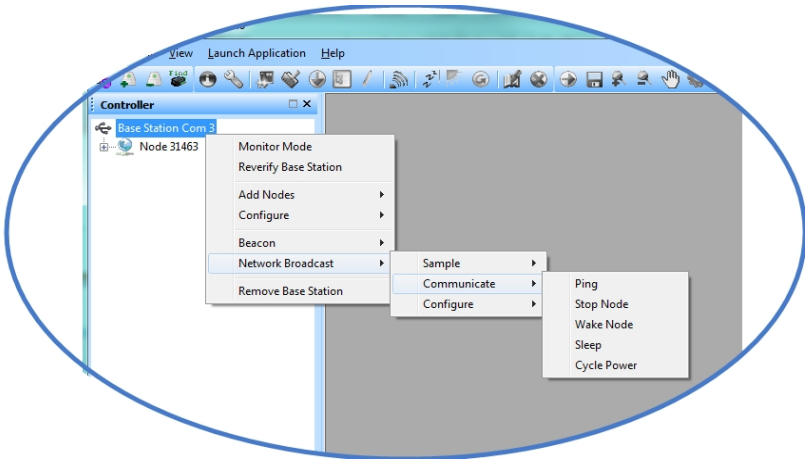

Figure 44 - Network Broadcast Commands

Configure

- Read/Write EEPROM

6.6 Removing Nodes

To remove a node that is no longer used, right click on the node name in the Controller window and select Remove Node from the node menu.

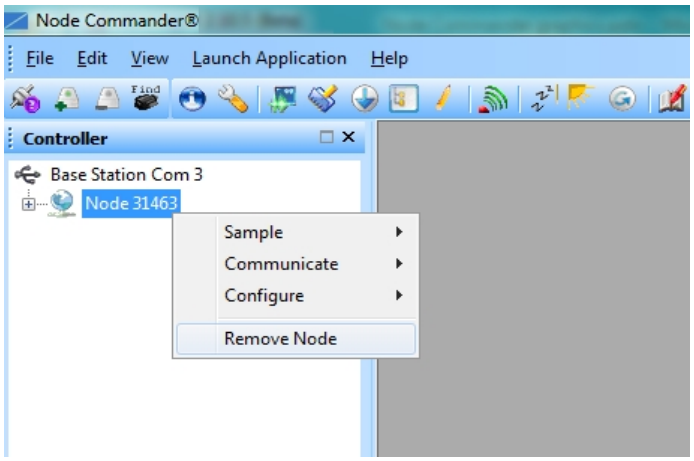

Figure 45 - Removing a Node

7. Node Settings

7.1 Node Information

Node information, such as the model type, serial number, radio type, operating frequency, node address, and memory size, is found below the node name in the Controller window or more extensively in the node Info window.

Clicking in the "+" symbol next to the node name will produce a list of some of the node information (*Figure 46 - Node Information*). The same thing can also be accomplished through the Communicate menu by right clicking on the node name and selecting Communicate > Load Node Information.

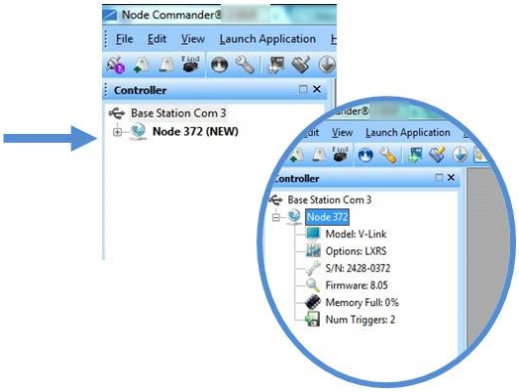

Figure 46 - Node Information

If the node information will not load, the node is not communicating. Try executing the Stop Node command to ensure the node is not in a sampling or sleep mode, and then load node information.

More node information can be found in the node Info window. This window is accessed by right clicking on the node name and selecting Configure > Configure Node and the Info tab. In the node Info tab there is a field to give the node a unique name, which is useful when there are multiple nodes (*Figure 47 - Additional Node Information and Name*). Node settings can be saved and loaded as well. *See Saving Node Settings on page 62*.

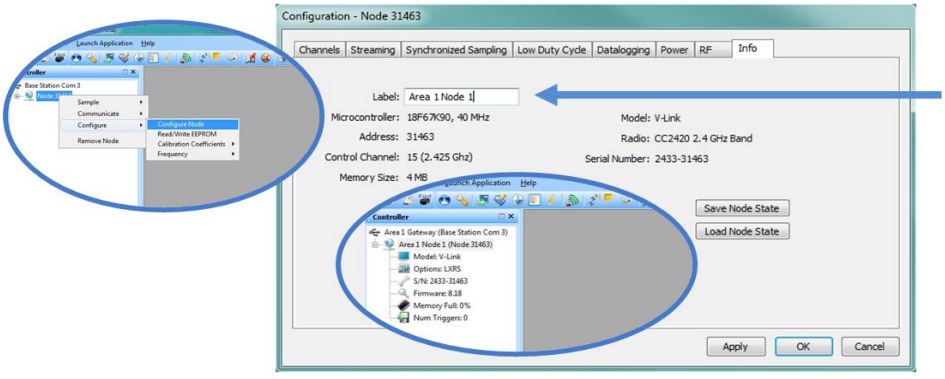

Figure 47 - Additional Node Information and Name

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7.2 Node Power Management

The node power management features can be used to conserve power when the node is not actively sampling. Power management features include an ultra low power sleep mode, node boot up options, radio check interval settings, and an inactivity timeout.

Node power management features are available in two menus. For direct control over the current state of the node, right click on the node name and select, Communicate > Power Management. This menu is used to set the node into sleep mode. The node will stay in sleep mode until the Wake command is executed from the same menu. The Action Log window will display the status of the command. There is also a command to cycle power to the node. This software reboot feature is used in special cases, such as when using the Read/Write EEPROM command to program the node or for troubleshooting if the node is unresponsive.

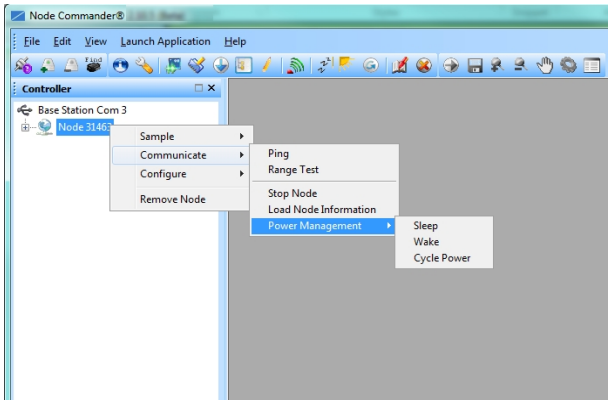

Figure 48 - Node Power Basic Commands

Additional power settings are found by right clicking on the node name and selecting Configure > Configure Node. Select the Power tab.

NOTE

If the inactivity timeout is set to a very short duration, it may be difficult to execute commands before the timeout occurs. In this case, use the Stop Node command to re-establish communication and extend the timeout before it occurs again.

- **Radio Check Intervals** is how frequently the node turns on the radio to listen for communications while it is sleeping. Longer wait intervals will result in less power use but also means there may be a delay between the time when the node is sent a Wake command and when it actually wakes up.

- **User Inactivity Timeout** is the amount of time that has to pass with no commands before the activity related to node boot mode occurs. For Normal Boot mode, this is the time of inactivity that has to pass before the node goes to sleep. In some boot modes, such as Synchronized Sampling, it will begin sampling after that period of time .

- **Boot Mode** determines what the node will do when it is turned on. Most of the boot options are related to what type of sampling is desired and not directly to do with power consumption, however some sampling modes use significantly less power than others. For example, Low Duty Cycle uses a lot less than streaming because the node is only on and transmitting periodically. *See Node Boot Modes on page 59*.

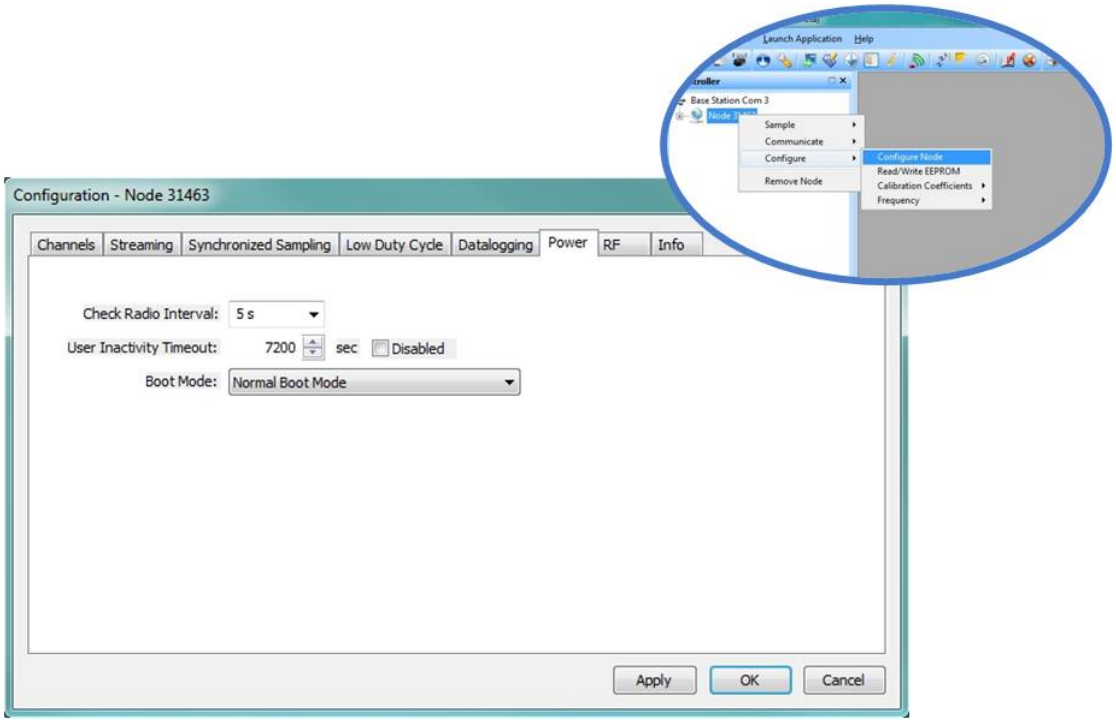

Figure 49 - Advanced Power Settings

7.3 Transmit Frequency

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.

The frequency setting for the node is found in the node Configure menu.

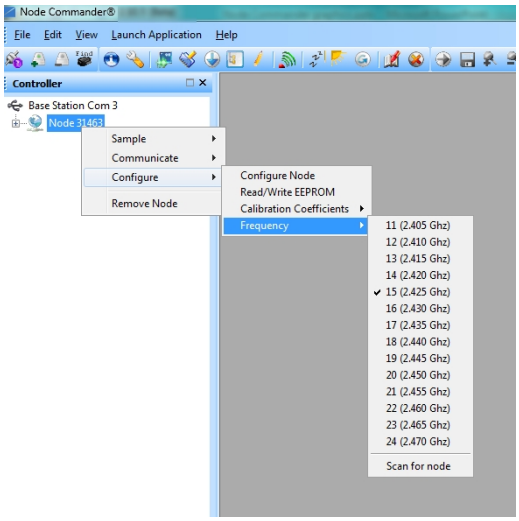

Figure 50 - Node Frequency

7.4 Transmit Power

The transmit power level may require adjustment if power consumption is a concern or in regions where there are transmit power restrictions. Lowering the power output reduces power consumption, but it also reduces the wireless communication range between the gateways and nodes.

NOTE

Actual range is highly dependent of how the nodes and gateways are installed and the conditions in the surrounding environment (*see Range Test on page 56*).

Setting	Power Output	Maximum Range
Extended	16 dBm (39mW)	2 km
Standard	10dBm (10mW)	1 km
Low	0dBm (1mW)	70 m

Table 2 - Transmit Power Settings

The transmit power setting for the node is found in the Configure Node menu.

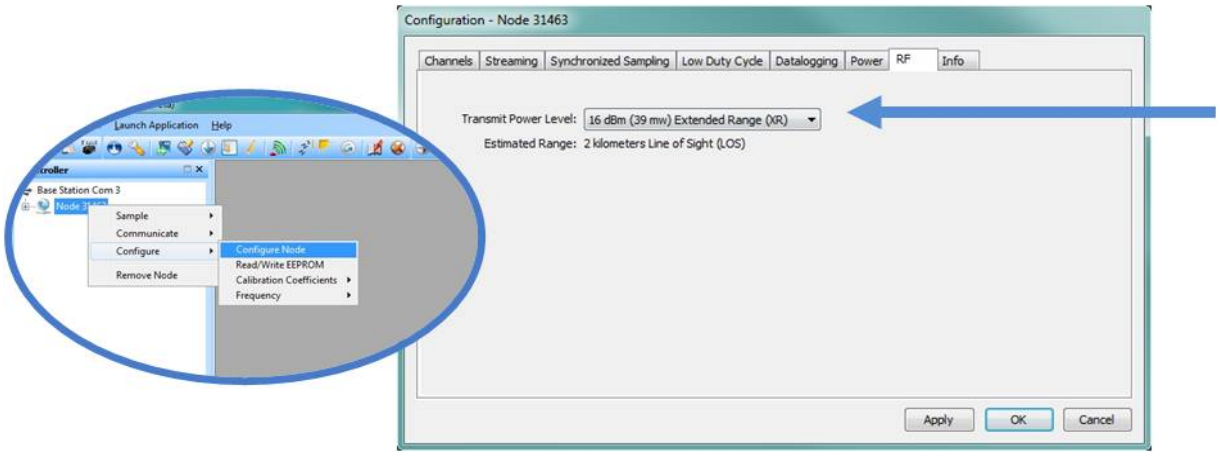

Figure 51 - Transmit Power Setting

7.4.1 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.

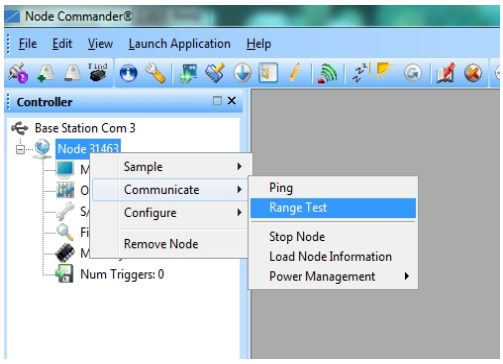

Figure 52 - Range Test Menu

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 53 - Range Test Statistics

7.5 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. In the following example (*Figure 54 - Node Channels Menu*): a1) analog differential channel icon, a2) analog single ended channel icon, and a3) temperature channel icon.

    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.

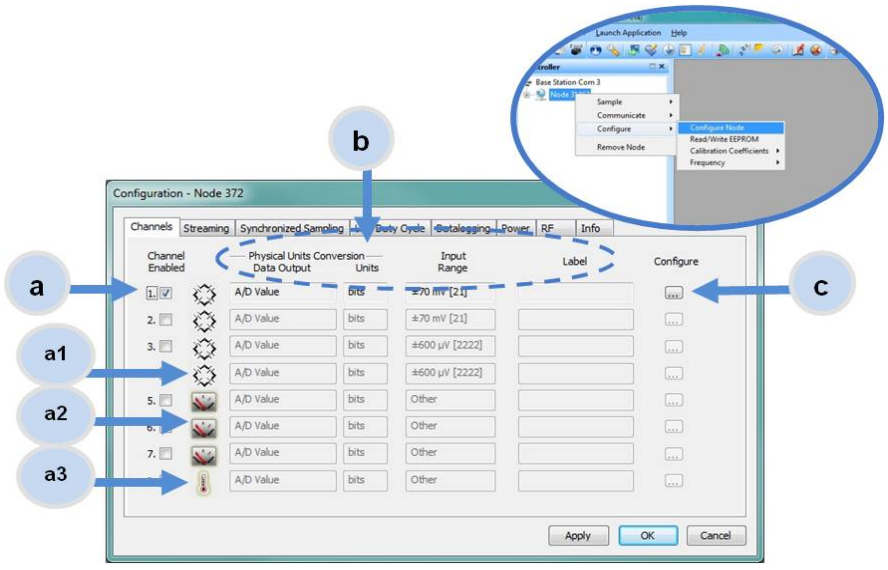

Figure 54 - Node Channels Menu

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2. To enter the channel configuration menu, select the Configure button as shown in *Figure 54 - Node Channels Menu*.

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

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

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

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

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

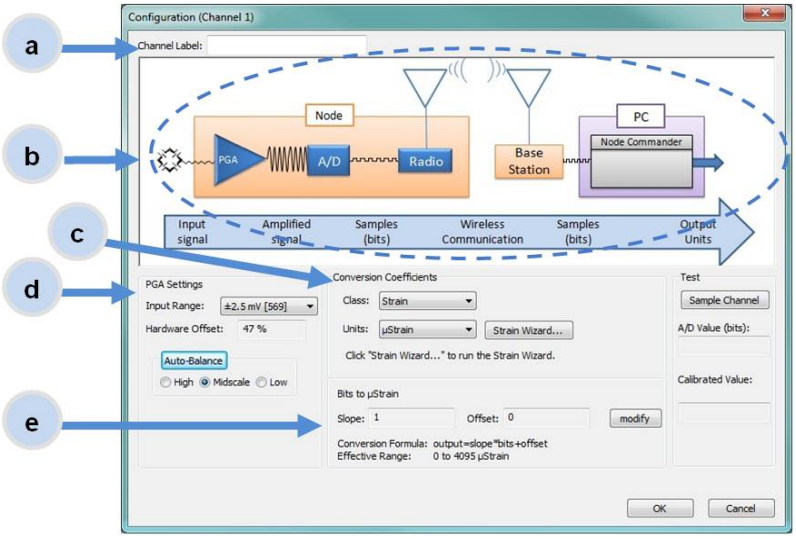

Figure 55 - Channel Setup

7.6 Node Boot Modes

Nodes can be configured to boot up in several different ways, depending on the application requirements (*Table 3 - Node Boot Modes*). For sample on boot up modes, the node will sample according to the sampling settings configured for the node. This is especially useful when data acquisition through SensorCloud™ is desired. By setting the node to sample on boot up Node Commander® will not be required to initiate sampling as the node will begin sampling automatically. Depending on the settings, it may either boot up and sample continuously or boot up, sample for a fixed interval, and then go into idle state.

Setting the node up for different modes will effect the way communication can be established with the node.

- If the node is sampling or sleeping on boot up, node configuration cannot occur until the sampling is completed or the Stop Node command is executed.
- Node boot modes can be bypassed by toggling the node ON/OFF switch rapidly three times and leaving it in the ON position. This will result in a normal boot up.

Boot Mode	Description	Node Device Indicator Sequence
Normal	Node turns on, sends out a status message, and then waits, in idle, for a command.	Several rapid flashes, then pulses in one second intervals.
Low Duty Sampling	Node turns on and takes a sample at set parameters. If set for a fixed sample interval, on completion, the node sends out a status message and then waits, in idle, for a command. If set for continuous sampling, the node turns on and samples until a stop command is sent. If set to synchronized sampling the node turns on, waits until a beacon is received on the same frequency, and then samples	Pulses at the set sample interval when sampling. Normal boot indicator sequence on completion
Synchronized Sampling		On solid while sampling. Normal boot indicator sequence on completion
Stream		On dimly while sampling, normal boot indicator sequence on completion
Datalog		One flash when sampling, then on dimly when datalogging. Normal boot indicator sequence on completion
Sleep	Node turns on, and then goes into sleep mode.	Off, with occasional flash at set radio check interval.

Table 3 - Node Boot Modes

1. To change the node boot mode, right click on the node name and select Configure > Configure Node from the node menu.
2. Select the Power tab.
3. Select the desired boot mode from the drop down menu.
4. Select Apply or OK. The next time the node is restarted it will boot up in the new mode. It must be a full power reset; the Cycle Power command in Node Commander® will not work for this.

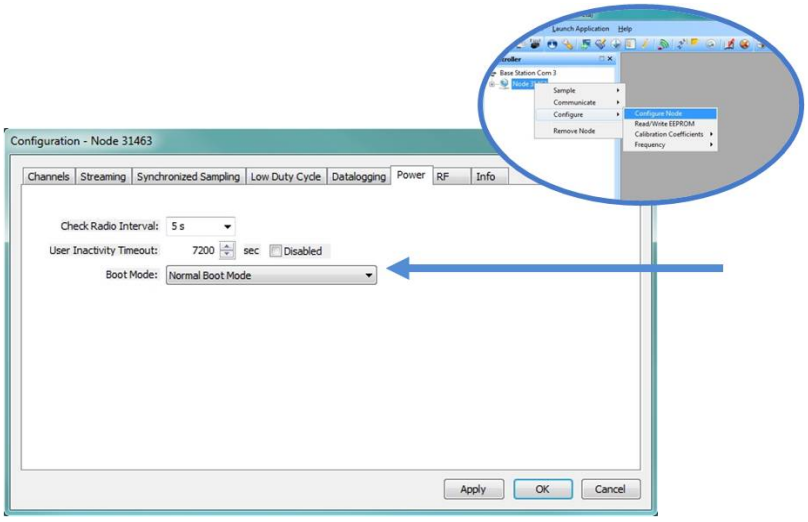

Figure 56 - Boot Mode Setting

7.7 Applying Node Configuration

Node values set in any of the tabs in the node Configure menu are saved to the node using either the OK or Apply buttons. The OK button saves and exits the menu, while the Apply button writes the values, but does not exit the menu, allowing additional settings to be changed. Changes must be applied before selecting another tab, or they will not be saved.

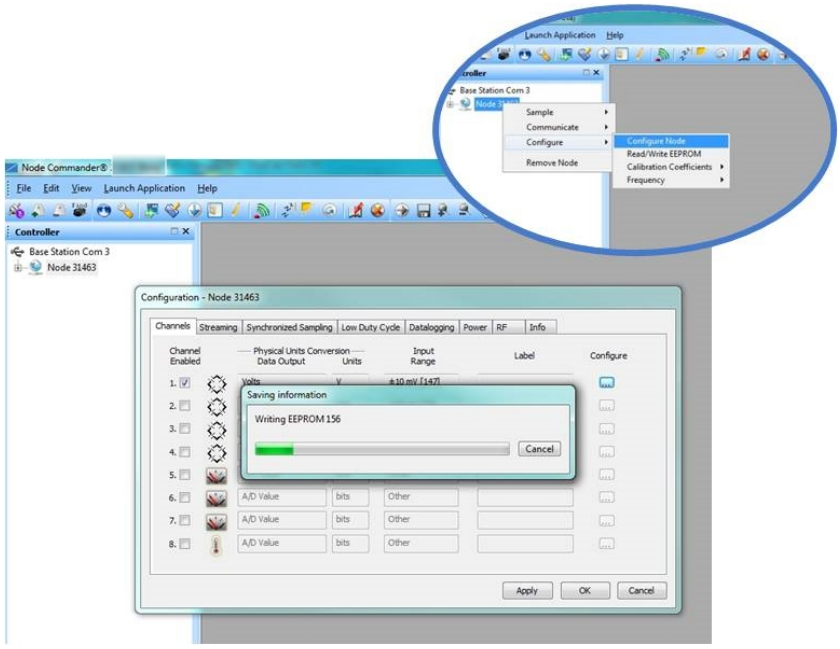

Figure 57 - Applying Node Settings

7.8 Saving Node Settings

The Save Node State feature creates a file to backup all of the node settings, including factory and user entered calibration values, channel configurations, sampling settings, and communication settings. The settings file contains the unique node address and any applicable factory calibration values and is therefore unique to each node . It is important that a saved file only be loaded on the node it was created on, or the node address and factory calibration values will be overwritten. If external sensors have been replaced or disconnected since the settings file was created, recalibration of the sensors may be necessary.

The Save Node State and Load Node State features are found in the node Info window. The Info window is accessed by right clicking on the node name in the Controller window and selecting Configure > Configure Node. Name the node settings file with a name that indicates which node it is, for example using the serial number.

Use the Load Node State button to reload previously saved node settings files.

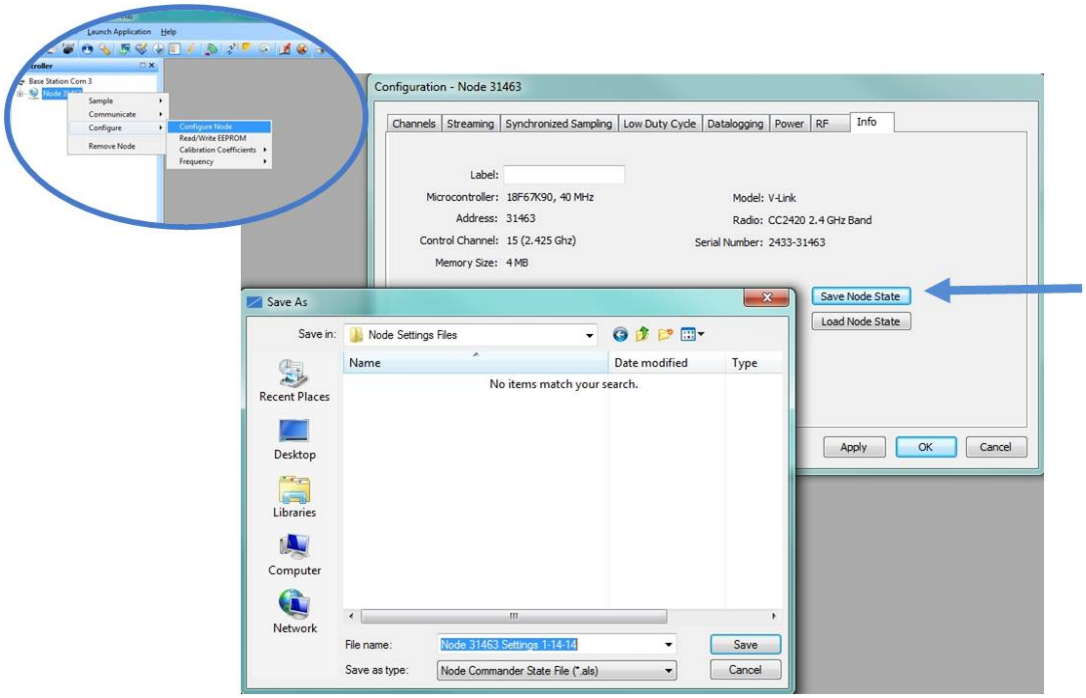

Figure 58 - Node Settings File

7.9 Node EEPROM Settings

Advanced settings can be configured by using coded commands to write directly to the node EEPROM. The EEPROM addresses and settings are available from LORD MicroStrain® Technical Support Engineers and are only required in special circumstances.

The EEPROM read/write menu is available though the node menu. Right click on the node name and select Configure, Read/Write EEPROM. Enter the EEPROM command address and value and then click Read or Write, as applicable.

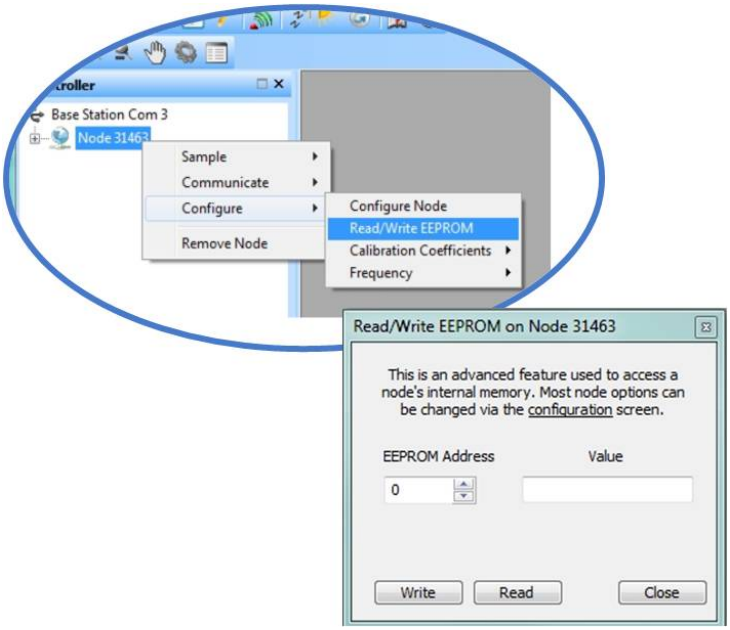

Figure 59 - Read/Write Node EEPROM

8. Sensor Settings

LORD MicroStrain® sensor nodes are designed to accept many sensor types and some have integrated sensors. Some nodes have multiple input channels and channel types. Available sensor settings vary depending on the type of node being used and what channel the sensor is connected to. The node configuration interface changes accordingly and can include settings for measurement units, gain settings, and conversion values. For more information *see Sensor Calibration on page 74*. *See Channel Configuration on page 57* for menu interface information. 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 volts and 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 67*, and for instruction of adjusting units *see Measurement Units on page 66*.

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.

Internal sensors are assigned to a specific channel at the factory and the channel number cannot be changed. Some internal sensors are also calibrated at the factory. The calibration values can be changed. *Table 4 - Example Internal Sensor Types*, describes some internal sensor types, units and calibration options.

example internal sensors	units	calibration options
accelerometer	acceleration g-force A/D value custom	factory calibration user entry from lab or field calibration
temperature	temperature A/D value custom	calibration not required factory calibration user entry from lab or field calibration

Table 4 - Example Internal Sensor Types

External sensors can be attached to any channel that is suitable for sensor type. *Table 5 - 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	calibration wizard 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
accelerometer	accelerometers	acceleration g-force A/D value custom	user entry from manufacturer data, lab or field calibration

Table 5 - Example External Sensor Types

8.1 Measurement Units

Sensor measurement units are set in the channel Configuration menu.

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

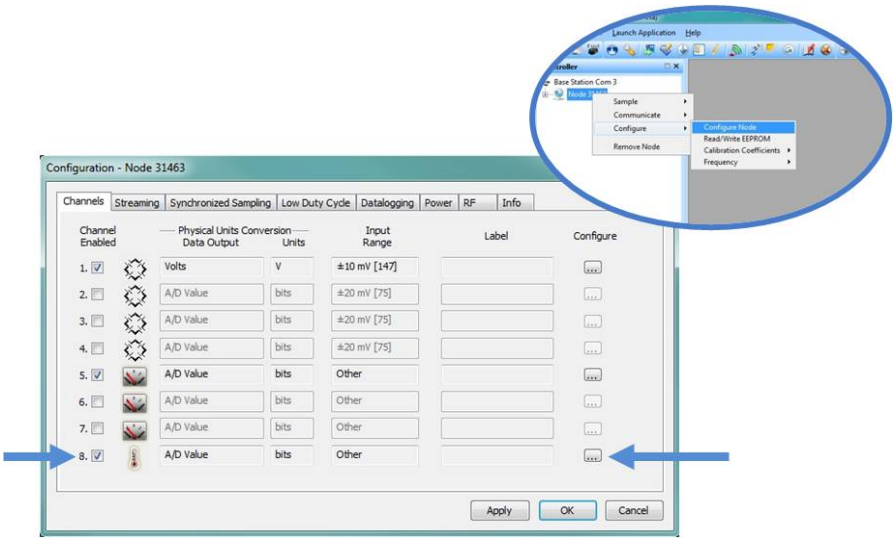

Figure 60 - Channel Configuration Menu

2. Select the type of measurement from the Class menu, and then select Units.

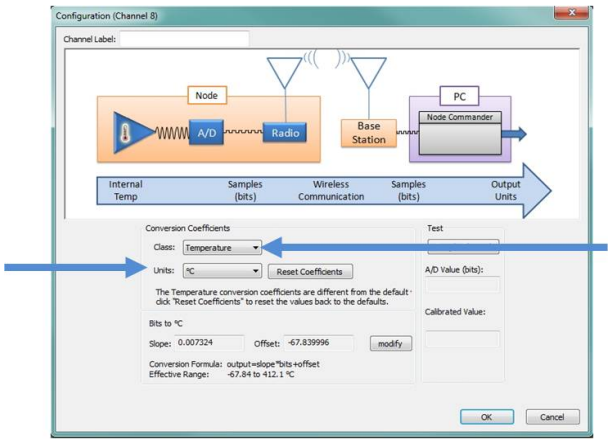

Figure 61 - Select Sensor Units

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8.2 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® and saved in the node memory for the applicable channel.

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. *See Sensor Calibration on page 74*.

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.

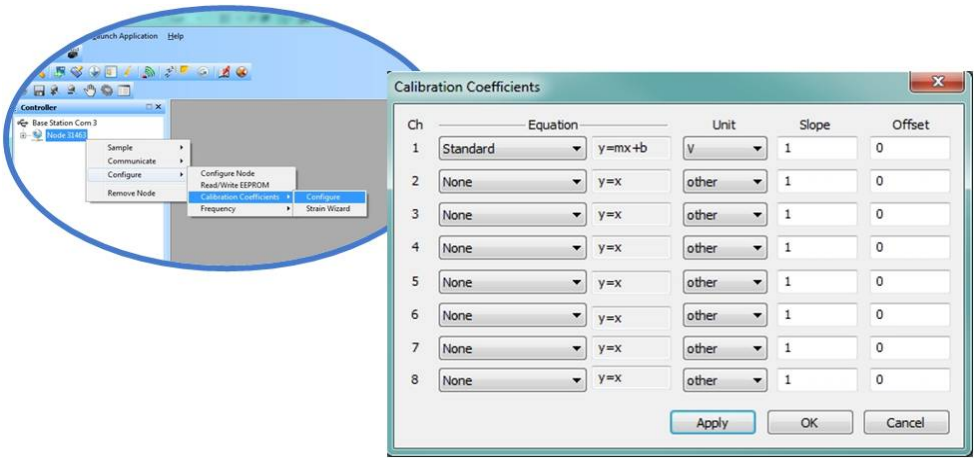

Figure 62 - Abbreviated Conversion Values Menu

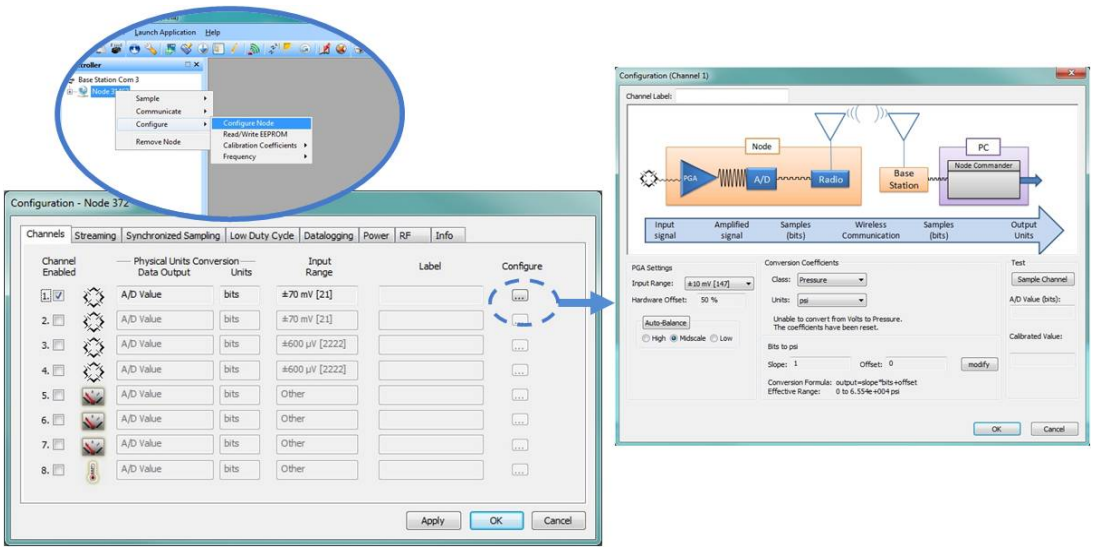

Figure 63 - Advanced Conversion Values Menu

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), 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 $y = mx + b$.

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 $y = mx + b$.

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).

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.

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).

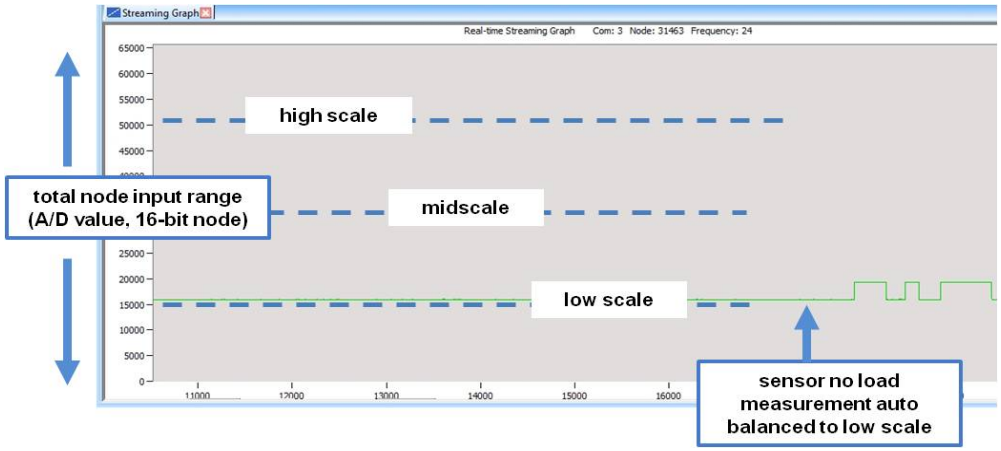

Figure 64 - Offset Scale Setting

8.2.1 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 74*.

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.

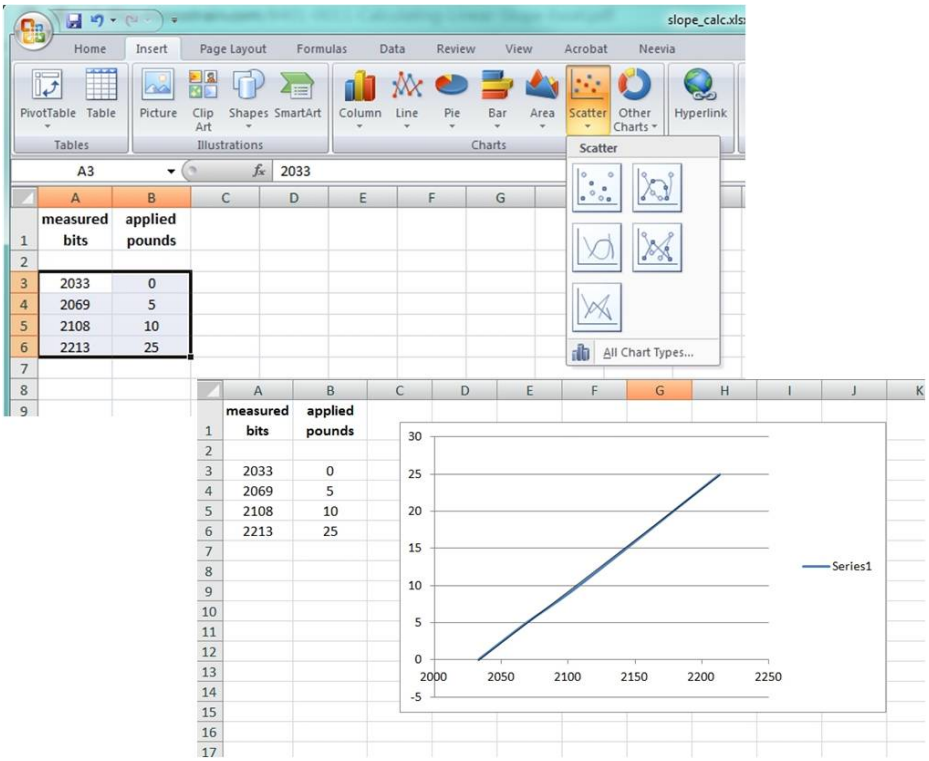

Figure 65 - Generate a Scatter Chart

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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 66 - Plot Trendline*).

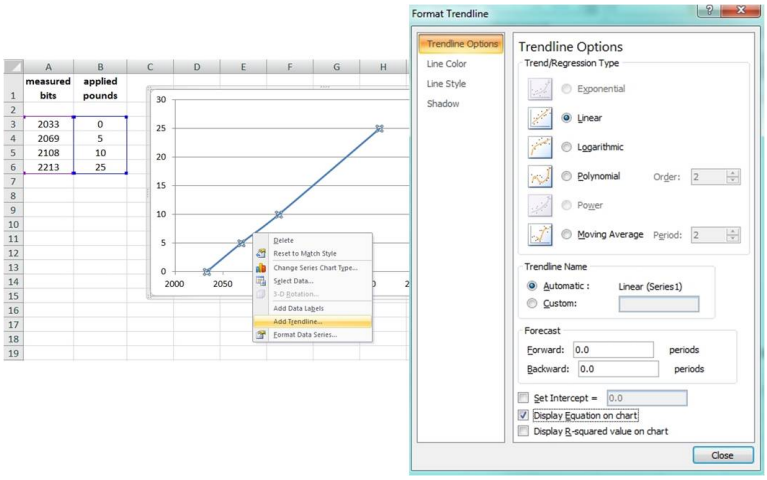


Figure 66 - Plot Trendline

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.

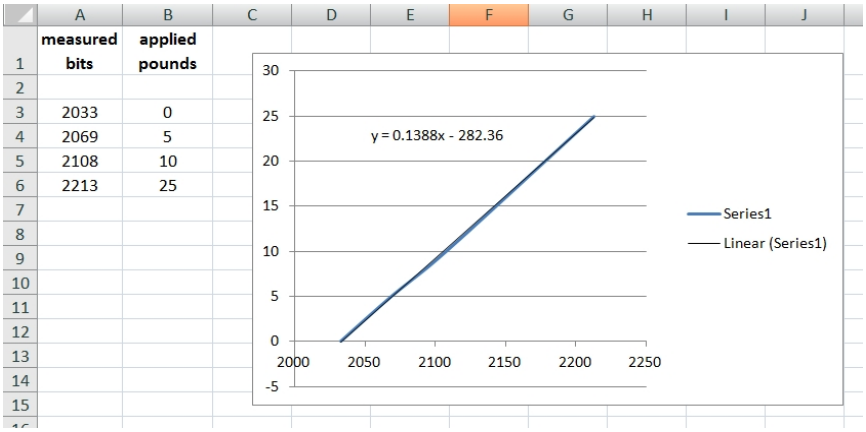


Figure 67 - Slope and Offset Values

8.2.2 Differential Input Gain and Offset

The combination of the gain, offset, and sensor signal cannot exceed the 0 to 3 V dc input of the analog to digital converter within the node. *See Example Gain and Offset Calculations on page 73*.

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 3V 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 3V range of the node input. The range of A/D counts that corresponds with the 0 to 3V node input depends on the resolution of the node. For example, a 12-bit node will have a full scale bit range of 4096 and a 16-bit node will have a full scale bit range of 65535. A mid-range setting positions the baseline offset in the middle of the range (1.5 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 (750 mV 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 (2.25 V or full scale bits *3/4) and is used for mostly negative going signals.

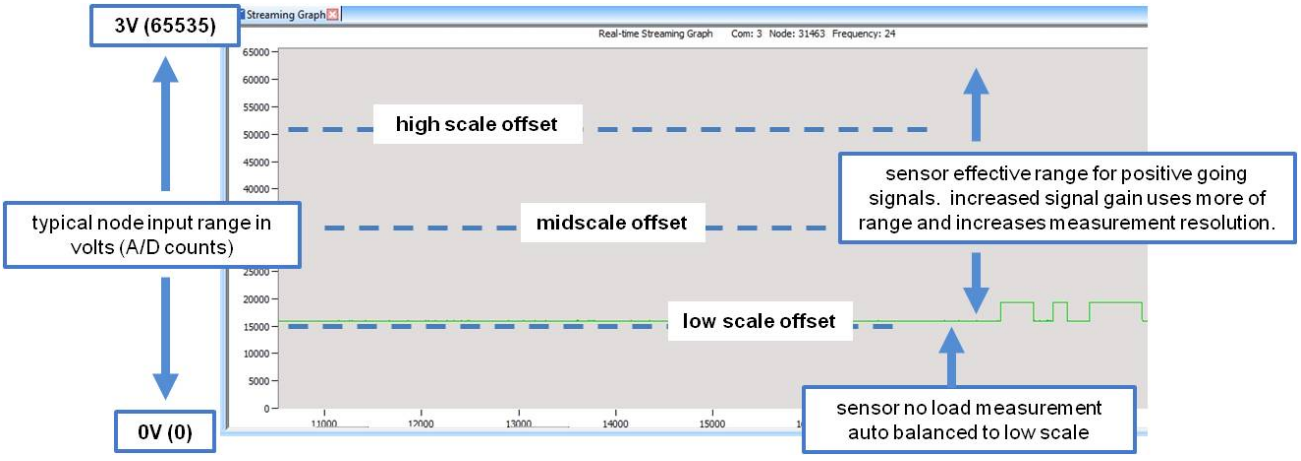


Figure 68 - Differential Input Resolution and Offset (16-bit Node)

8.2.2.1 Example Gain and Offset Calculations

EXAMPLE 1:

Sensor signal range: 0 to 50 mV
Gain setting: 21
Baseline offset range setting: Mid-range

Calculations:

50 mV * 21 = 1.05 V (maximum voltage of sensor signal with gain)
1.05 V + 1.5 V = 2.55 V (maximum input voltage to node with gain and offset)

Calculated node input over sensor range: 1.5 to 2.55 V

This is a good setting because the node input voltage is within the 0 to 3 V range.

EXAMPLE 2:

Sensor signal range: 0 to 50 mV
Gain setting: 30
Baseline offset range setting: Low-range

Calculations:

50 mV * 30 = 1.5 V (maximum voltage of sensor signal with gain)
1.5 V + 750 mV = 2.25 V (maximum input voltage to node with gain and offset)

Calculated node input over sensor range: 750 mV to 2.25 V

This may be a better setting than in Example 1 because the gain is higher, which could increase the resolution of the measurement. The node input voltage is still within the 0 to 3 V range.

EXAMPLE 3:

Sensor signal range: 0 to 50 mV
Gain setting: 75
Baseline offset range setting: Low-range

Calculations:

50 mV * 75 = 3.75 V (maximum voltage of sensor signal with gain)
3.75 V + 750 mV = 4.5 V (maximum input voltage to node with gain and offset)

Calculated node input over sensor range: 750 mV to 4.5 V

This setting will not work because the node input voltage is outside of the 0 to 3 V range.

8.3 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 Node Commander® software facilitates multiple calibration methods. Calibration calculators for some applications are also available by contacting LORD MicroStrain® Technical Support. *See Technical Support on page 127*.

- **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 Node Commander® 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) and utilizes a calibration wizard in Node Commander®. 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 Node Commander® this can be accomplished by taking sensors readings while applying the known loads.

8.3.1 EXAMPLE: Lab or Field Calibration

The lab and field calibrations use similar methodology. *See Sensor Calibration on page 74*. 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® -LXRS® ,16 bit (65535 A/D values)

CHANNEL TYPE: differential analog input, 0 to 3 V dc input range

SENSOR TYPE: load cell

SENSOR PARAMETERS: application voltage range: +/-20 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 Node Commander®, and establish communication with the gateway and node (*see System Operational Overview on page 13*).
2. Right-click on the node heading and select Configure > Configure Node. Select the check-box for Channel 1, which is where the strain gauge is connected, and then select the Configure button.

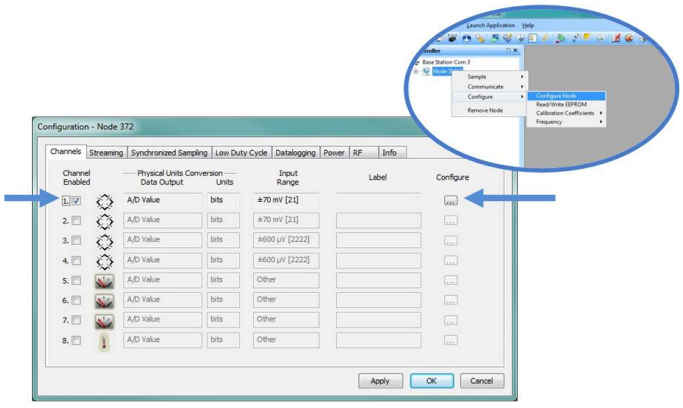


Figure 69 - Node Configuration Menu

LORD MicroStrain® SENSING SYSTEMS

3. Use the following settings (*Figure 70 - Channel Settings*):

    a. **Conversion Coefficients, Class:** A/D value

    b. **Conversion Coefficients, Units:** bits

    c. **PGA Settings, Input Range:** +/-20mV (expected sensor range)

    d. **PGA Setting:** Midscale (for positive and negative going signals)

4. Select the Auto Balance button to tare the no-load value of the strain gauge. Click OK to apply the node settings and exit configuration.

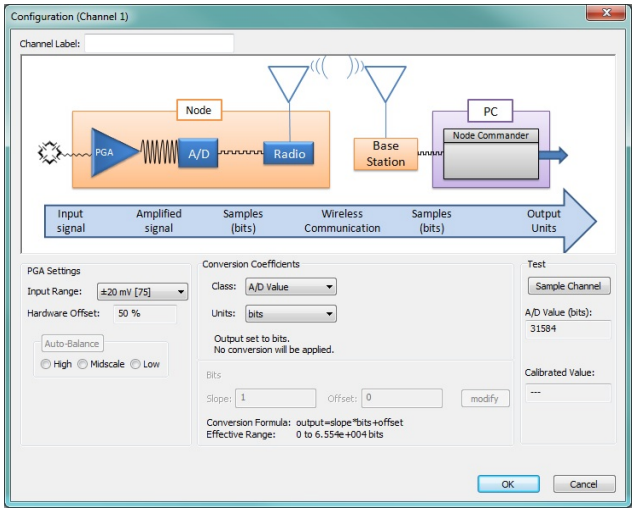


Figure 70 - Channel Settings

5. Right-click on the node heading, and then Sample > Stream > Start.

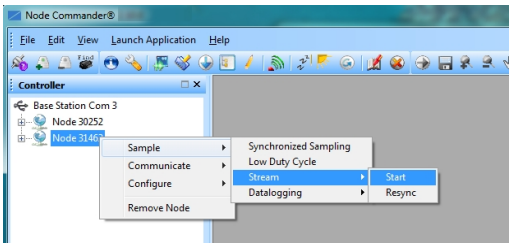


Figure 71 - Start Node Streaming

6. The streaming graph shows the bit output of the channel.

7. Using a calibrated tool (or some other way of applying and measuring a known load) and apply loads to the sensor at a number of intervals over the expected range of use. At each of the calibration intervals, record the applied force and the corresponding sweep value on the y–axis of the graph (the A/D value output of the sensor).

    a. Zoom in and out on the graph by un-checking the Auto Y-Axis Zoom box, and then right clicking on the graph and selecting Zoom In. Draw a box around the desired area to zoom in on.

    b. Adjust the Y-Axis Width from the field next to the Y-Axis Zoom.

    c. End sampling by clicking the red X box on the Streaming Graph tab.

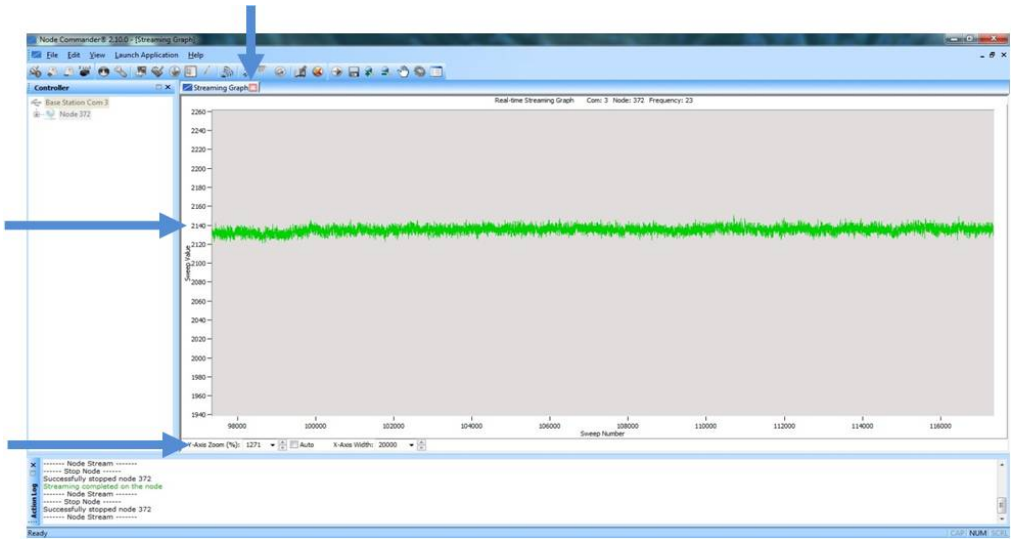


Figure 72 - Node Sampling

8. 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 70*.

9. Return to the Node Configuration screen for the sensor channel, and select the Conversion Coefficients Class and Units, and enter the Slope and Offset values derived in the data analysis program.

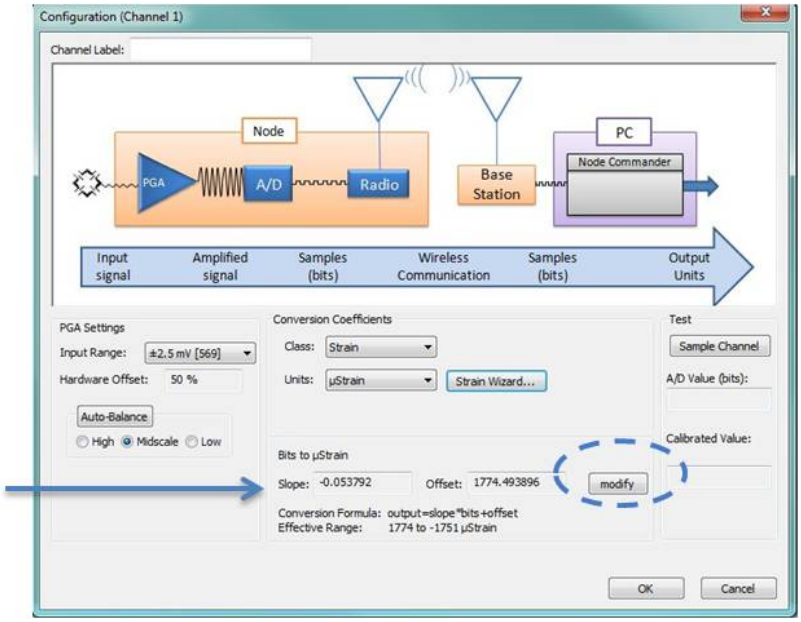


Figure 73 - Enter Calibration Values

10. Save the values, and exit configuration. This is the end of a lab calibration.

11. For field calibrations, bbegin node data streaming again with no load on the sensor.

12. Observe the value in the stream graph. If the stream is not at zero, return to the channel configuration menu, and adjust the offset by increasing or decreasing the value.

13. 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.

8.3.2 EXAMPLE: Internal Shunt Calibration

NODE: V-Link® -LXRS® ,16 bit (65535 A/D values)

CHANNEL TYPE: differential analog input, 0 to 3 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 Node Commander®, and establish communication with the gateway and node. (*See System Operational Overview on page 13*.)

2. Right-click on the node name, and select Configure > Configure Node.

3. Select the check-box for Channel 1, which is where the strain gauge is connected, and then select the Configure button.

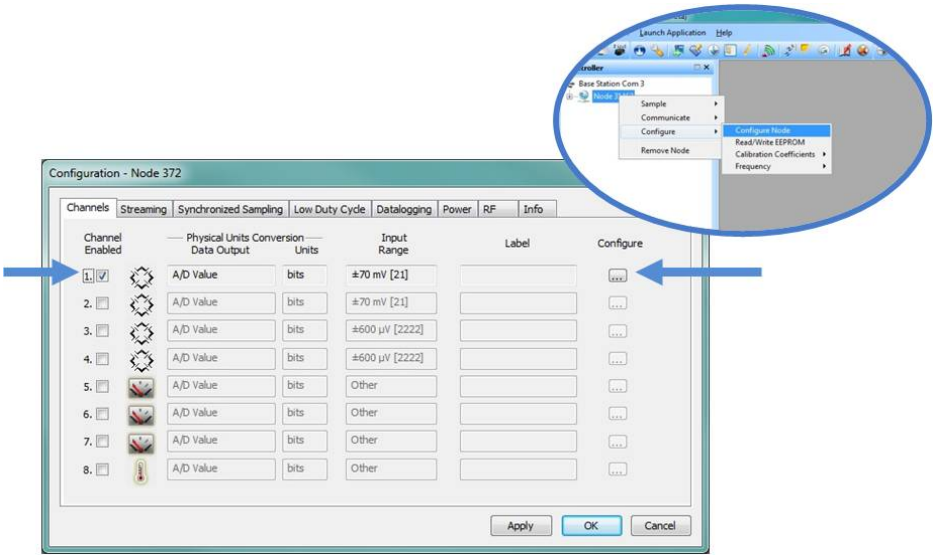


Figure 74 - Node Configuration Menu

4. Use the following settings;

    a. **Conversion Coefficients, Class:** Strain

    b. **Conversion Coefficients, Units:** uStrain

    c. **PGA Settings, Input Range:** +/-2.5 mV (expected sensor range)

    d. **PGA Setting:** Midscale (for positive and negative going signals)

5. Select the Auto Balance button to tare the no-load value of the strain gauge. Observe the value returned for the Auto Balance value.

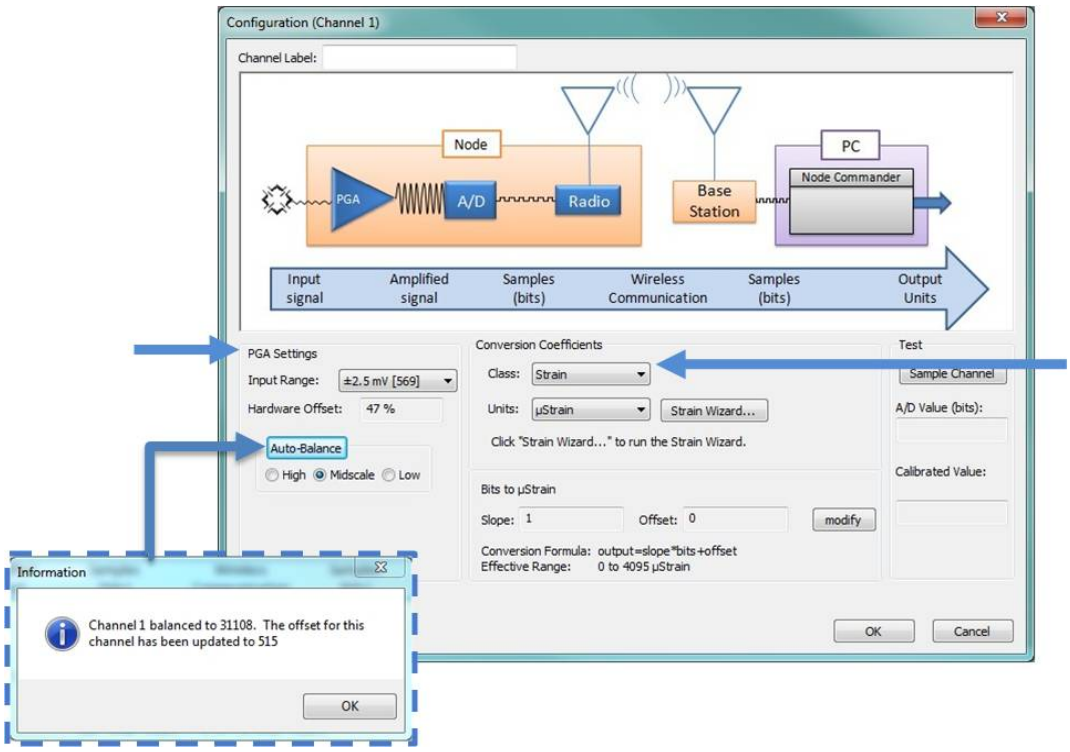


Figure 75 - Channel Settings

6. Select the Strain Wizard.

7. Select the appropriate Bridge Type and click Next.

8. Select Use the Strain Measurement Wizard and click Next.

9. Set the following parameters:

    a. **Number of Active Gauges:** number of a strain elements connected (for example: 4 for a full-bridge, and 2 for a half-bridge)

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

    c. **Gauge Resistance:** Enter the strain gauge ohm value (a gauge specification).

    d. **Shunt Resistance:** 499000 ohms

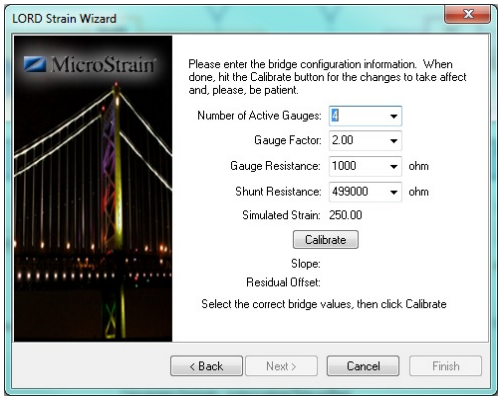


Figure 76 - Strain Wizard Settings

NOTE

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

10. Select Calibrate.

11. Verify the calibration looks as shown in *Figure 77 - Strain Gauge Calibration*. The green line represents the output of the strain gauge. With no load applied it should sit near the Auto Balance baseline value, represented by the red dashed line. During calibration, a shunt resistance (selected on the Parameters page) is applied across the strain bridge, shown by the square pulse on the output. The Offset value, shown with the dashed blue line, is the average output value of the pulse and should sit across the top of the pulse. If the gauge has not had to time to equilibrate before sampling, or if varying environmental factors exist, spikes in the gauge output may occur and affect the Baseline and Offset values. If this occurs, the Offset and Baseline values can be adjusted to clip the spikes in the output values. Adjust them as needed, and select Accept when completed.

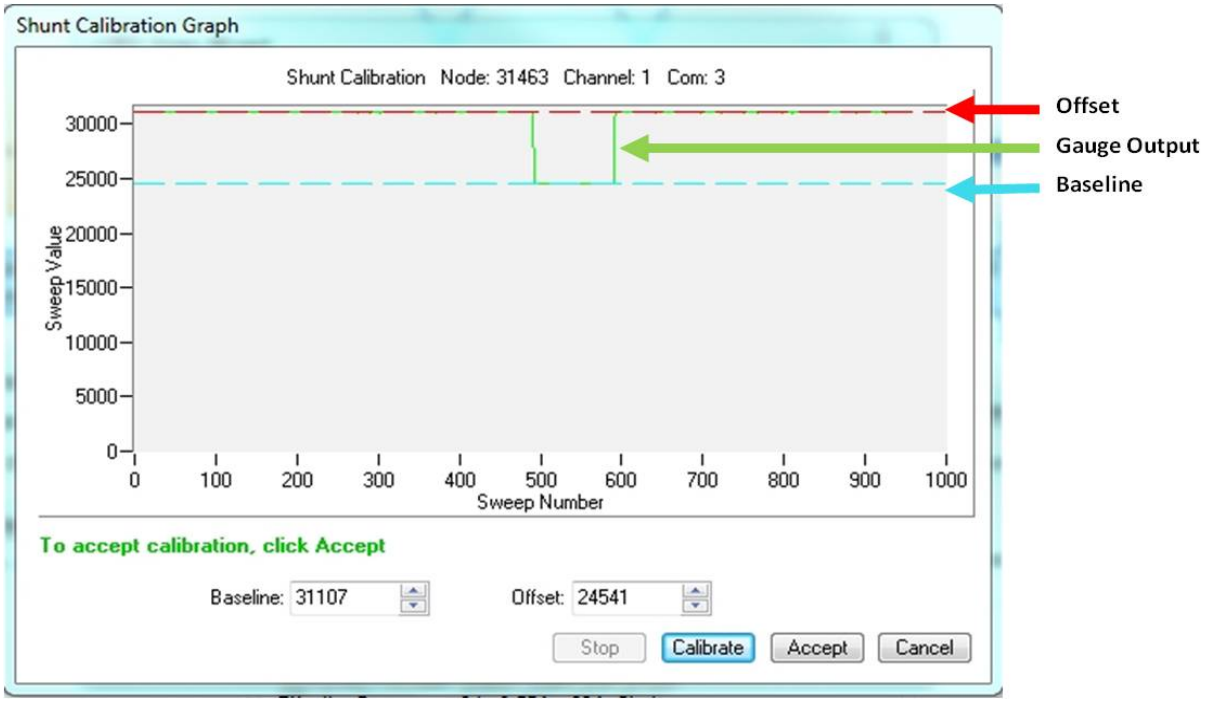


Figure 77 - Strain Gauge Calibration

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

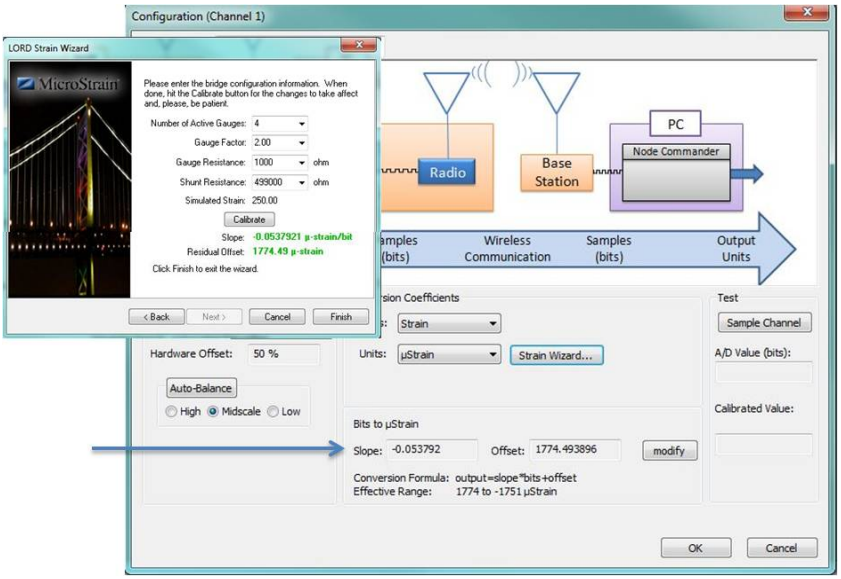


Figure 78 - Completed Strain Wizard

13. Select OK to exit the Channel Configuration window.

14. In the Node Configuration window, select Apply to write the configuration and calibration values to the node.

15. Select OK to exit.

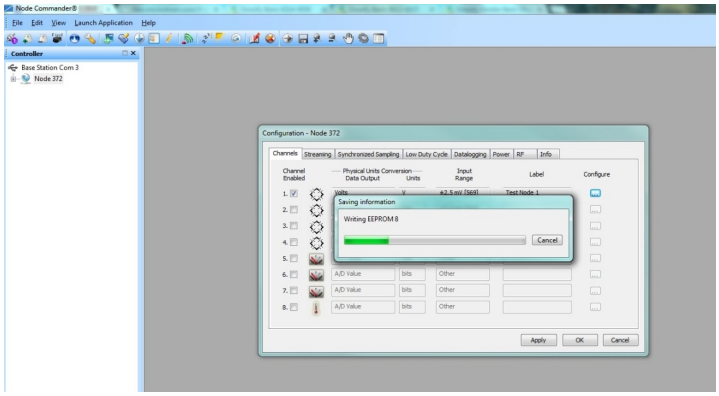


Figure 79 - Apply Node Settings

8.3.3 EXAMPLE: Manufacturer Calibration

NODE: V-Link® -LXRS® ,16 bit (65535 A/D values)

CHANNEL TYPE: differential analog input, 0 to 3 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: 3V supply from the node

DESIRED OUTPUT: engineering units (EU), psi

CALCULATIONS:

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

(3 V/10 V) * 86.07 mV = 25.82 mV

Select a gain and offset scale value appropriate for the sensor. Because the signal is positive going in this example application, the low offset scale will provide the largest range. With the low offset selected, the effective input range of the node is 750 mV to 3 V (2.25 V) (*see Differential Input Gain and Offset on page 72*). Calculate the highest gain possible by dividing the actual input range by the sensor FSO.

2.25 V/25.82 mV = 87

The closest gain setting below optimal gain for a V-Link® -LXRS® is 75 (+/-20 mV). Using a higher gain value would exceed the input voltage capacity of the node when the sensor is at higher pressures. This selection makes sense because the approximate input range designation for a gain of 75 is +/-20 mV (a 40 mV delta minus 10 mV for the low offset), which is close to the FSO range of the sensor.

Multiply the sensor FSO by the gain setting to get the sensor voltage after amplification.

75 * 25.8 2 mV = 1.9365 V

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

1.9365 V/250 psi=3 V/x
(250 psi * 3 V)/1.9365 V = x = 387. 3 psi

The node converts voltage inputs to A/D values. For a 16-bit node, there are 65536 A/D values over the 3 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.

387.3 psi/65536 bits = 0.00591 = 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.

9. Sampling Modes

Node Commander® offers up to four sampling modes: streaming, low duty cycle (LDC), synchronized sampling, and datalogging. Available sampling modes are node specific. Refer to the node specifications for what modes it has.

Synchronized Sampling: Synchronized sampling uses the LORD MicroStrain® LXRS® communication protocol for micro-second time synchronization, lossless data throughput, and predictable network scaling. Wireless nodes synchronize to a common time source to guarantee node sampling within ±32 microseconds of each other. The common time source also allows slotted transmission to avoid over-the-air collisions. Through the use of data buffering, acknowledgments, and retransmissions the nodes are able to achieve lossless data throughput under most conditions.

Synchronized sampling includes many options to facilitate easy data collection. These options include continuous, periodic burst, or event triggered sampling schemes, as well as adjustable sample rates, durations, and datalogging. To learn more about synchronized sampling and the LXRS data protocol *see Synchronized Sampling on page 89*.

Low Duty Cycle: LDC mode is used in applications which require a low sample rate or low latency. Features include configurable sample rate and duration, event based sampling, datalogging, and data arrival time stamping (*see Low Duty Cycle on page 94*).

Datalogging: Datalogging used for saving data to internal node memory for future retrieval. Features include adjustable sample rates, duration, multiple node triggering, and time stamping (*see Datalogging on page 96*).

Streaming: Streaming is a general purpose sampling mode with very little latency between sampling and the data display. Sampling rates are automatic, although duration is configurable. Streaming mode does not support time stamping and is considered a legacy feature (*see Streaming on page 98*).

Within the sampling modes, data is sampled either continuously, in period bursts, or in reaction to a reading threshold (event-based). Availability of these options vary between sampling modes and node models. The node specifications describe the available options, and the range of sampling rates for each across sampling modes. Sampling mode options are included in the following descriptions.

Continuous sampling- With continuous sampling, samples will be taken at the set sample rate for a set amount of time or until stopped. Used in LDC, streaming, datalogging, and synchronized sampling modes.

Periodic burst sampling - In burst sampling the node samples at the set sample rate in a fixed window of time (burst), and then repeats that window at set sampling intervals. The burst duration and time between bursts is configurable. Burst sampling continues until stopped. Only available with synchronized sampling.

Event-based sampling - samples continuously while evaluating the data for a user-configured sensor measurement value (threshold). When detected the data will be saved with pre and post-event data, as defined in the event-based sampling settings. Available in synchronized sampling and LDC modes.

Sampling settings are accessed through the Configure Node menu. There is a tab for each sampling mode.

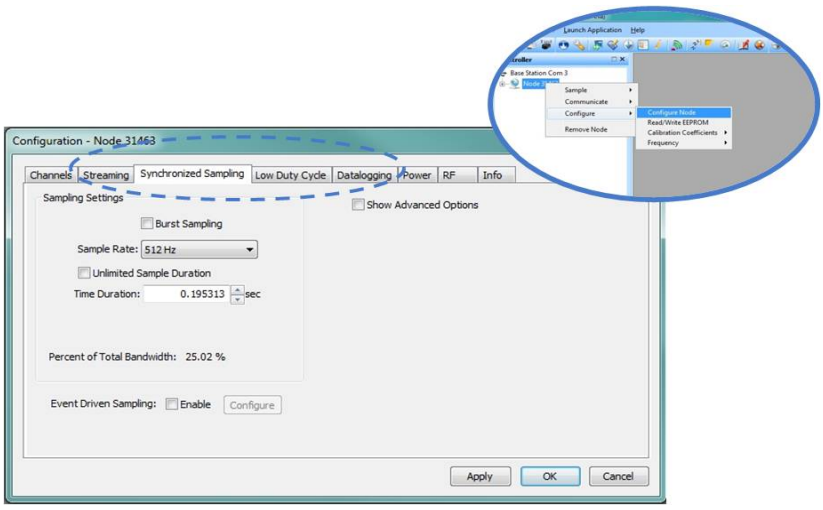


Figure 80 - Sample Settings Menu

9.1 Synchronized Sampling

Synchronized sampling should be used when sample synchronization between nodes, network scalability, or data loss prevention are critical to the application. The following describes these main features of synchronized sampling.

Synchronization: Node to node synchronization is achieved through the use of a beacon. During synchronized sampling, the gateway broadcasts a beacon packet containing a Coordinated Universal Time (UTC) timestamp once per second. Nodes within the network periodically synchronize to this beacon in order to maintain node-to-node timing within ±32 us. Between synchronizations timing is maintained by a node-based, temperature compensated real-time-clock, with drift rate of ±3 ppm. Sampled data is timestamped on the node in order to retain the absolute timing of its measurement. For information about other available gateway timing sources *see Time Sources and Stamping on page 99*.

Scalability: Nodes with similar or differing configurations may be included together in an LXRS® network. Within synchronized sampling networks, time division multiple access (TDMA) is utilized to avoid data packet collisions during radio transmission. Nodes are allocated time slots based on the amount of data required to be transmitted, which is calculated from settings such as sample rate, number of sensor channels, and data type. Time slot allocation information is written to the nodes prior to sampling and determines how many nodes can be on the network. To check the capacity of a network based on these settings, use the online network bandwidth calculator:

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

Lossless: Nodes achieve lossless wireless communication during synchronized sampling through the use of data buffering, acknowledgments, and retransmissions. Measured data and time stamps are cached in a circular buffer on the node. The cache memory is a stand-alone 256 KB RAM (may be larger for some node models) that is separate from the flash storage used for long term data logging. It can hold up to 100 K samples in standard bit format, or 50 K samples in floating point format (see *Figure 82 - Synchronized Sampling Settings*, Packet Formats setting (item f)). The data is transmitted in a first in/first out sequence within its allotted time slots. Data packets are acknowledged by the beaconing gateway. If acknowledgment is not received, the data packet is retransmitted in the next time slot. Nodes are allocated enough radio bandwidth to allow recovery from environments with up to 20% or more packet loss. Follow best practices to optimize radio transmissions links (*see Range Test on page 56*, and node and gateway user manuals for more detailed information).

Auto-sleep: An optional auto-sleep feature allows nodes to save power when the beacon is removed. When enabled, nodes will auto-sleep after the beacon is lost for a configured amount of time. In auto-sleep the node saves power, and will rejoin the network within 2 minutes of the beacon returning. Refer to *Figure 82 - Synchronized Sampling Settings*, Beacon Lost Timeout setting (item g).

Latency: In order to achieve lossless data throughput during synchronized sampling, non-deterministic latency is introduced between sampling and data collection and display. During normal operation when data packets are not being cached at a rate that exceed the capacity of the data buffer, latency in synchronized sampling will be less than 1 second (up to 16 seconds in high capacity mode - *see Synchronized Sampling Data Acquisition on page 101*). However, if there are many transmission acknowledgment errors (as when there are RF range integrity problems, including beacon loss, and a lot of data packets are being saved and retransmitted) latency will increase. If the application requires very low latency, Low Duty Cycle (LDC) sampling should be considered.

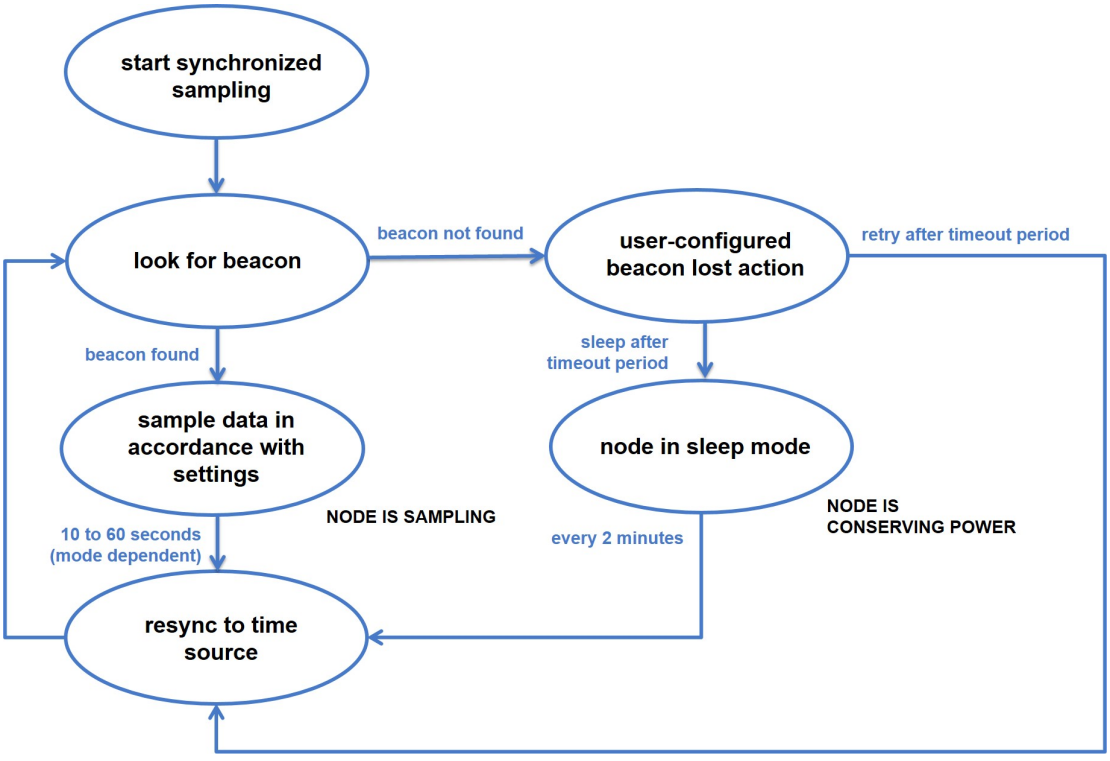


Figure 81 - Synchronized Sampling Sequence

To adjust synchronized sampling settings, open the node configuration menu by right clicking on the node name and then selecting Configure > Configure Node. Select the Synchronized Sampling tab. Key menu options include the burst and event based sampling features (*Figure 82 - Synchronized Sampling Settings*).

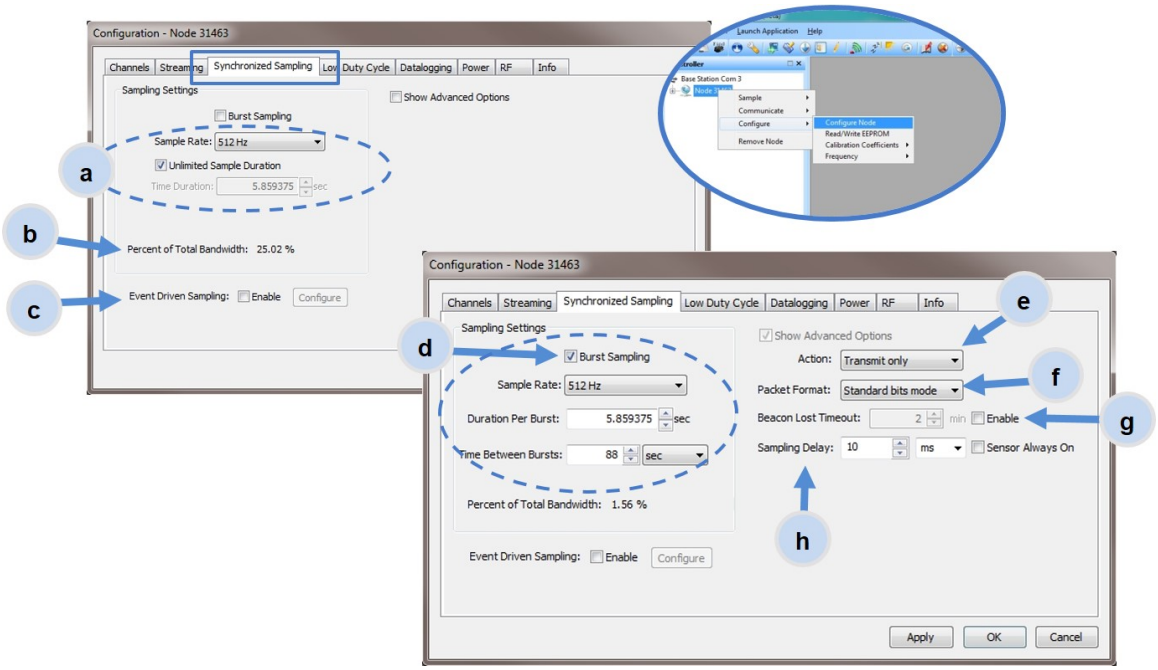


Figure 82 - Synchronized Sampling Settings

a. **Sampling settings:** Sampling can be set to repeat for a fixed interval of time after the sampling has started, or continuously until a stop command is sent. Only appropriate settings combinations will be available in the sampling settings selections (per the node specifications and bandwidth limitations).

b. **Percentage of Total Bandwidth:** as the sampling settings are adjusted the used network bandwidth is calculated and displayed.

c. **Event Driven Sampling:** the data will be continuously sampled but only recorded or transmitted when it meets the event criteria. *See Event Driven Sampling on page 97*.

d. **Burst sampling:** In periodic burst sampling, the duration of the burst and time between bursts is configurable. The sampling repeat interval is limited to one day.

When the Show Advanced Options check-box is selected several new menu options appear:

e. **Action:** configures the node to store sampled data in the node memory (log), to log the sampled data and transmit it to the gateway, or to only transmit it.

f. **Packet Format:** There are two options for packet format; standard bits mode and floating point mode.

Packet Format	Data Bytes Used	Data Description
Floating Point	4	Data sent in engineering units selected during channel configuration using applicable conversion values and formula.
Standard Bits	2	Data sent in digital bit format (A to D values), units conversion coefficients applied during post processing. Uses half the bandwidth of floating point mode and is recommended for high sample rate or data intensive applications.

Table 6 - Packet Formats

g. **Beacon Lost Timeout:** sets what the node will do when the beacon is lost. If enabled, the node will go into a low-power state when the beacon has been lost and the timeout period expired. While in this state it will periodically (every 2 minutes) check for the beacon. If found the node will resynchronized and resume sampling.

If not enabled, the node will continue sampling after the beacon is lost, and store the data in a cache in node memory. When the cache is full, the oldest data will be dropped and new data will take its place. Once the beacon is restored that data will be transmitted oldest to newest.

h. **Sampling Delay:** To to save power, at sample rates under 32 Hz the node automatically turns the sensor excitation off when not sampling. The sampling delay is used in applications where the sensor being sampled requires a warm-up period before the sample is taken. The delay sets the time that the node excitation voltage will be turned on before the sample is taken. With sample rates higher than 32 Hz the excitation voltage is always be on and this setting is not applicable.

9.1.1 Using the Beacon

Nodes must be on the same transmission frequency (channel) as the gateway to receive the beacon broadcast command. When the beacon is active, the gateway device status indicator will pulse blue once per second. When the nodes connected to the gateway are in synchronized sampling mode, the network can be put to sleep by turning off the beacon and then resuming transmitting once the beacon is enabled. Any node that is actively sampling in synchronized sampling mode on the same frequency as the gateway will synchronize to it automatically if the beacon is activated.

To avoid interference with other devices it is recommended that the beacon be disabled when not in use. Do not operate multiple gateways on the same frequency.

Alternately, the beacon can be activated from the synchronized sampling window when sampling is started, and stopped with the stop node command which can be executed when sampling is ended (*see Synchronized Sampling Data Acquisition on page 101* and *see Ending Sampling Sessions on page 114*).

9.1.2 Synchronized Sampling with Multiple Gateways

If synchronization is desired between gateways, it is recommended that a WSDA® -1500 - LXRS® gateway be used because they can be configured to reference external time sources and therefore get periodic same time updates. WSDA® - Base - 10*x* - LXRS® gateways do not have this feature and instead rely on the internal clock (which can vary between gateways). For more information refer to the WSDA® -1500 - LXRS® User Manual.

9.2 Low Duty Cycle

Low duty cycle (LDC) sampling is used for sampling at 512 Hz and below when low latency is critical to the application. LDC mode utilizes carrier sense multiple access (CSMA) for transmitted data collision avoidance. Data packet loss is still possible as the network size, sampling frequencies, and packet size are increased. Packet loss statistics are available in the data acquisition display (*see Low Duty Cycle Data Sampling on page 106*) and can be reduced by optimizing the RF operating environment and conducting a range test (*see Range Test on page 56*). Large networks can also be divided in to smaller networks operating on different frequencies.

In LDC mode, many sample settings are user-adjustable. To adjust low duty sample settings, open the node configuration menu by right clicking on the node name and then selecting Configure > Configure Node. Select the Low Duty Cycle tab.

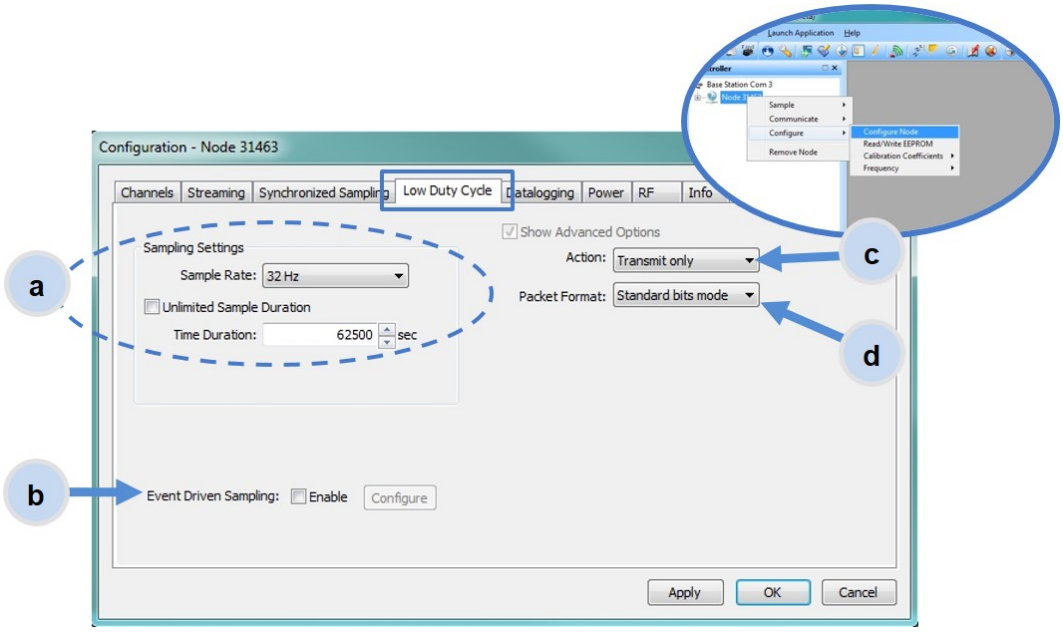


Figure 83 - Low Duty Cycle Settings

a. **Sampling settings:** The sampling can be set to repeat for a fixed interval of time after the sampling has started, or continuously until a stop command is sent. Only appropriate settings combinations will be available in the sampling settings selections (per the node specifications and bandwidth limitations).

b. **Event Driven Sampling:** the data will be continuously sampled but only recorded when it meets the event criteria. *See Event Driven Sampling on page 97*.

When the Show Advanced Options check-box is selected several new menu options appear:

c. **Action:** configures the node to store sampled data in the node memory (log), to log the sampled data and transmit it to the gateway, or to only transmit it.

d. **Packet Format:** There are two options for packet format; standard bits mode and floating point mode.

Packet Format	Data Bytes Used	Data Description
Floating Point	4	Data sent in engineering units selected during channel configuration using applicable conversion values and formula.
Standard Bits	2	Data sent in digital bit format (A to D values), units conversion coefficients applied during post processing. Uses half the bandwidth of floating point mode and is recommended for high sample rate or data intensive applications.

Table 7 - Packet Formats

9.3 Datalogging

Use this mode when high sample rates are required, and immediate data access are not critical to the application.

In datalogging mode, sampled readings are stored in the node memory instead of being transmitted to the gateway during sampling. The sample rate is adjustable, and sampling can be set to repeat for a fixed interval of time after the sampling has been started or continuously until a stop command is sent. If the node is set to sample continuously, it will do so until the node memory is full and then stop. The data is not transmitted to the gateway until the download command is initiated from the gateway menu (*see Armed Datalogging on page 109*).

To adjust datalogging settings, open the node configuration menu by right clicking on the node name and then selecting Configure > Configure Node. Select the Datalogging tab.

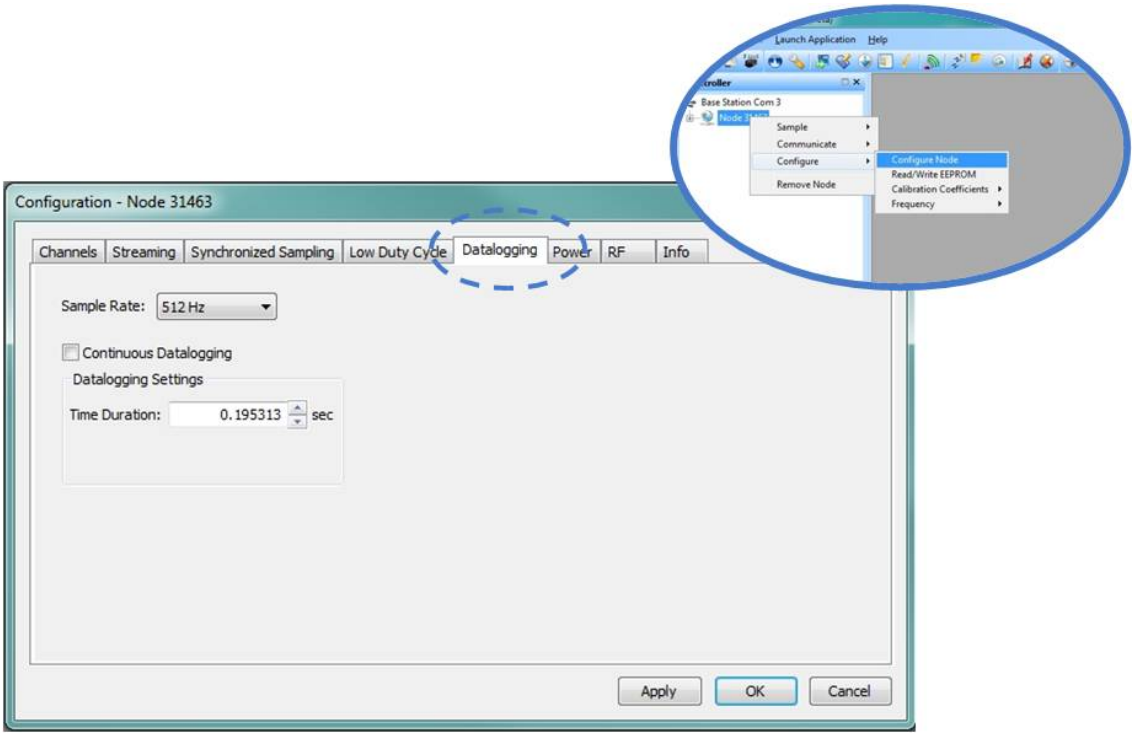


Figure 84 - Datalogging Settings

9.4 Event Driven Sampling

Event driven sampling is available in both the low duty cycle and synchronized sampling modes. In either mode the node is still taking continuous measurements based on the sample rate and duration settings, however it only reports the measurement that meet the event criteria. The node can be configured to also transmit the data just before and just after the event. The pre and post event duration settings define the window of time before and after the event that will be reported.

The event triggers are set for each channel in the form of a voltage threshold. The trigger occurs when the channel reading is either above or below the threshold, depending on the trigger operation settling.

The event driven sampling menus are accessed through the node configuration menu. Right click on the node name and then select Configure > Configure Node. Select the desired sampling mode (synchronized sampling or low duty cycle) and then select the Event Driven Sampling check box, or the Configure button if the check box is already selected. The Configure Event Driven Sampling menu will appear.

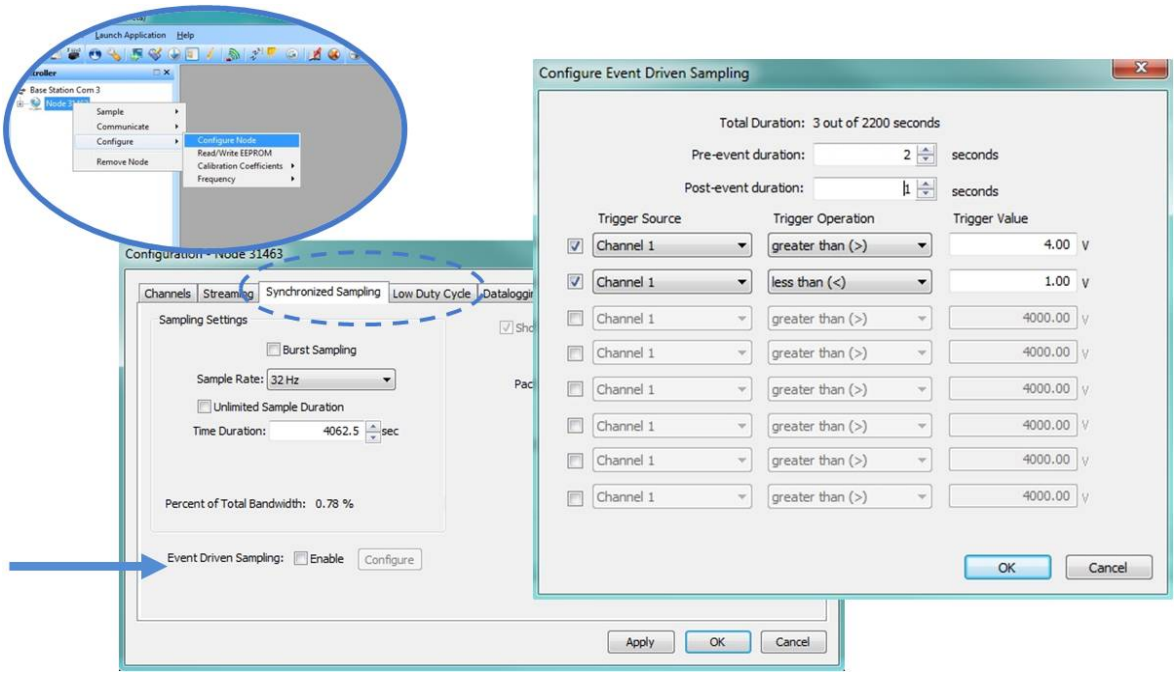


Figure 85 - Event Based Sampling Settings

9.5 Streaming

In streaming mode, sample rates are automatic, based on the number of active channels. *Table 8 - Streaming Sample Rates* describes the automatic settings. Sampling can be set to repeat for a fixed interval of time after the sampling has been started or continuously until a stop command is sent. The data is transmitted continuously during sampling, and none is saved to the node memory. It is saved on the host computer in a data file.

Active Channels	Sample Rate (samples/sec)
1	736
2	679
3	617
4	565
5	520
6	485
7	452
8	424

Table 8 - Streaming Sample Rates

To adjust streaming sample settings, open the node configuration menu by right clicking on the node name and then selecting Configure > Configure Node. Select the Streaming tab.

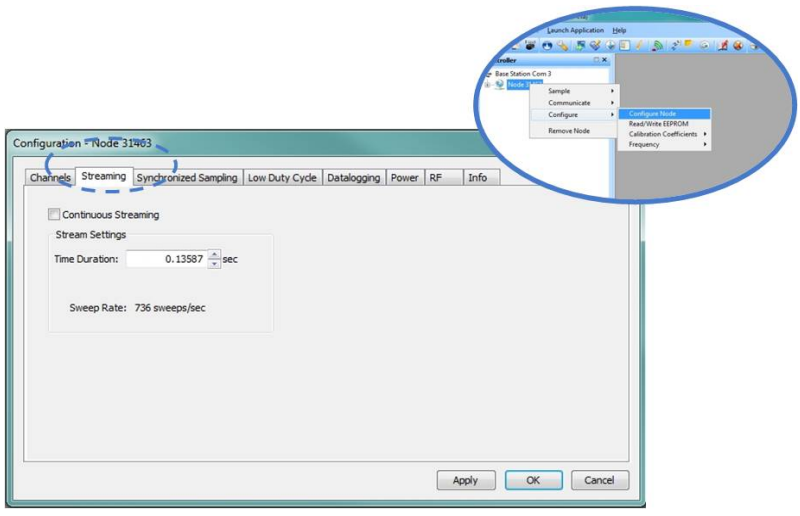


Figure 86 - Streaming Settings

9.6 Time Sources and Stamping

A time stamp is attached to the sensor data packets to indicate what time a sample was taken. Each sampling mode handles time stamping differently.

Synchronized Sampling: Synchronized sampling has the most accurate sample timing scheme. The time stamp is obtained from the host computer when sampling is started. Each sample is then incrementally stamped from the precision real time clock inside the node (+/- 3 ppm) before it is sent to the gateway. As a result, node-to-node timing accuracy is guaranteed to be within +/-32 microseconds. For more information *see Using the Beacon on page 93*.

Low Duty Cycle: For sample rates under 1 Hz, samples are stamped when the data arrives at the host computer after sampling and transmission. For sample rates over 1 Hz, a time stamp is obtained from the host computer when sampling is started, and the time stamp for each subsequent sample is then calculated from the sample rate.

Datalogging: A time stamp is obtained from the host computer when sampling is started. The time stamp for each subsequent sample is then calculated from the sample rate.

Streaming: No time stamp is used in streaming mode.

NOTE

Absolute time accuracy of timestamps are dependent on the accuracy of the time on the host computer at the initialization. For applications that require absolute accuracy, use the network-ready WSDA® -1500 - LXRS® gateway for data acquisition, as there are several time source options that are available . They include using network-based time servers, manual user entry, or an attached Global Positioning System (GPS) device. Refer to the WSDA® -1500 - LXRS® User Manual for details.

10. Data Acquisition

During data acquisition, one sampling mode is chosen for each node. Nodes connected to the same gateway can sample in different modes, however each node can only run one sampling mode at a time. The sampling settings for the node will be applied to all channels. *See Sampling Modes on page 87* for information about the sampling settings.

Nodes can continue to sample even without Node Commander® running or actively displaying data. *See Ending Sampling Sessions on page 114*.

All modes automatically save data to the host computer. *See Sensor Data Files on page 117*.

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. To resume viewing data acquisition after the sampling window has been closed, use Monitor Mode (found in the gateway menu).

NOTE

A maximum file space allocation is set in Node Commander to avoid filling the data acquisition computer's memory in high sample rate or otherwise data intensive applications. Once the limit is reached data will no longer be saved on the computer. *See Software Preferences on page 12*. Alternatively, port data automatically to SensorCloud™ with a WSDA® -1500 - LXRS® gateway for unlimited online cloud storage (*see Data Handling on page 23*).

NOTE

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

10.1 Synchronized Sampling 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 87 - Starting a Sampling Session*).

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.

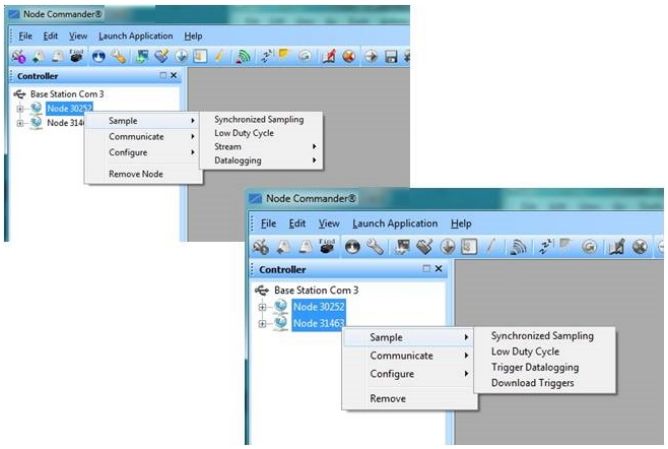


Figure 87 - Starting a Sampling Session

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 88 - 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 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.

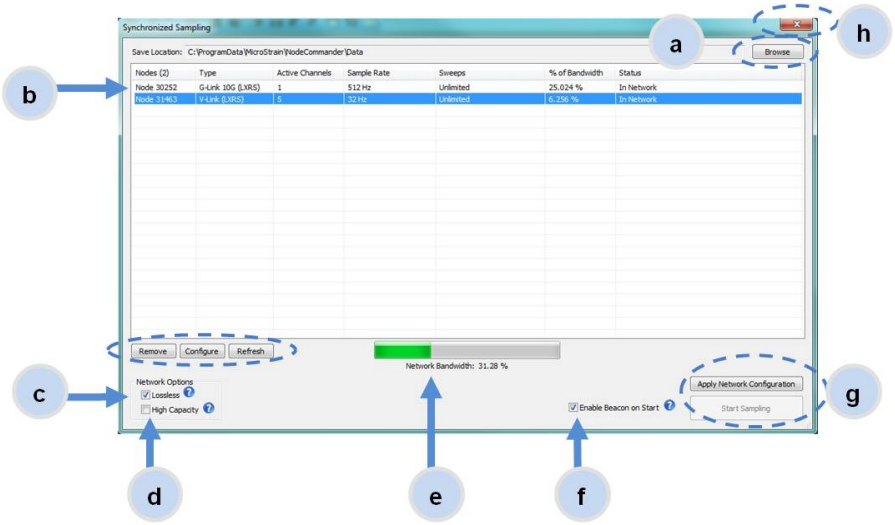


Figure 88 - Synchronized Sampling Menu

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 For more information *see Using the Beacon on page 93*.

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 89 - Synchronized Sampling Data View*).

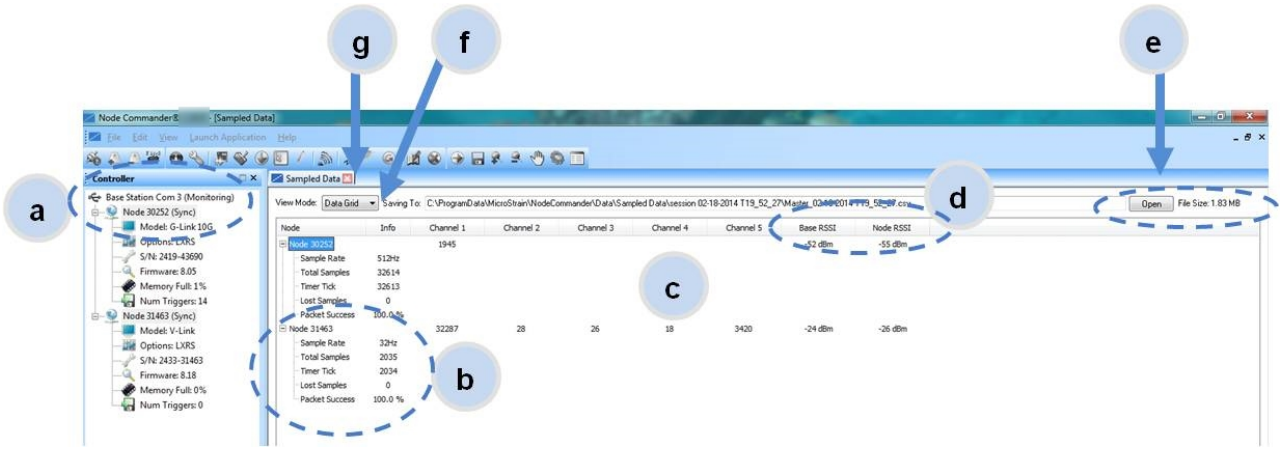


Figure 89 - Synchronized Sampling Data View

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 56*.

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. *See Ending Sampling Sessions on page 114*.

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 104*). Click on the node name to view the graph for that node. Click again to hide it.

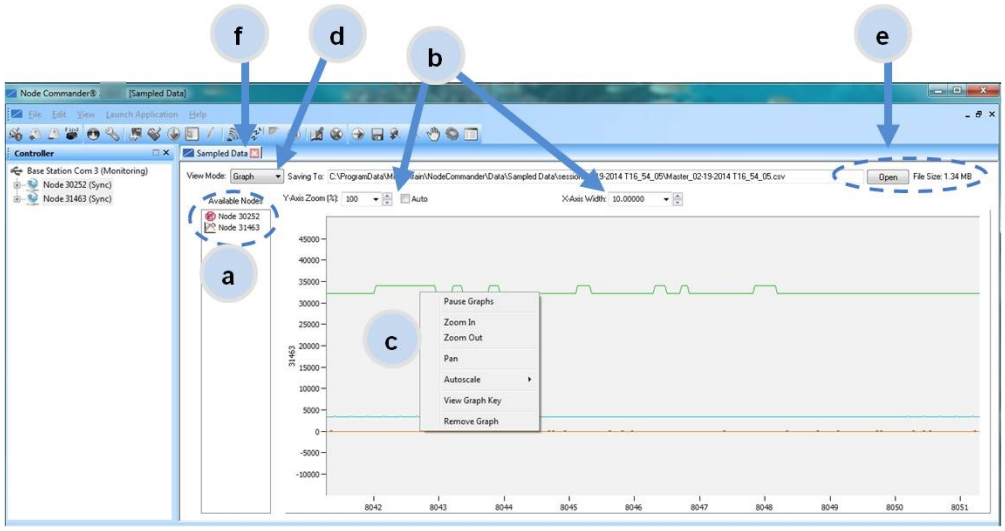


Figure 90 - Synchronized Sampling Graph View

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.

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. *See Ending Sampling Sessions on page 114*.

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®.

10.2 Low Duty Cycle Data Sampling

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 > Low Duty Cycle.

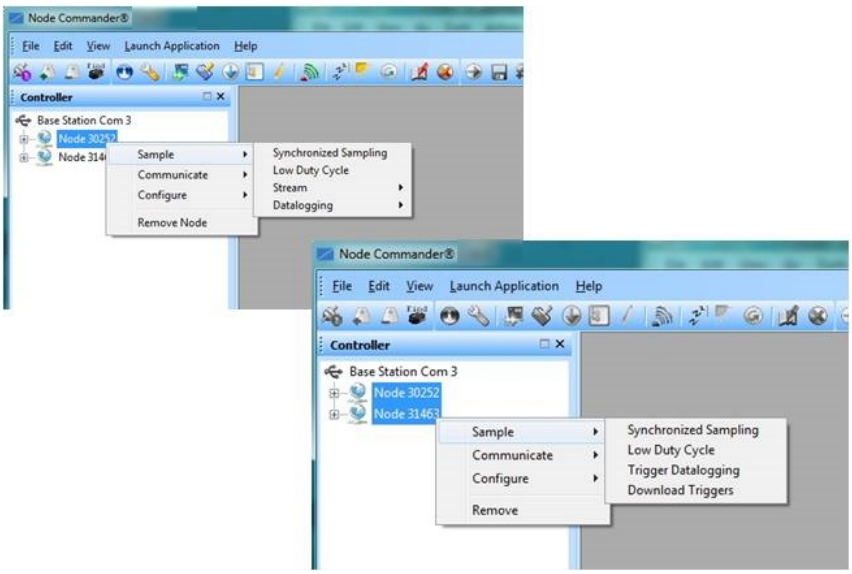


Figure 91 - Starting a Sampling Session

The Low Duty Cycle sampling window features two data views; a grid view and a graph view. The data grid view is the default view when sampling is started. *Figure 92 - Low Duty Cycle Data Grid View* shows the indicators and options in the grid view.

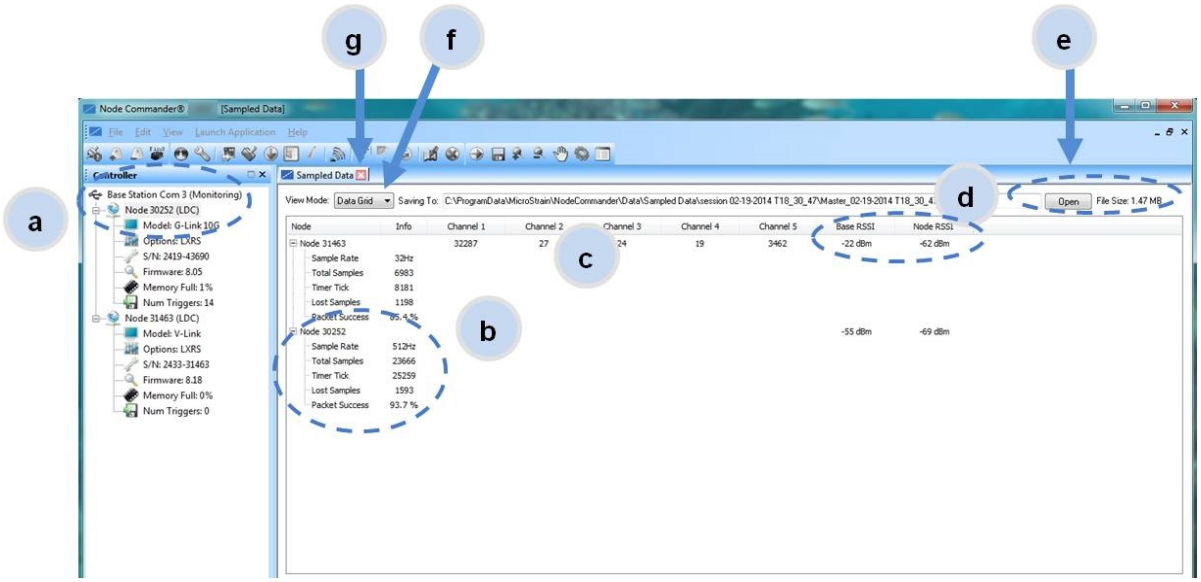


Figure 92 - Low Duty Cycle Data Grid View

a. **Device status:** Node sampling mode and gateway status are displayed in parentheses next to the device name. When the node is sampling, the gateway will display "Monitoring", and the node will display "LDC" for Low Duty Cycle. Right-click on the node name in this window to start a new sampling data file.

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

c. **Data:** displays the sampled data; each channel is in a column

d. **Radio strength:** indicates how good the communication is between the gateway and node. For more information *see Range Test on page 56*.

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. *See Ending Sampling Sessions on page 114*

Use the view menu to select the Graph view of the data (*Figure 93 - Low Duty Cycle Graph View*). Click on the node name to view the graph for that node. Click again to hide it.

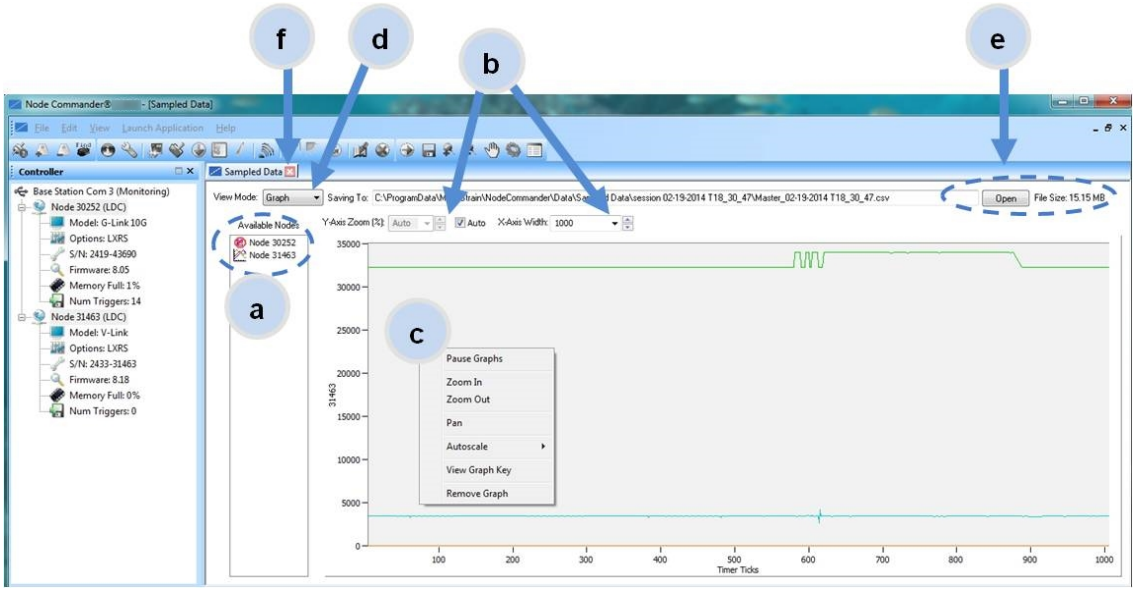


Figure 93 - Low Duty Cycle Graph View

a. **Available nodes:** Click on the node name 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 (saves current data).

b. **Axis range:** Select the X-axis width and Y-axis zoom percentage, or used the Auto check box for automatic scaling.

c. **Graph:** The node graph shows the sampled data. Each active channel is displayed as a different color. The X-axis is time in seconds and the Y-axis in 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.

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. *See Ending Sampling Sessions on page 114*

10.3 Armed Datalogging

Datalogging is initiated (armed) by opening a trigger session in Node Commander®. Datalogging settings are selected in the node configuration menu and can vary between nodes (*see Datalogging on page 96*).

1. Right click on one node or multiple node selections and select Sample > Datalogging > Trigger Session or Trigger Datalogging, depending if there is one or multiple nodes selected.

2. The selected nodes will appear in the Armed Datalogging window. The gateway will send a Ping command to each node. The Status column will indicate if the ping was successful, meaning the node is communicating with the gateway and ready for data acquisition.

3. Enter a note for the data file, if desired.

4. Select Trigger All to begin data acquisition.

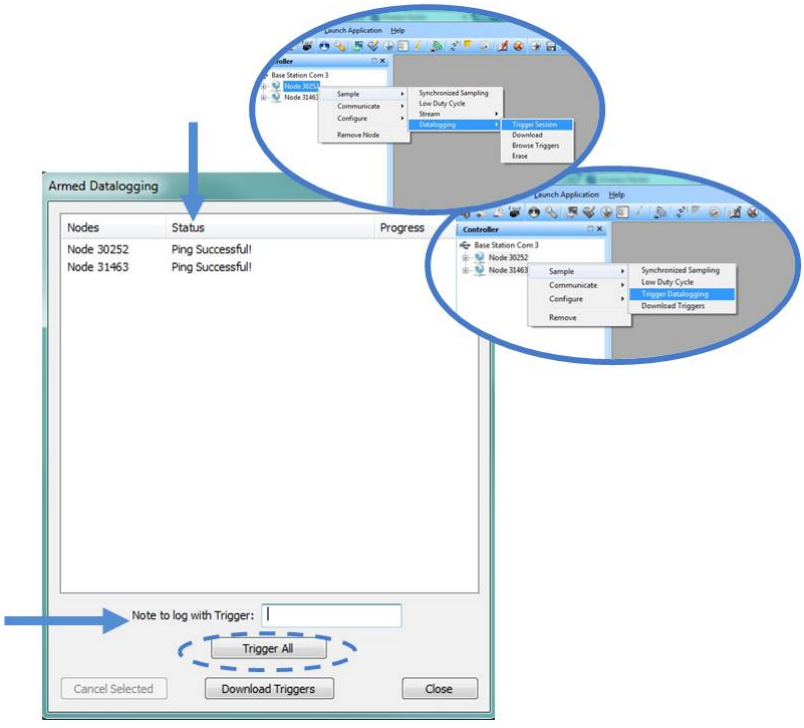


Figure 94 - Datalogging Menu

5. The Progress column will indicate the percentage of sampling that has occurred. When it reaches 100%, data acquisition is complete. At any time during the data acquisition, one or all nodes can be stopped by selecting the Cancel Selected or Broadcast Stop All button. This stops the data acquisition process and sets the node back in idle. Alternatively, the Close button can be used to close the datalogging window without ending the data acquisition. Data acquisition will continue until done or until a stop command is sent to the node.

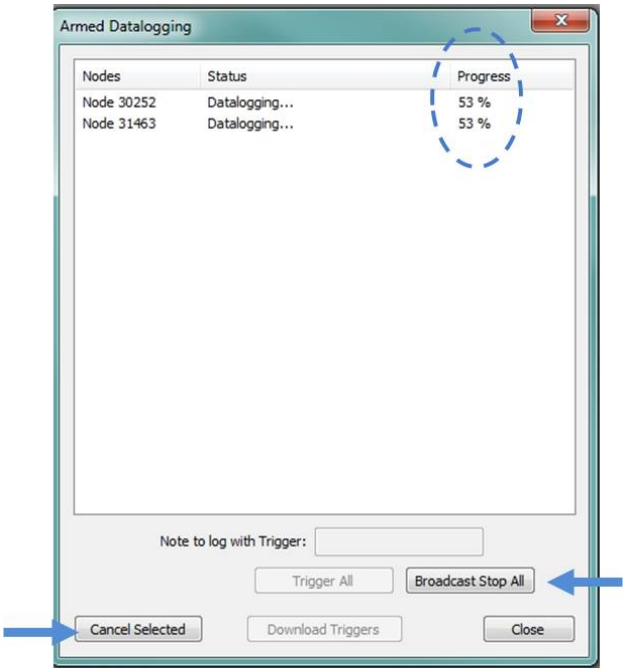


Figure 95 - Datalogging

NOTE

Depending on datalogging settings for each node, data acquisition may take longer to complete on some nodes than others. The Close button can be used to close the datalogging window without stopping the data acquisition. The Close Selected or Broadcast Stop All buttons are used to stop data acquisition on one, or all nodes.

6. Once the datalogging menu is closed, the nodes that have acquired data will automatically display the node information in the Controller window. The Memory Percent Full indicates the percentage of memory that has been used for datalogging. Number of Triggers indicates how many datalogging files have been created.

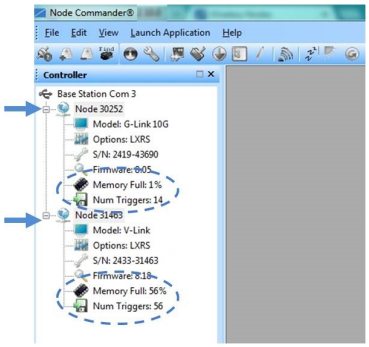


Figure 96 - Node Memory Statistics

7. To download the datalogging files off of the node onto the host computer, right click on a node name, or group of nodes, and select either Sample > Datalogging > Download or Sample > Download Triggers.

8. In the Download Triggers menu, select the node or nodes, and the Start Download button.

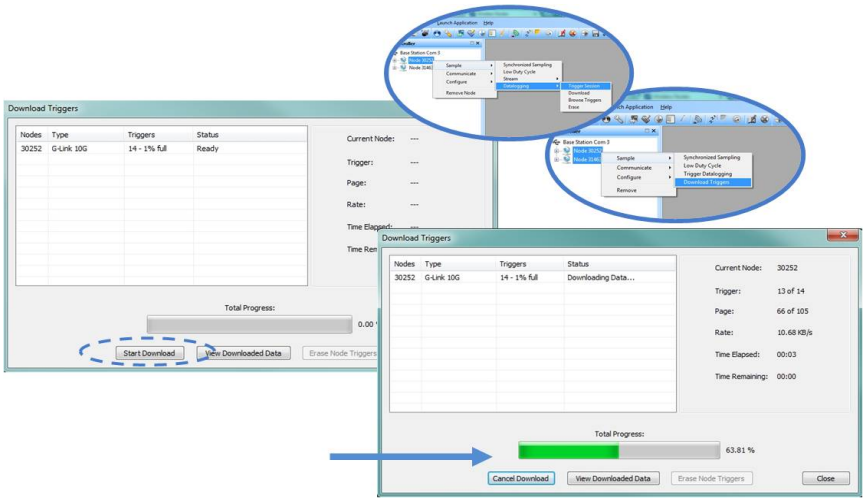


Figure 97 - Datalogging File Download

The data that is stored in the node memory can be erased from the download window or from the node menu. The erase selection is only available in the node menu when selecting just one node at a time. Right click on the node name, and select Sample > Datalogging > Erase.

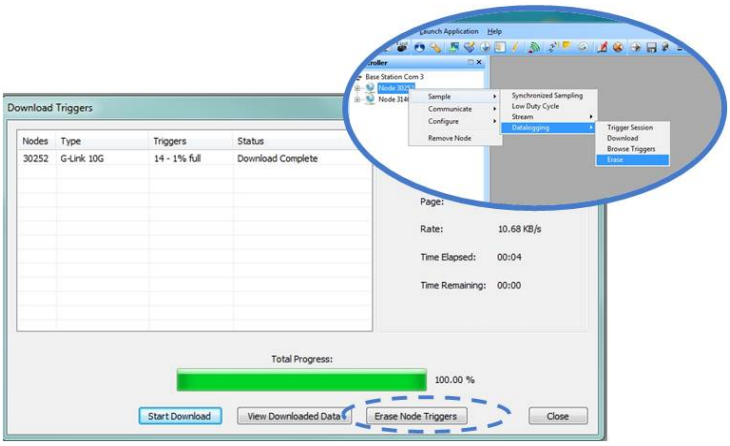


Figure 98 - Erase Node Memory

Data can be viewed from the download window, or from the node menu. The view triggers selection is only available in the node menu when selecting just one node at a time. Right click on the node name, and select Sample > Datalogging > Browse Triggers. Browse to the desired files to open. The data files are in CSV format.

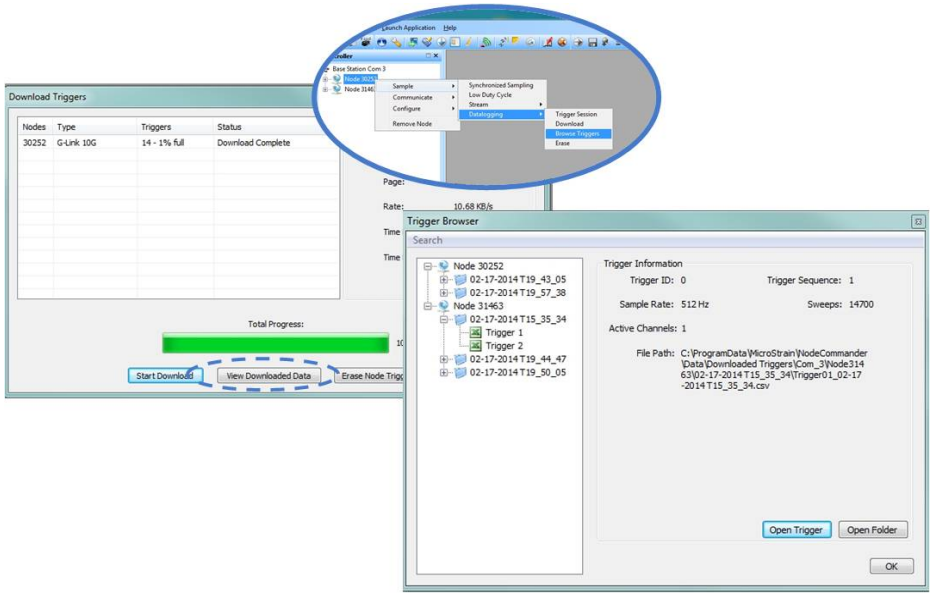


Figure 99 - View Downloaded Data

LORD MicroStrain® SENSING SYSTEMS

10.4 Streaming Data

Streaming may only be initiated on one node at a time. To start a streaming data session, right click on the node name in the Controller window and select Sample > Stream > Start. The Resync menu option is used to resume viewing a streaming session that is already running.

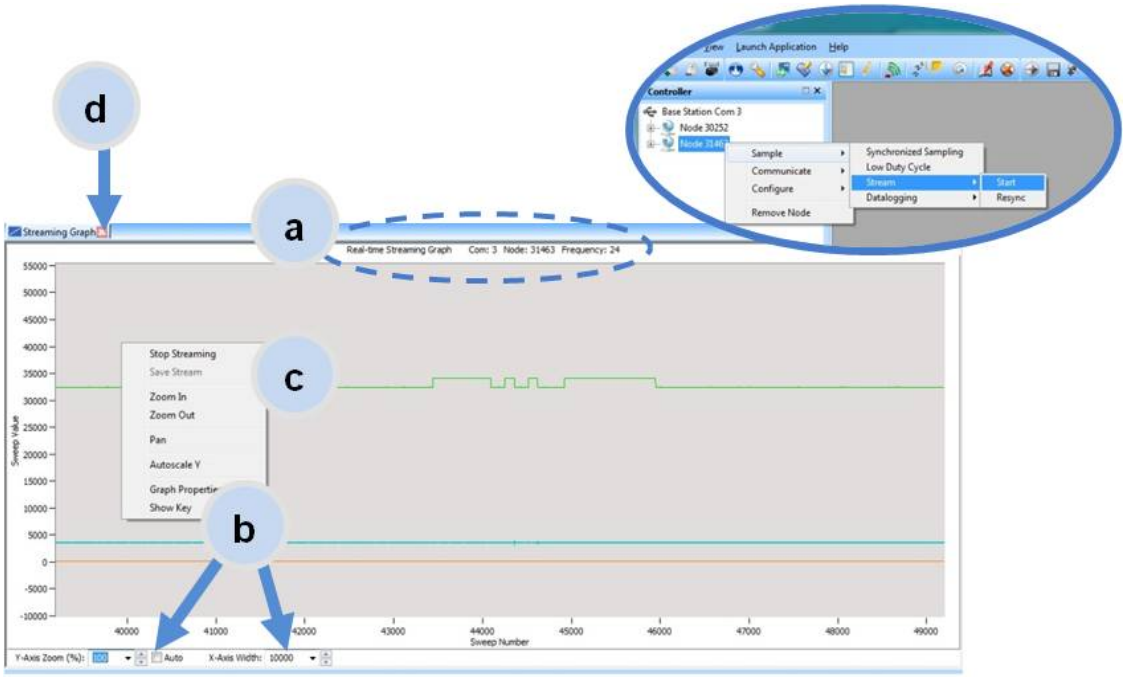


Figure 100 - Streaming Data Graph

a. **Node information:** displays the node serial number, frequency,and communications port.

b. **Axis range:** select the X-axis width and Y-axis zoom percentage, or used the Auto check box for automatic scaling.

c. **Graph:** the node graph shows the sampled data. Each active channel is displayed as a different color. The X-axis is time in seconds and the Y-axis in the A/D value (bits). Right click on the graph for additional menu options such as show key, pan, zoom, and stop streaming.

d. **End sampling:** the red "X" is used to exit the sampling window and/or end sampling. *See Ending Sampling Sessions on page 114*.

10.5 Ending Sampling Sessions

There are multiple ways to end sampling sessions. Some end the session and stop the sampling, while other methods just end the session and allow the node to continue sampling.

1. **Exit the data view window:** Click the red "X" in the upper right of the data sampling or datalogging window. This option is used to continue sampling after Node Commander® is closed, or to end sampling.

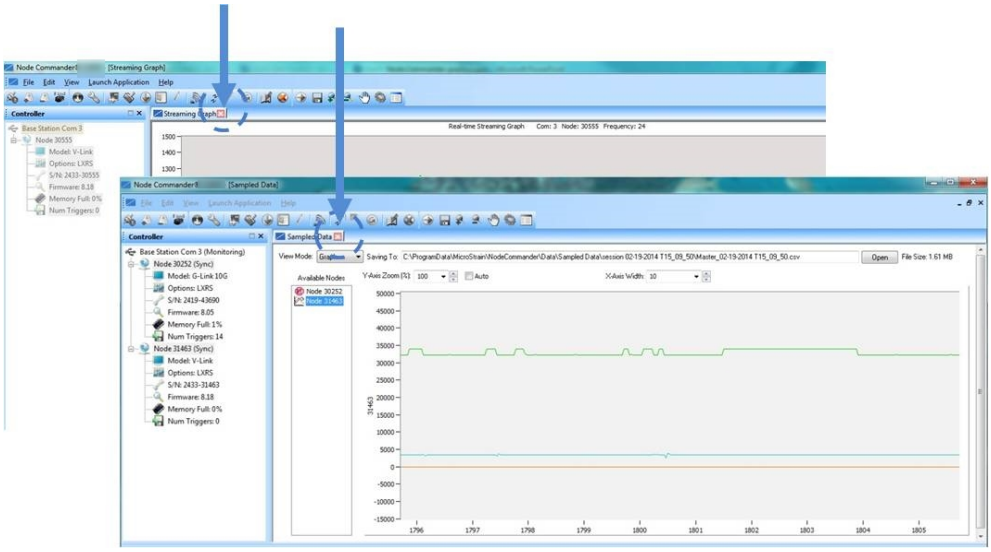


Figure 101 - Ending a Sampling Session

When exiting the sampling session in this way, data acquisition can be stopped, or continue after the data view is closed.

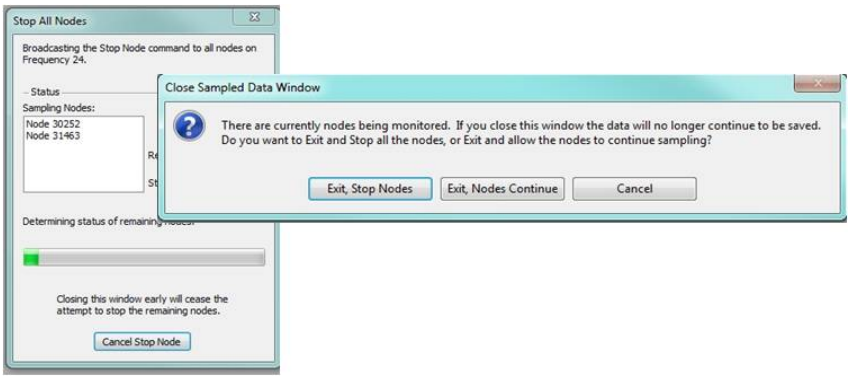


Figure 102 - Stop Nodes or Continue Sampling

2. **Stop the nodes during sampling:** In modes with data grid and graph views, right click in the data sampling window, or on the node name to display a menu with the Stop All Nodes or Stop Streaming command. In datalogging mode there is a Stop Broadcast button. This ends all data acquisition.

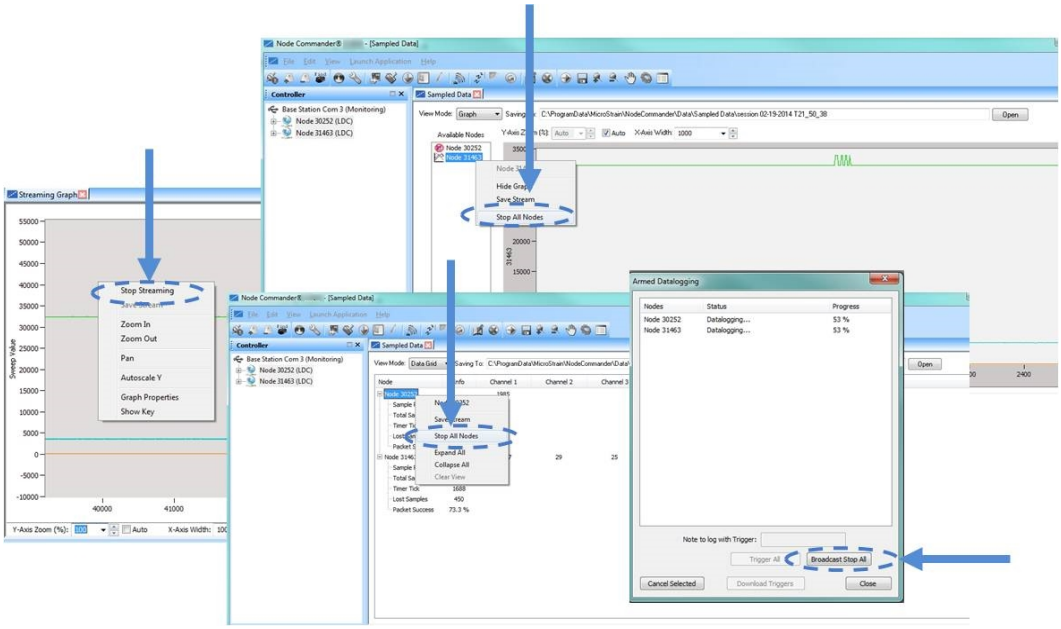


Figure 103 - Stop All Nodes

3. **Use the stop node command:** If the node is sampling without an active view of the data acquisition, right click on the node name in the Controller window and select the Stop Node Command to end sampling. This ends data acquisition for the selected node.

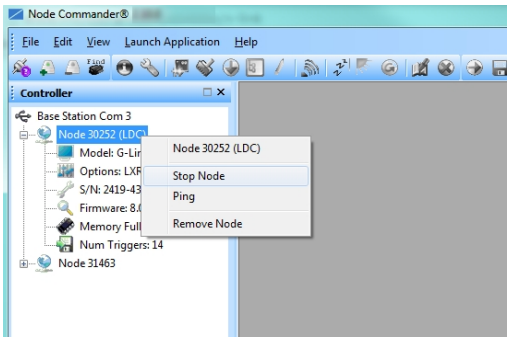


Figure 104 - Stop Single Node

10.6 Monitor Mode

Monitor mode is used to observe any low duty cycle and synchronized sampling activity that is occurring on nodes connected to a particular gateway. When monitor mode is selected, the sampling window opens and displays the data. This is useful if the node was configured to start sampling on boot up or if the data acquisition screen was closed without stopping the node. It is a way to enter the data and graph view windows after data acquisition has already begun. The gateway will only monitor nodes that are on the same frequency (channel) that it is on. All nodes on that frequency will automatically be displayed.

To monitor a node, right click on the gateway name and select Monitor Mode.

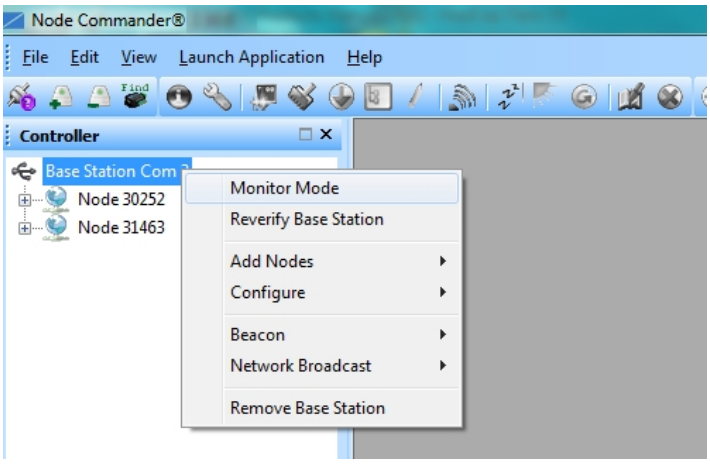


Figure 105 - Monitor Mode

10.6.1 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**

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

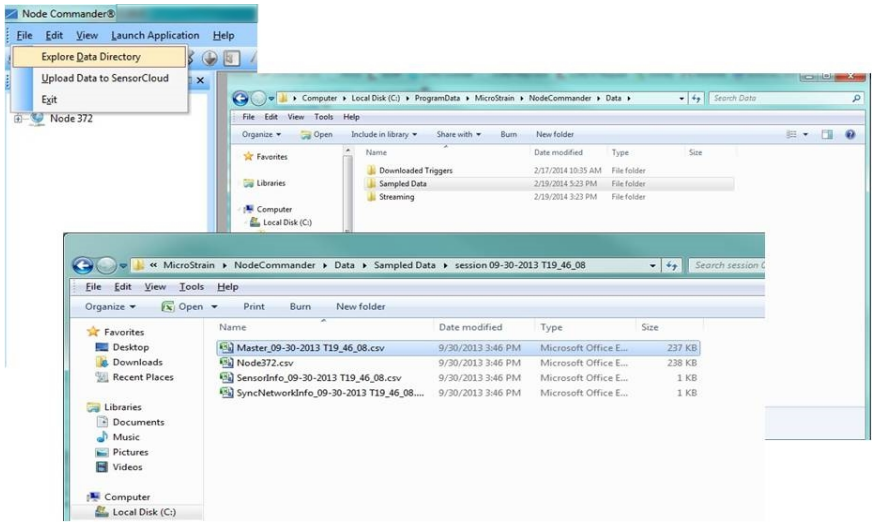


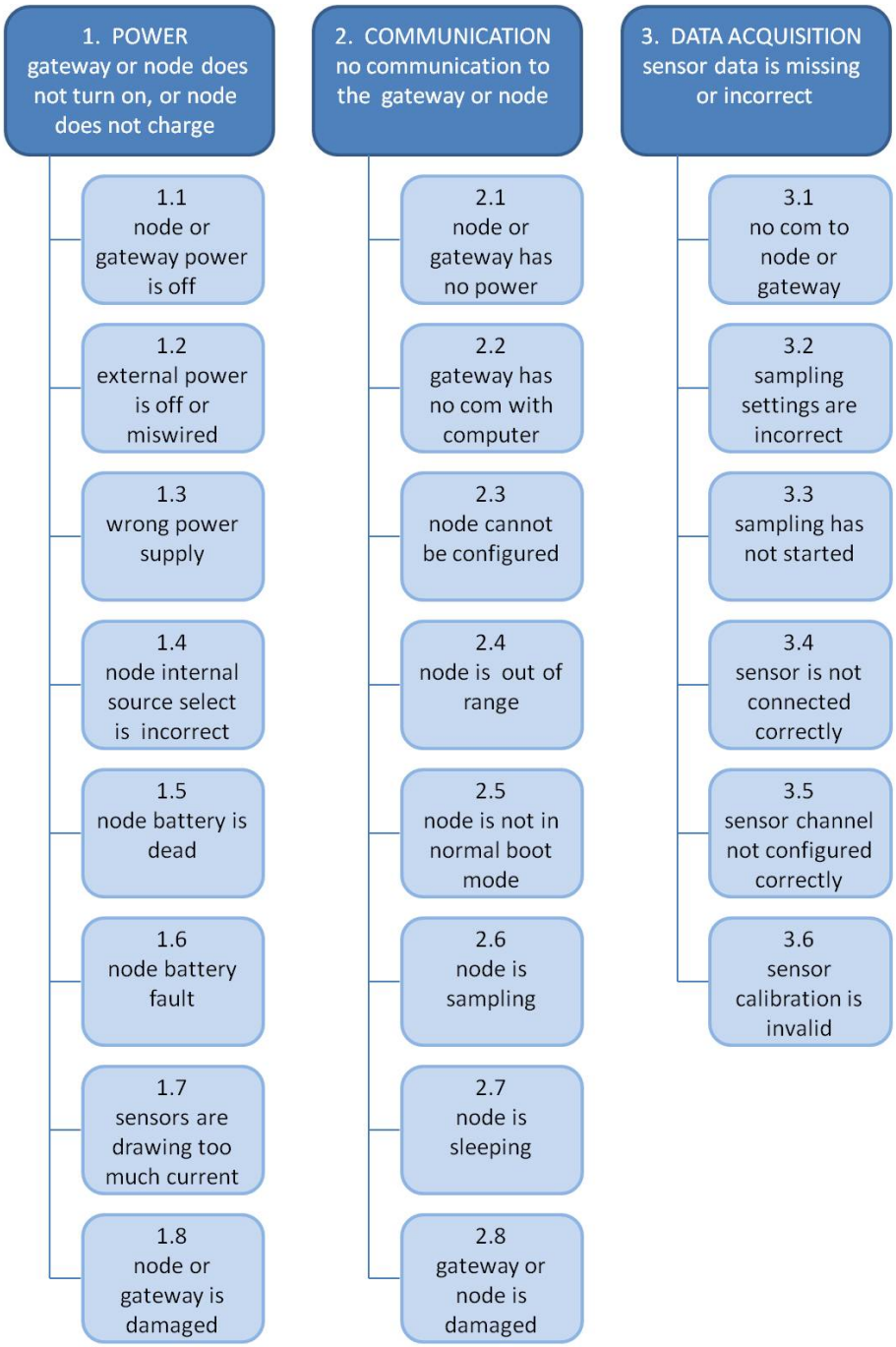
Figure 106 - Exploring Data

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.

11. Support

11.1 Troubleshooting Guide



Problem	Possible cause and recommended solution
1. POWER **gateway or node does not turn on, or node does not charge**	**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 127*).
	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 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. Consider powering the node or sensors with an external source.

Problem	Possible cause and recommended solution
	1.8 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 127*).
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.

Problem	Possible cause and recommended solution
	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 56*. 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 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 127*).
	3.1 no communication to node or gateway

Problem	Possible cause and recommended solution
3. DATA ACQUISITION **sensor data is missing or incorrect**	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 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 127*).

11.2 Communications Ports in Windows®

Serial gateways (including USB gateways) have either a standard serial or virtual communications port in Windows®. Windows®Device Manage can be used to determine what communication port the gateway is connected to.

1. Click on the Windows® Start icon, and select Control Panel.

2. Navigate to the System menu, and select Device Manger. The menus may appear different depending on the version of Windows and the View settings.

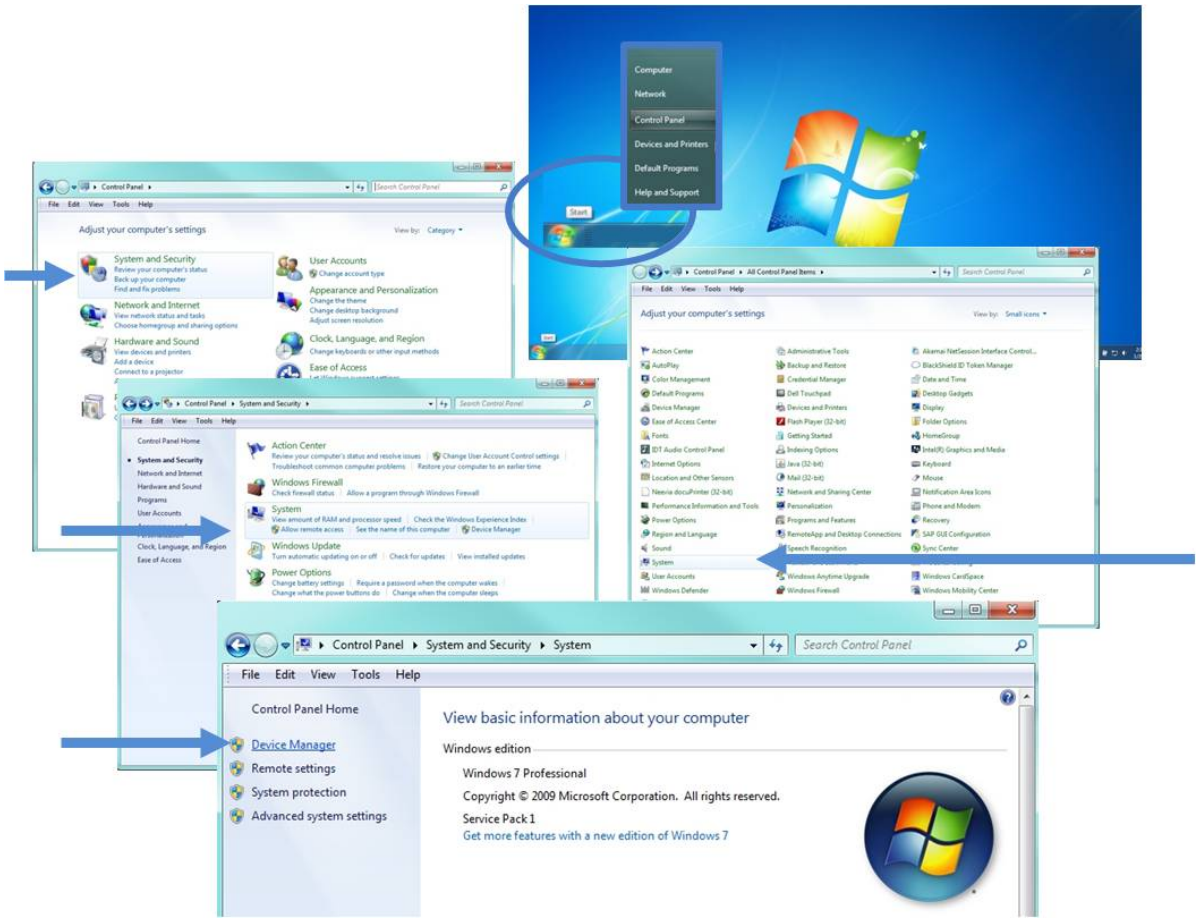


Figure 107 - Windows® System Menu

3. In Device Manager, expand the view for Ports (COM and LPT). Active COM ports will appear on this list with the COM port number. A USB gateway will be displayed as USB to UART Bridge (COM *X*). A serial gateway will be attached to the Communications Port (COM*X*). An Ethernet gateway will be connected to a Virtual Serial port (COM*X*). If no port is listed, the port is not recognized by the computer, and no gateway communication can be established.

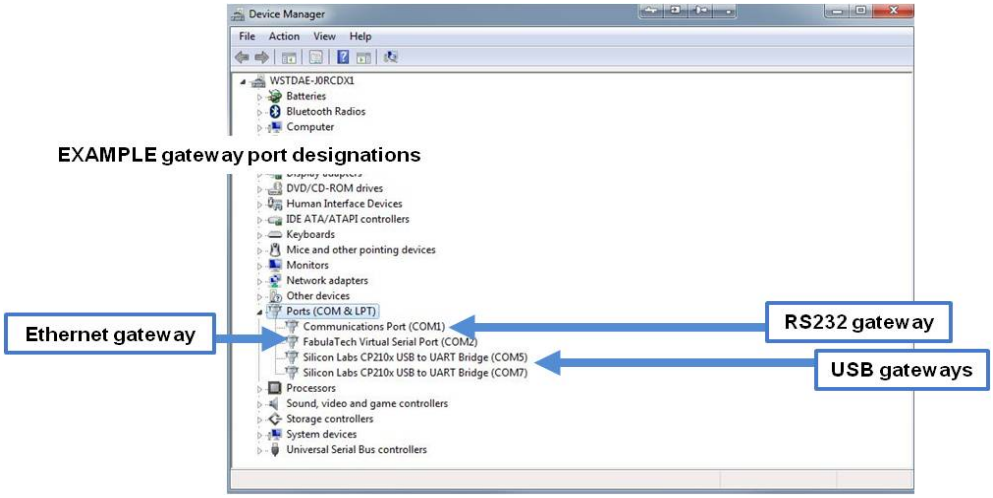


Figure 108 - Windows® Device Manger Menu

4. To view the port settings, select the device, right click on it, and select Properties. *Table 9 - Serial Port Settings*, describes the settings for serial communication. The baud rate for the RS232 gateway can be adjusted in Node Commander® only. Changing it in the Windows port settings menu will not work. *See Setting the Serial Baud Rate on page 39*. USB gateways run only at 921,600 baud.

Port Setting	Value
Baud Rate	115,200 (RS232 gateways) or 921,600*
Parity	none
Data Bits	8
Stop Bits	1

* for RS232 gateways, *see Setting the Serial Baud Rate on page 39*.

Table 9 - Serial Port Settings

11.3 Live Connect™ Interface

Live Connect™ is a bridge between Ethernet gateways, Node Commander® , and the LORD MicroStrain® web based SensorCloud™ data aggregation and data visualization software.

See Gateway Ethernet Communications on page 32 for information on connecting to the Ethernet gateway in Node Commander®. Once communication is established, data files created in Node Commander® can be uploaded to SensorCloud™ through the Node Commander® File menu.

Live Connect™ also provides access to the Ethernet gateway configuration Control Panel. Refer to the gateway user manual for more information (*see Reference Information on page 130*).

11.4 WSDA® Data Downloader

The WSDA® Data Downloader is included with the Node Commander® Software Suite and allows the user to download sensor data stored in the WSDA® -1500 - LXRS® gateway memory to a host computer. The data will be in CSV format. Only the sensor channels selected will be downloaded into the CSV file. Data can also be erased from the gateway memory in this menu.

Open the WSDA® Data Downloader by running it from the Windows® Start menu. Enter the gateway IP address and log-in information. The IP address can be determined in Live Connect™, and the log-in credentials are the same as for logging into the gateway Control Panel (refer to the WSDA® -1500 - LXRS® user manual).

The WSDA® Data Downloader has four main features; the ability to select and download sensor data, apply calibration coefficients to the data prior to downloading, combine all downloaded data into one file, and clear the data from the gateway memory (*Figure 109 - WSDA® Data Downloader*). How long it takes to download depends on the amount of data selected.

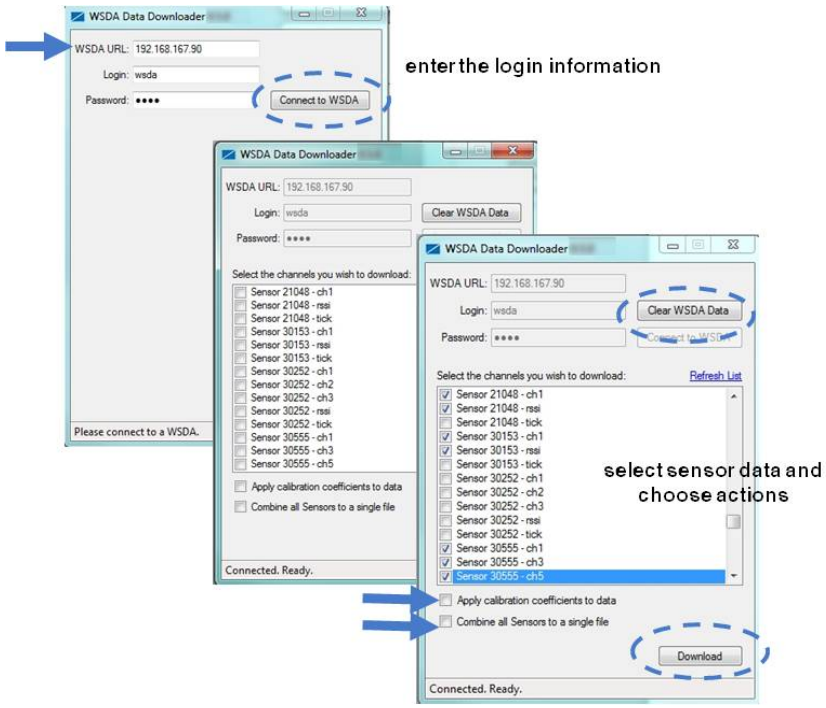


Figure 109 - WSDA® Data Downloader

11.5 Software Specifications

Parameter	Specification
Software Name	Node Commander® , Live Connect™, and WSDA® Data Downloader
Operating Systems	Microsoft Windows® XP Pro, Vista, and 7, 32/64-bit
Computer Requirements	1 GHz processor, 256MB memory, 50MB free hard drive space for the application, 32 MB video card, 800 x 600 video resolution
For Use With	All LORD MicroStrain®LXRS®, mXRS™and legacy 2.4Ghz wireless sensors nodes and gateways.

11.6 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)

11.7 Wireless System Equipment

Model	Description	LORD MicroStrain® Part Number
WSDA-1500-SK	Ethernet Data Gateway Starter Kit	**6314-1501**
--	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**
IEPE-Link -LXRS	Wireless IEPE Accelerometer Node	**various models**

Table 10 - Wireless System Equipment

11.8 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)

12. References

12.1 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
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 11 - Related Documents

12.2 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.

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.

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.