User Guide **Version 8500-0017 rev 001**

WSDA®-Base-101 Analog Output Base Station

MicroStrain® Little Sensors, Big Ideas.®

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Node Commander® software
This product is designed for use with MicroStrain's Node Commander® software version 2.4.0 and higher.

About this manual

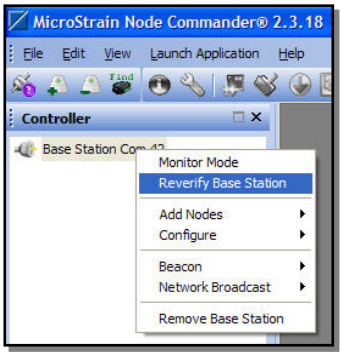
The following annotations have been used to emphasize information, provide software instruction, and so forth.

The user should pay particular attention to this symbol. It means there is a chance that physical harm could happen to the equipment if the instruction is not observed.

WARNING: The WSDA®-Base-101 should not be disassembled by the user. Damage not covered by warranty may result.

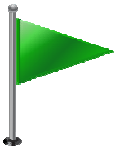
This symbol indicates that a step-by-step instruction is given to use Node Commander® software to operate the equipment.

Node Commander®
Establish communication with the Base Station



1. Launch Node Commander software.
2. The base station will appear as Base Station Com X in the Controller frame, e.g., Com 42 indicating the base station has been assigned com port 42.
3. Right-click the Base Station and click Reverify Base Station if it is grayed-out.

This symbol indicates that the item has significant meaning to the user.



IMPORTANT: The WSDA®-Base-101 analog functions are only available with Streaming and Low Duty Cycle mode sampling. The analog functions do not work with Synchronized Sampling (both Continuous and Burst modes), Armed Datalogging, and Datalogging.

Table of Contents

Overview

The WSDA®-Base-101 Analog Output Base Station operates as an integral part of MicroStrain's mXRS™ Wireless Sensor Networks. It provides seamless communication between a host PC, single board computer or microcontroller, and single or multiple remote wireless nodes, including:

- V-Link®-mXRS™ Wireless Voltage Node
- SG-Link®-mXRS™ Wireless Strain Node
- G-Link®-mXRS™ Wireless Accelerometer Node
- DVRT-Link™-mXRS™ Wireless Displacement Node
- TC-Link®-6CH-mXRS™ Wireless Thermocouple Node
- TC-Link®-1CH-mXRS™ Wireless Thermocouple Node
- EH-Link® Wireless Energy Harvesting Node
- SG-Link®-OEM-S Wireless Strain Node
- TC-Link® OEM Wireless Thermocouple Node
- MicroStrain's legacy 2.4 GHz wireless nodes including V-Link®, SG-Link®, SG-Link® OEM, G-Link®, TC-Link®-6CH, TC-Link®-1CH, TC-Link® OEM and DVRT-Link™.

Coupled with MicroStrain's Node Commander® software, the WSDA®-Base-101 supports configuration of the wireless nodes including discovery, initialization, radio frequency, sample rate, reading/writing to node EEPROM, calibrating nodes' sensors, managing the nodes' batteries including sleep, wake and cycle power, and upgrading the nodes' firmware.

The WSDA®-Base-101 supports all data acquisition sessions between wireless nodes and host computers including **Synchronized Sampling (both Continuous and Burst modes), Armed Datalogging, Datalogging, Streaming** and **Low Duty Cycle**.

Each MicroStrain mXRS™ wireless node has an embedded precision timekeeper. The WSDA®-Base-101 provides a continuous, system-wide synchronization signal, or 'beaconing', that maintains a precision timing reference for all node timekeepers. Time-stamp synchronization of all sensors in the network is maintained within +/- 32 microseconds as a result.

As a special feature, WSDA®-Base-101 has an analog output back panel that supports analog data acquisition equipment (DAQs). Up to 8 sensor channels from one or multiple wireless nodes can be fed into a DAQ with simultaneous digital feed into a PC, or into a DAQ with the PC removed (stand-alone configuration).

Software

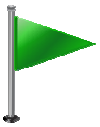
Software Installation

The WSDA®-Base-101 is configured and operated using MicroStrain's Node Commander® software. Place the Node Commander® CD into your CD-ROM drive and follow the on-screen instructions to install the software. The software is written for the Microsoft Windows operating system; the software will also work in Windows emulators on the MAC OS.

Communicating with Node Commander®

Node Commander®, MicroStrain's Wireless Sensor Networks software, is designed to operate the mXRS™ wireless nodes and base stations including the WSDA®-Base-101. The software provides for configuration of the individual wireless nodes, configuration of the base station, operation of Synchronized Sampling (both Continuous and Burst modes), Armed Datalogging, Datalogging, Streaming and Low Duty Cycle data acquisition sessions, real time display of data, and writing data to file. The software also provides intuitive 'wizards' that allow the user to set-up any sensor attached to the wireless nodes including strain gauges, displacement sensors, load cells, torque transducers, pressure sensors, accelerometers, geophones, temperature sensors, etc. The software can discover any wireless nodes within range, set the nodes and base stations to operate on separate frequencies, acquire data from multiple nodes and multiple base stations all at the same time, manage the nodes' batteries including sleep, wake and cycle power, and upgrade the nodes' firmware.

In addition and in particular, Node Commander® provides for 1) analog configuration, or 'pairing', of the wireless nodes with the base station and 2) configuration of the B1 and B2 buttons on the front panel of the base station.



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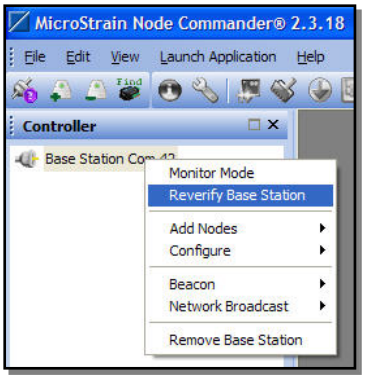
Node Commander®
Establish communication with the Base Station

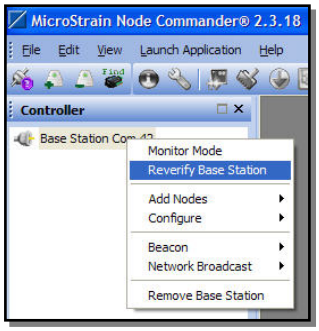


1. Launch Node Commander software.
2. The base station will appear as Base Station Com X in the Controller frame, e.g., Com 42 indicating the base station has been assigned com port 42.
3. If it is grayed-out, right-click the Base Station and click Reverify Base Station.

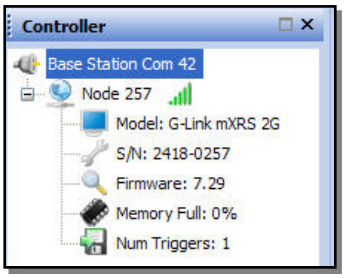
Communicating with Wireless Nodes

The WSDA®-Base-101 is the communication link between Node Commander® and the wireless nodes. Node Commander® sends configuration commands and requests for sensor data through the base station to the nodes. The nodes send their acknowledgements and data back through the base station to Node Commander®. The base station is essentially transparent to the back and forth traffic. A session involves 1) configuring the node, 2) sampling the node's sensors, 3) displaying the data, and 4) writing the data to file. Let's walk through a typical **Low Duty Cycle** session using a MicroStrain G-Link® Wireless Accelerometer Node as our example.

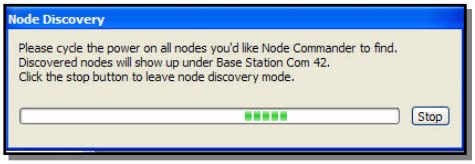
Node Commander®
Configuring and running a Low Duty Cycle session



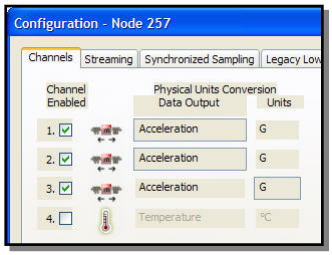
1. Launch Node Commander software.
2. The base station will appear as Base Station Com X in the Controller frame, e.g. Com 42, indicating the base station has been assigned com port 42.
3. Right-click the Base Station and click Reverify Base Station if it is grayed-out.
4. Right-click the Base Station.
5. Click Add Nodes.
6. Click Node Discovery and the Node Discovery window will appear.



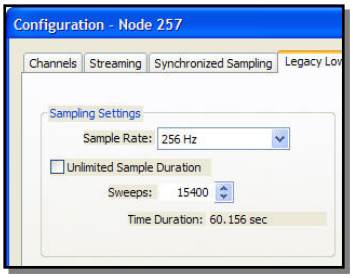
7. Turn the G-Link wireless node on.
8. The Node and its unique address, e.g. Node 257 (NEW), will be discovered automatically and appear in the tree under the Base Station.
9. Click the Stop button and the Node Discovery window will disappear.
10. Right-click the Node.
11. Click Load Node Information and the model, serial number, firmware version, datalogging memory and datalogging triggers information will appear.



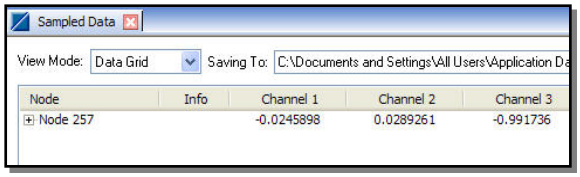
12. Right-click the Node.
13. Click Configure.
14. Click Configure Node and the Configuration window will appear.



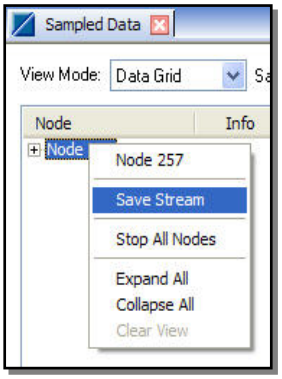
15. Click the Channel Enabled checkboxes to enable channels 1, 2 and 3 (X, Y and Z axis accelerometers on the G-Link).
16. Click Apply.
17. Click the Low Duty Cycle tab.
18. Select a Sample Rate of 256 Hz.
19. Uncheck the Unlimited Sample Duration checkbox.



20. Set a Sweeps value of 15400, a finite sampling session of ~60 seconds.
21. Click Apply.
22. Click OK and the Configuration window will disappear.
23. Right-click the Node.
24. Click Sample.



25. Click Low Duty Cycle and the Sampled Data window will appear.
26. Node 257 and its 3 channels of data will be displayed.
27. Channel 1 is the X axis accelerometer, channel 2 is the Y axis accelerometer and channel 3 is the Z axis accelerometer, all displaying in Gs.

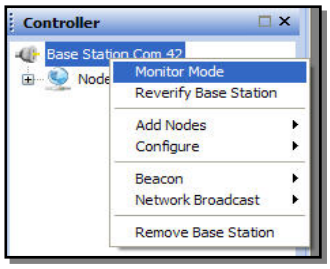


28. The sampling will continue for ~60 seconds and stop.
29. Right-click Node 257.
30. Click Save Stream and the Save As dialog box will appear.
31. Name your data file, select your data folder and click Save.
32. The data will be saved in a standard CSV (comma separated value) file which is readily importable into most analysis software.

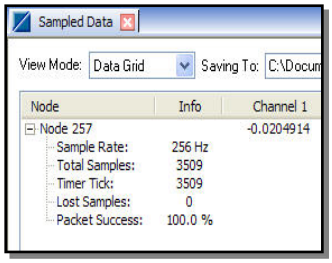
Monitor Mode

Monitor Mode is a Node Commander® function that instructs the base station to monitor for either Synchronized Sampling activity or Low Duty Cycle activity by any wireless nodes on the same radio channel (frequency) as the base station. The nodes may have already been discovered by the base station or may not. An example of this function's use would be to capture the data arriving from wireless nodes that have been set to begin Low Duty Cycle on start-up, i.e., when power is applied.

Node Commander®
Start Monitor Mode



1. Right-click the Base Station Com X, e.g., Com 42.
2. Click Monitor Mode.
3. The Sampled Data window will appear.
4. Any nodes found will be displayed along with their channel data.
5. Right-click the Base Station Com X to Exit Monitoring.



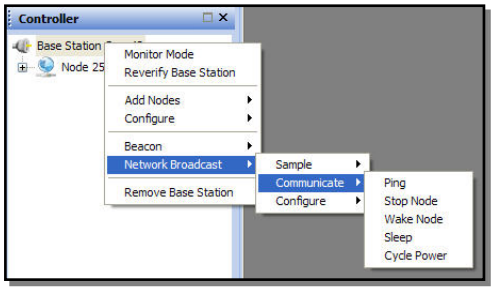
Network Broadcast

Network Broadcast is a Node Commander® function that allows the user to send the same command to multiple wireless nodes at the same time. Examples of this function's use would be to command all the nodes to go to Sleep, or command all the nodes to Trigger Datalogging Session. The Network Broadcast command uses the node broadcast address 65535 and will be responded to by only those nodes that are on the same radio channel (frequency) as the base station. The list below shows the Network Broadcast commands that are available:

- Sample
  - Synchronized Sampling Start
  - Low Duty Cycle Start
  - Armed Datalogging
  - Trigger Datalogging Session
  - Erase
- Communicate
  - Ping
  - Stop Node
  - Wake Node
  - Sleep
  - Cycle Power
- Configure
  - Read/Write EEPROM

Node Commander®
Start Monitor Mode

1. Right-click the Base Station Com X, e.g., Com 42.
2. Click Network Broadcast.
3. Monitor Mode.
4. Click either Sample, Communicate or Configure to send the appropriate command.



Hardware

WSDA®-Base-101 Installation

1. Install the antenna on the WSDA®-Base-101 antenna connector. Tighten hand tight; do not over tighten.
2. Insert the Micro-B connector of the USB cable into the USB connector on the back panel of the WSDA®-Base-101.
3. Insert the Type A connector of the USB cable into any USB connector on your host computer.
4. The green LED on the front panel of the WSDA®-Base-101 will illuminate continuously, indicating the device is powered (through the USB connection from the host computer).

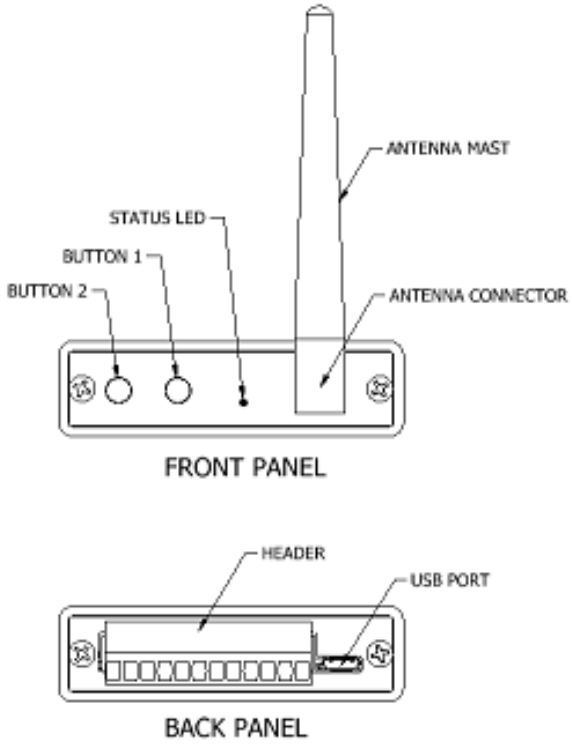


Figure 1. *Base Station Nomenclature*

Communication Interface

USB Interface

The WSDA®-Base-101 and the host computer communicate via a USB connection. The USB interface, from a physical standpoint, resides in a communication cable connecting a Micro-B USB connector to the base station and a Type A USB connector to the host. The USB communication on the base station is provided via a Silicon Laboratories CP210x USB to UART Bridge chip. The CP210x is a single-chip USB to UART bridge that converts data traffic between USB and UART formats. The chip includes a complete USB 2.0 full-speed function controller, bridge control logic and a UART interface with transmit/receive buffers and modem handshake signals. Specifications for the chip may be found at: https://www.silabs.com/products/interface/usbtouart/Pages/usb-to-uart-bridge.aspx

This physical architecture is supported by a Silicon Laboratories CP210x USB to UART Bridge Virtual COM Port (VCP) driver installed on the host. This driver is required for device operation as a Virtual COM Port to facilitate host communication. The driver is normally installed during installation of MicroStrain's Node Commander® software. The driver may also be downloaded from Silicon Labs at: https://www.silabs.com/products/mcu/Pages/USBtoUARTBridgeVCPDrivers.aspx

With the installation of this driver, the software developer will find that communication between base station and host will be, for all intents and purposes, typical serial communication. The various coding languages will interact as if a standard serial port existed. The WSDA®-Base-101 communicates with its host computer at 921,600 baud (921.6 Kbaud) by default. All operations on the base station and the wireless nodes communicating with it are supported at this baud rate.

Device Manager

The Device Manager in Microsoft Windows can be used to determine the presence of the communications driver and the state of the host-to-base station connection. Here's how:

- Click Start on your Windows desktop.
- Click Control Panel.
- Click System and the System Properties window will appear.
- Click the Hardware tab.
- Click the Device Manager button and the Device Manager window will appear.
- Locate the Ports (COM&LPT) item in the tree.
- Click the '+' sign to the left of Ports to open the tree.
- Locate a line item that reads *Silicon Labs CP210x USB to UART Bridge (ComX).*
- This will indicate that the driver is installed and the base station and host are ready to communicate.
- If the line item is not found, the driver has not been installed, the base station is not connected, or some other problem exists.

Connecting to Analog Data Acquisition Equipment

The WSDA®-Base-101 is supplied with a 12-pin header (as shown in **Figure 2**) to make wiring connections to your analog data acquisition equipment (DAQ). The 12-pin header, located on the back panel of the WSDA®-Base-101, provides 8 channels of 0-3 volt DC data, a one pulse-per-second channel, and an update indicator channel. The header accepts a minimum 14 AWG wire and a maximum 28 AWG wire. The wire clamping screws adhere to the DIN 5264 screwdriver blade standard. MicroStrain recommends that good practices should be used when constructing the wiring harness to the data acquisition equipment including shielding, tinning, length, etc. Replacement headers can be acquired from the manufacturer Weidmuller part number 1615730000, or from third party vendors such as Digi-Key www.digikey.com part number 281-1060-D.

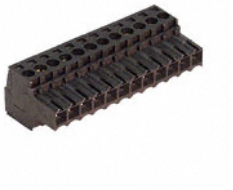


Figure 2. *12-pin Header for analog wiring harness*

Figure 3 shows the WSDA®-Base-101 back panel with the 12-pin header installed. Pins are numbered 1 to 12 from left to right when looking at the back of the header. Please be careful to install your wiring with these pin positions in mind.

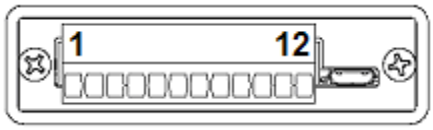


Figure 3*. WSDA®-Base-101 back panel*

Table 1 shows the details of the Header pinout including pin number, use and nomenclature.

Pin number	Use	Nomenclature
1	Auxiliary Power	VAUX
2	Common/Ground	GND
3	Analog Out Update Indicator	AOI
4	1 Pulse Per Second Output	1PPS
5	Analog Out Channel 1	AO1
6	Analog Out Channel 2	AO2
7	Analog Out Channel 3	AO3
8	Analog Out Channel 4	AO4
9	Analog Out Channel 5	AO5
10	Analog Out Channel 6	AO6
11	Analog Out Channel 7	AO7
12	Analog Out Channel 8	AO8

Table 1*. WSDA®-Base-101 Header Pinout*

DAQ Example

For purposes of this manual, let's use the Wikipedia (Data Acquisition 9 November 2011) definition of data acquisition equipment:

Data acquisition *is the process of sampling signals that measure real world physical conditions and converting the resulting samples into digital numeric values that can be manipulated by a computer. Data acquisition systems (abbreviated with the acronym* ***DAS*** *or* ***DAQ****) typically convert analog waveforms into digital values for processing. The components of data acquisition systems include:*

- *Sensors that convert physical parameters to electrical signals.*
- *Signal conditioning circuitry to convert sensor signals into a form that can be converted to digital values.*
- *Analog-to-digital converters, which convert conditioned sensor signals to digital values.*

A widely used DAQ system is the National Instruments USB-6211, as shown in **Figure 4**, coupled with LabVIEW SignalExpress software. The DAQ is a USB plug and play with 16 inputs, 16-bit, 250 kS/s, multifunction I/O. The software configures analog input without programming, and performs basic signal processing, trace display, scaling engineering units, analysis, and file I/O. Reference will be made to this example system elsewhere in the guide.

IMPORTANT: The WSDA®-Base-101 analog functions will work with literally any analog data acquisition system capable of sampling 0-3 volt analog signals. If you are unsure of the interoperability of any specific DAQ, please contact your MicroStrain Support Engineer for assistance.

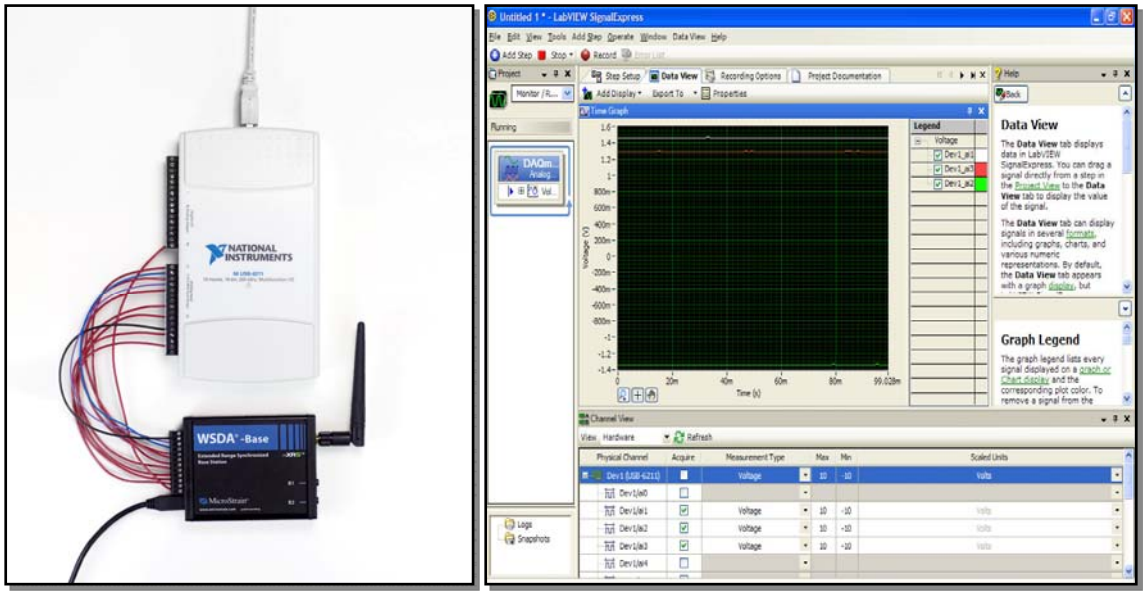


Figure 4*. National Instruments USB-6211 DAQ connected to the WSDA®-Base-101; LabVIEW SignalExpress software*

Analog Output

Analog-to-Digital-to-Analog

MicroStrain's wireless nodes support 0-3 volt analog sensors. As examples:

- The G-Link® has 3 on-board accelerometers and a temperature sensor.
- The V-Link® has 4 differential input channels to accommodate strain gauges and other wheatstone bridge sensors, 3 single ended channels to accommodate a range of 0-3 volt analog sensors, and an on-board temperature sensor.
- The SG-Link® has 1 differential input channel to accommodate strain gauges and other wheatstone bridge sensors, 1 single ended channels to accommodate a range of 0-3 volt analog sensors, and an on-board temperature sensor.
- The TC-Link®-6CH has 6 thermocouple channels, 1 CJC channel and 1 relative humidity sensor.

As each of these sensors is sampled during any given sampling session, .i.e., datalogging, streaming, Low Duty Cycle, etc., its 0-3 volt output is digitized by a 12-bit analog-to-digital (A2D) converter on the node. This results in a digital representation of the voltage as a range of 0 to 4095 'bits'. As examples we see:

- 0 volts = 0 bits
- 1.5 volts = 2048 bits
- 3 volts = 4095 bits

These digital values are transmitted to the WSDA®-Base-101, returned to the analog domain by a digital-to-analog converter on the base station, and made available as analog output for sampling by your analog data acquisition equipment (DAQ). By this method we see that the sensor's analog signal measured at the node is effectively the same as the reconstructed sensor's analog signal delivered through the analog header on the base station. Please refer to the *Scaling Engineering Units* and *Floating Point Operations* section of this guide for further discussion on this subject.

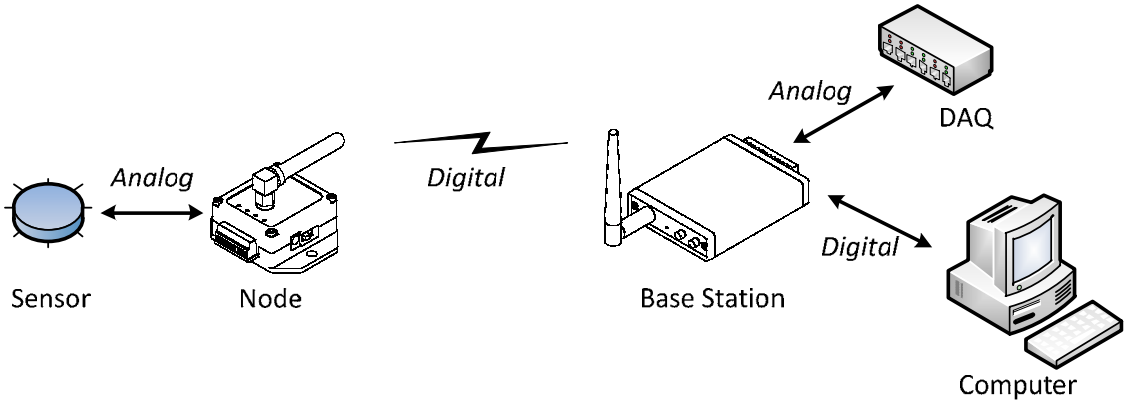
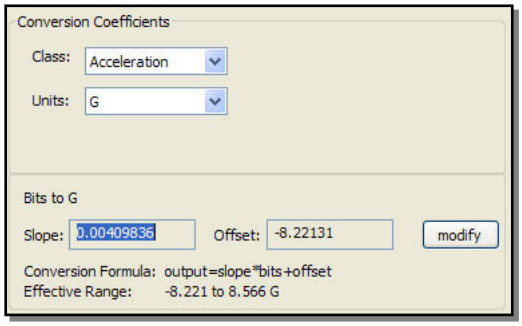


Figure 5. *Analog-to-Digital-to-Analog*

Scaling Engineering Units

As introduced in the *Analog-to-Digital-to-Analog* section of this guide, the sensor data arriving from the nodes into the base station is a 0-4095 value, representing the 0-3 volts sensor output. This digital representation of volts is also passed on to Node Commander® and is scaled into actual engineering units. Accelerometer data is scaled into Gs, strain gauge data is scaled into microstrain, temperature sensor data is scaled into °C, and so forth. Node Commander® accomplishes this by reading the calibration coefficients that are stored in non-volatile memory on-board the wireless nodes. It applies these calibration coefficients to the bit values on-the-fly and reports the actual engineering units in its graphing functions, displays and data files. Let's take a look at this process using Node Commander® and a G-Link®-mXRS™.

Node Commander®
Confirm each sensor channel's calibration coefficients

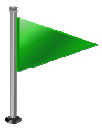


1. Right-click Node X, e.g., Node 257.
2. Click Configure.
3. Click Configure Node and the Configuration window opens.
4. Click the Configure button (with the … dieresis) for Channel 1 and the Channel 1 Configuration window opens.
5. Observe in the Conversion Coefficients frame that the accelerometer on channel 1 of the G-Link is being scaled into 'G' Units.
6. Observe in the Bits to G frame that channel 1 carries a Slope of 0.00409836 and Offset of -8.22131. Node Commander has read these values from the G-Link's memory. These calibrations coefficients are applied by Node Commander using the Conversion formula Output = Slope * Bits + Offset to produce actual engineering units.

The same Slope and Offset can be applied in your DAQ if the DAQ has the capability to post-process the voltages acquired. In its simplest form, this requires a 2-step calculation, i.e., 1) convert volts to bits, i.e. Bits = Volts / 3 Volts * 4095 Bits, and 2) apply the Output = Slope * Bits + Offset formula we talked about above.

For example, if we had an output of 1.5 volts on channel 1 of our G-Link, channel 1 being our X axis accelerometer, we would calculate:

- 2048 Bits = 1.5 Volts / 3 Volts * 4095 Bits
- 0.172g = 0.00409836g/Bit * 2048 Bits + -8.22131g



IMPORTANT: Scaling engineering units varies from DAQ to DAQ. The equations we present above may have to be inverted or otherwise calculated to accommodate the scaling inputs of the particular DAQ.

Analog Configuration, or 'Pairing'

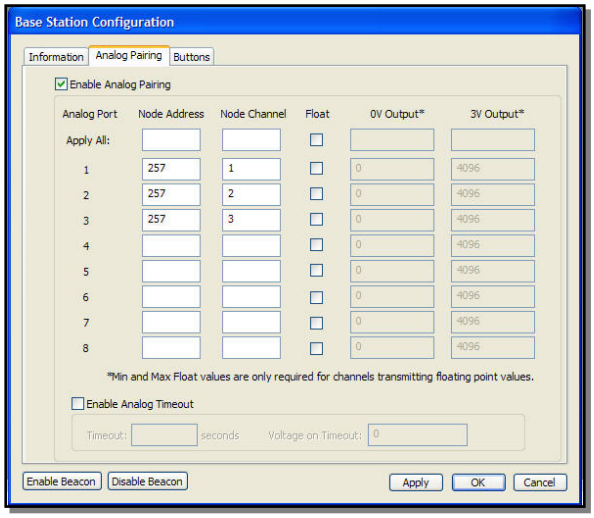
Node Commander® allows the user to configure, or 'pair', each node's sensor channel to any of the 8 analog channels on the header of the WSDA®-Base-101. **Table 2** shows the standard pairing of –mXRS™ wireless node channels to the analog channels on the base station. As an example, the G-Link®-mXRS™ has 3 accelerometer channels; channel 1 is the X axis accelerometer, channel 2 is the Y axis accelerometer, and channel 3 is the Z axis accelerometer. Let's walk through a typical Analog Pairing using the G-Link® Wireless Accelerometer Node as our example.

Wireless Node Sensor Channels	Base Station Analog Output Channels							
	1	2	3	4	5	6	7	8
V-Link®-mXRS™	1	2	3	4	5	6	7	8
SG-Link®-mXRS™	1		3	4				
G-Link®-mXRS™	1	2	3	4				
DVRT-Link™-mXRS™			3	4				
TC-Link®-6CH-mXRS™	1	2	3	4	5	6	7	8
TC-Link®-1CH-mXRS™	1						7	
EH-Link®	1	2	3	4	5	6		
SG-Link®-OEM-S	1		3	4				
TC-Link® OEM	1	2	3	4	5	6	7	8

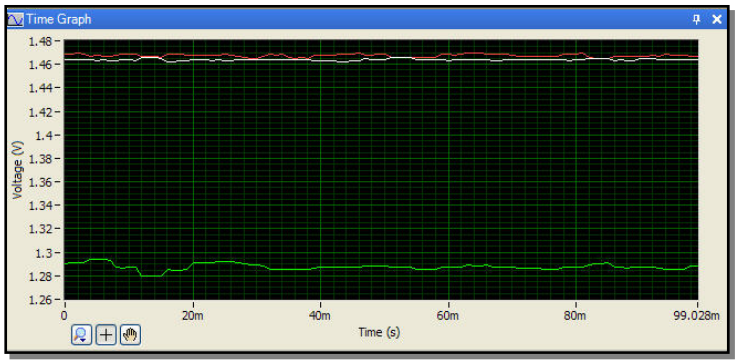
***Table 2**. Standard pairing of wireless node channels to base station analog out channels*

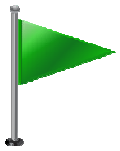
Node Commander®
Analog Pairing

1. Launch Node Commander and establish communication with the G-Link.
2. Configure the node for Low Duty Cycle with channels 1, 2 and 3 enabled, as demonstrated in the *Configuring and running a Low Duty Cycle session* instruction previously given.
3. Right-click the Base Station Com X, Com 42 in our example.
4. A drop-down menu will appear.
5. Click Configure.
6. Click Configure Base Station and the Base Station Configuration window will appear.
7. Click the Analog Pairing tab.
8. Check the Enable Analog Pairing checkbox and the inputs become available.



9. Enter the Node Address, Node 257 in our example, into the Analog Port channel 1 textbox under the Node Address. Likewise, enter 257 into channels 2 and 3.
10. Enter 1, 2 and 3 into the Node Channels textboxes.
11. Click Apply. We have now paired Node 257's sensor channels 1, 2 and 3 with the base station's analog output channels 1, 2 and 3.
12. Click OK.
13. Run a Low Duty Cycle session with your DAQ connected and observe the channel 1, 2 and 3 traces.
14. In our example LabVIEW SignalExpress screen, we see the WHITE trace (channel 1 X axis accelerometer) outputting at ~1.46 volts, the RED trace (channel 2 Y axis accelerometer) outputting at ~1.47 volts, and the GREEN trace (channel 3 Z axis accelerometer) outputting at ~ 1.29 volts.

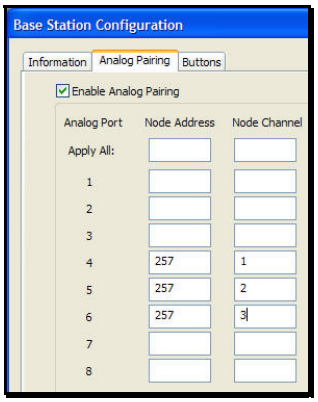




IMPORTANT: The latency between the node's sampling of the sensor and the corresponding analog output on the WSDA®-Base-101 is between 2 and 3 milliseconds.

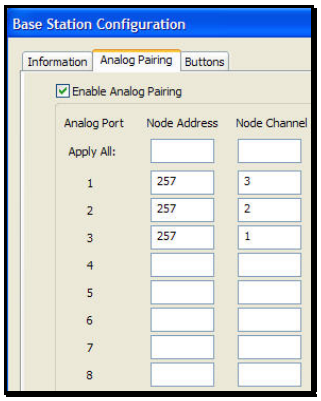
Pairing Combinations

The WSDA®-Base-101 supports many different pairing combinations of a single wireless node or multiple wireless nodes. Here are some examples:



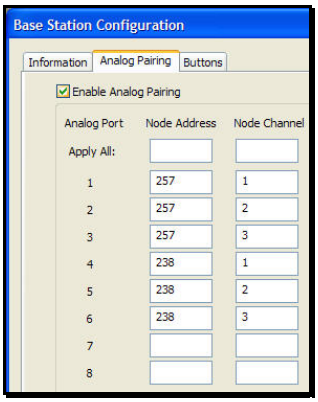
Example 1

Here is our example G-Link 257 with its sensor channels 1, 2 and 3 paired to the base station's analog out channels 4, 5 and 6.



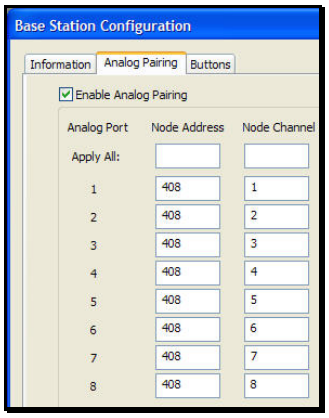
Example 2

Here is our example G-Link 257 with its sensor channels 1, 2 and 3 paired to the base station's analog out channels 3, 2 and 1 (reverse order).



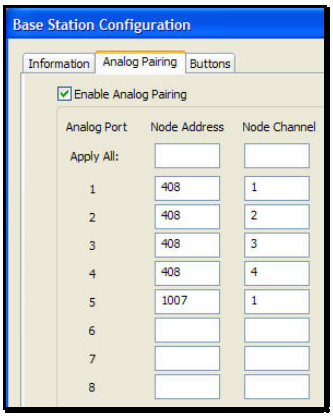
Example 3

Here is G-Link 257 with its sensor channels 1, 2 and 3, and G-Link 238 with its sensor channels 1, 2 and 3, paired to the base station's analog out channels 1-6.



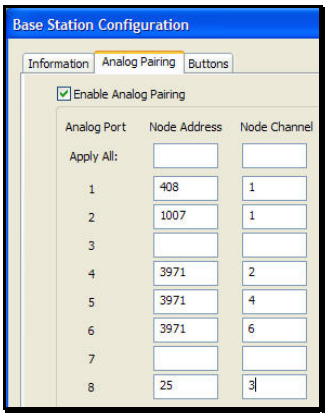
Example 4

Here is an 8 channel V-Link 408 with its sensor channels 1-8 paired to the base station's analog out channels 1-8.



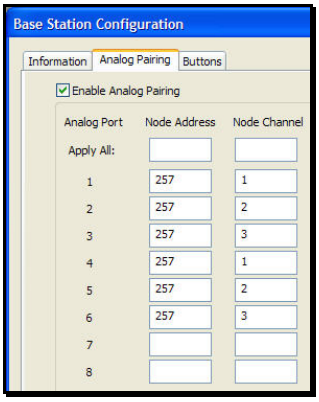
Example 5

Here is a V-Link 408 with its differential input channels 1-4 and an SG-Link 1007 with its differential input sensor channel 1 paired to the base station's analog out channels 1-5.



Example 6

Here is a V-Link 408 with its differential input channel 1, an SG-Link 1007 with its differential input sensor channel 1, a TC-Link-6CH 3971 with its thermocouple channels 2, 4 and 6, and a DVRT-Link 25 with its displacement channel 3 paired to the base station's analog out channels.



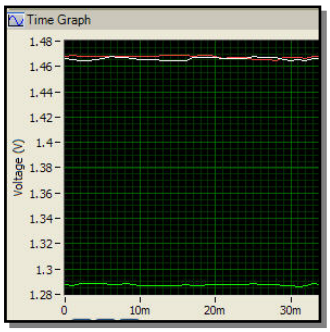
Example 7

Here is our example G-Link 257 with its sensor channels 1, 2 and 3 paired to the base station's analog out channels 1, 2 and 3 as well as 4, 5 and 6, providing a redundant signal sampling.

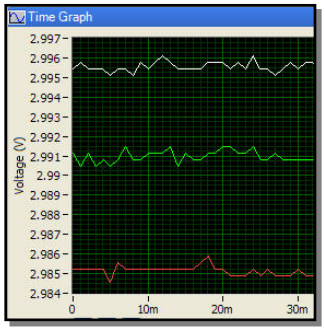
Enable Analog Timeout

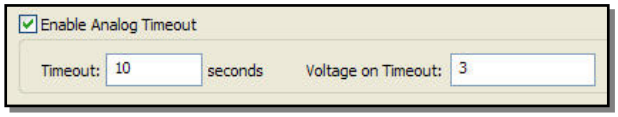
The Enable Analog Timeout function allows the user to automatically 'signal' the DAQ when there has been no change in the analog output for a period of time. The user may set a timeout period of 1 to 65535 seconds and a 'signal' voltage between 0 and 3 volts. The setting applies to all enabled analog channels on the base station. This function would be useful, for example, 1) if the user thought that radio communications might be interrupted during a session and wanted to know when that occurred, or 2) if the user wanted to know that the node power had failed.

Node Commander®
Enable Analog Timeout function



1. Navigate to the Analog Pairing tab on the Base Station Configuration window.
2. Check the Enable Analog Timeout checkbox.
3. Enter a Timeout between 1 and 65535 seconds, e.g. 10 seconds.
4. Enter a Voltage on Timeout between 0 and 3 volts, e.g. 3 volts.
5. Click Apply and run an analog sampling session.
6. Turn off the node during the sampling session and observe that the DAQ will drive to 3 volts on all channels after 10 seconds, indicating that no change has occurred in the analog signal on any of the channels during the last 10 seconds.





Floating Point Operations

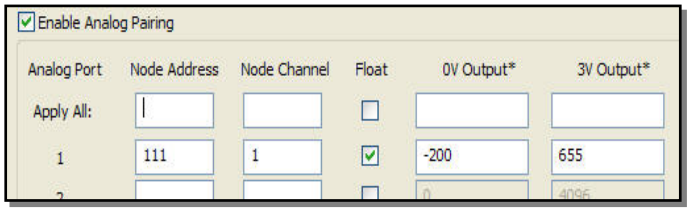
MicroStrain's wireless nodes can transmit their sensor data in either Standard Bits Mode or Floating Point Mode when using Synchronized Sampling or Low Duty Cycle. Standard Bits Mode (16-bit values) requires that the host software further process the bits into Scaled Engineering Units by applying the calibration Slope and Offset. Please refer to the *Scaled Engineering Units* section elsewhere in this guide for further details. Floating Point Mode (32-bit values) does not require the host software to further process the bits; calibration is applied on the node. When using the analog out functions of the WSDA®-Base-101, the user must configure the analog channels to accept the Floating Point Mode when the node is transmitting in Floating Point Mode. **Table 3** shows the default packet format of each wireless node; a Node Commander instruction follows.

Nodes	Default Packet Format
V-Link®-mXRS™ Wireless Voltage Node	Standard bits mode
SG-Link®-mXRS™ Wireless Strain Node	Standard bits mode
G-Link®-mXRS™ Wireless Accelerometer Node	Standard bits mode
DVRT-Link™-mXRS™ Wireless Displacement Node	Standard bits mode
TC-Link®-6CH-mXRS™ Wireless Thermocouple Node	Floating point mode
TC-Link®-1CH-mXRS™ Wireless Thermocouple Node	Floating point mode
EH-Link® Wireless Energy Harvesting Node	Standard bits mode
SG-Link®-OEM-S Wireless Strain Node	Standard bits mode
TC-Link® OEM Wireless Thermocouple Node	Floating point mode
MicroStrain's legacy 2.4 GHz wireless nodes including V-Link®, SG-Link®, SG-Link® OEM, G-Link®, TC-Link®-6CH, TC-Link®-1CH, TC-Link® OEM and DVRT-Link™.	Standard bits mode

Table 3. *Default Packet Format*

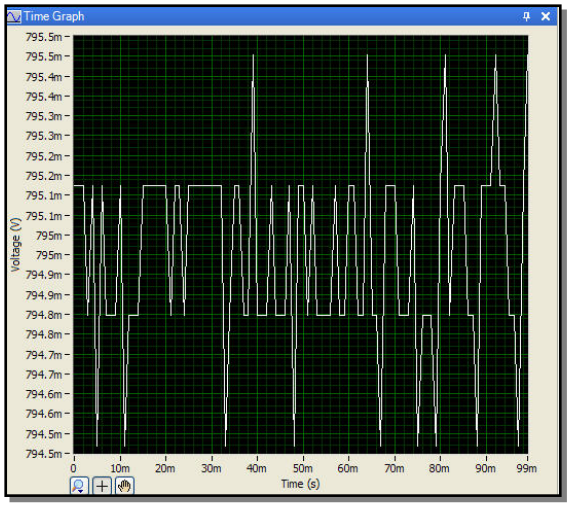
Node Commander®
Configure for Floating Point Operation

1. Right-click the Base Station Com X.
2. A drop-down menu will appear.
3. Click Configure.
4. Click Configure Base Station and the Base Station Configuration window will appear.
5. Click the Analog Pairing tab.
6. Check the Enable Analog Pairing checkbox and the inputs become available.
7. For our example we will use a TC-Link-1CH, node



address 111, with channel 1 supporting a J type thermocouple set to Standard Range -200 to 655 °C.

8. On analog channel 1, enter 111 in the Node address textbox.
9. Enter 1 in the Node Channel textbox.
10. Check the Float checkbox.
11. Enter -200 in the 0V Output textbox.
12. Enter 655 in the 3V Output textbox.
13. Click Apply. Click OK and the Base Station Configuration window will disappear.
14. Run a Low Duty Cycle session and observe the voltage on your DAQ.



The application of the J type thermocouple standard range (-200 to 655 °C) given in the example above results in an analog out resolution of 0 to 3 volts over a range of 855 degrees. The user can increase the resolution of the 0 to 3 volts range by adjusting the range of the sensor measurement to more closely 'bracket' the actual sensor output. As an example, let's assume that the thermocouple will only be exposed to a measurement range of 20 to 80 °C. The Floating Point minimum and maximum settings can actually be manipulated to target that expected temperature range and provide more resolution to the DAQ. By tightening up the minimum and maximum to 0 and 100, as we see in **Figure 6**, we can now output 0 to 3 volts covering a range of 100 degrees. We still will capture all the output activity of the thermocouple but with a much higher resolution going to our DAQ. To be clear: the range adjustment described here doesn't really increase the resolution because we can't get better resolution than the 12-bit A2D originally provides. The range adjustment does amplify changes in the signal. In the example the 0 to 100 °C signal is amplified ~8.55 times.

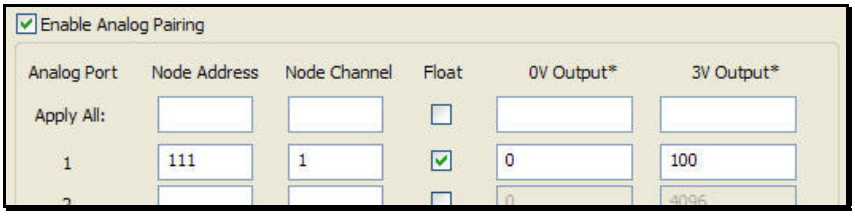


Figure 6. *Increasing resolution to the DAQ*

Analog Out Update Indicator

The Analog Out Update Indicator function on header pin 3 provides a variable width pulse each time an analog channel is updated by the base station. The pulse drives from 0 volts to 3 volts, holds at 3 volts for a varied length of time, and drives back to 0 volts. The time length of the hold indicates the channel being updated. A 5 microsecond hold indicates channel 1, a 10 microsecond hold indicates channel 2, with 5 microsecond increments indicating each channel up to 40 microseconds for channel 8.

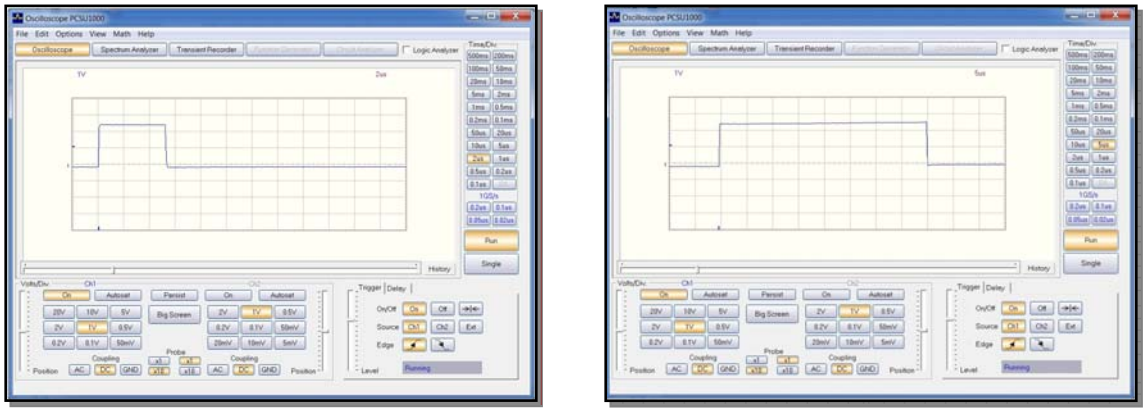


Figure 7. *5 microsecond and 40 microsecond pulses*

1 Pulse Per Second Output

The 1 Pulse Per Second **Output** function on header pin 4 provides a square wave to the DAQ for timing purposes. This function is directly derived from the base station's beaconing function and can be turned on and off with Enable Beacon and Disable Beacon. On base station power-up, the analog signal drives to 3 volts. With each 1 Hz beacon, the analog signal drives from 3 volts to 0 volts, holds for 160 milliseconds, drives from 0 volts to 3 volts, holds for the remainder of the second (840 milliseconds), and repeats second after second, beacon after beacon.

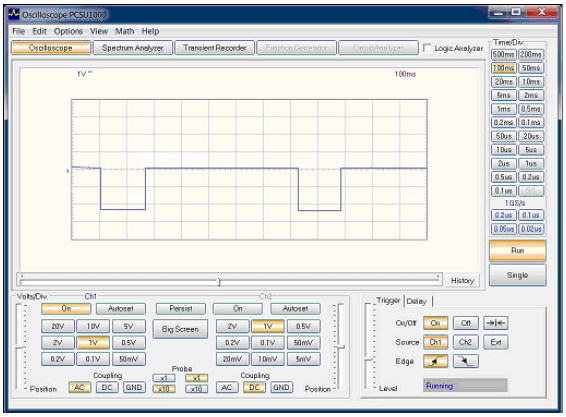


Figure 8. *1 Pulse Per Second* ***Output*** *square wave*

B1 and B2 Buttons

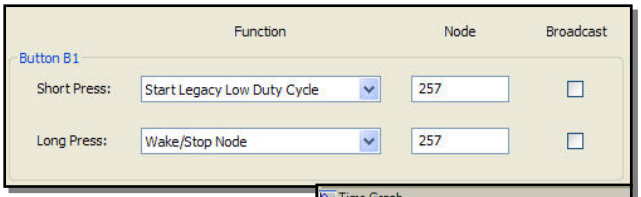
The B1 and B2 buttons on the front panel of the WSDA®-Base-101 allow the user to operate one or multiple wireless nodes without need of a host computer and/or Node Commander® software. By pushing the buttons, the user may send any of several commands to a single node or broadcast commands to multiple nodes. This means the base station can be placed in a remote area without having to be connected to a host computer or use Node Commander® software. To be clear, Node Commander® is used to provision the buttons prior to remote use but does not need to be connected once the base station is 'remoted'. Beacon commands require a connection to the computer, unless the base station can be removed without losing the power. Power loss will reset the internal RTC.

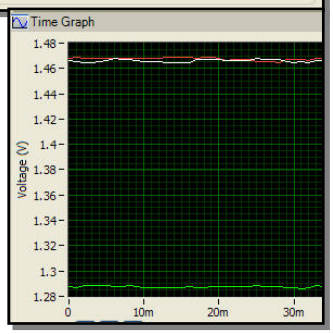
- The following commands are available under the B1 and B2 buttons:
  - Sleep
  - Wake/Stop Node
  - Enable Beacon
  - Disable Beacon
  - Start Low Duty Cycle
  - Start Synchronized Sampling
  - Arm and Trigger Datalogging
  - Cycle Base Station Power
- The B1 and B2 buttons transmit their commands only on the base station's current radio channel (frequency). This requires any wireless node to be on the same radio channel in order to receive the commands. Nodes on other radio channels will not receive the commands.
- The B1 and B2 buttons use the node's unique address when they transmit commands to that particular node.
- The B1 and B2 buttons use the node broadcast address 65535 when they transmit their broadcast commands. All wireless nodes respond to this special broadcast address.
- There are 5 different button presses that a user can make:
  - B1 long press
  - B1 short press
  - B2 long press
  - B2 short press
  - Momentary, simultaneous pressing of B1 and B2.
- Each of the 5 button presses is signaled by a unique Status LED activity, as discussed in the *Status LED* section elsewhere in this guide.

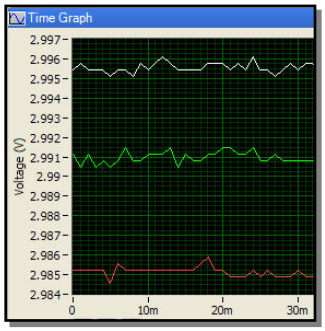
WARNING: Provisions must be made to power the base station through the back panel header when the base station USB cable is disconnected. See the *Power* section elsewhere in this user guide for details.

Node Commander®
Configure B1 Button

1. Configure a G-Link, e.g. Node 257, as follows: channels 1, 2 and 3 enabled, Low Duty Cycle at 256 Hz with 7700 sweeps (~30 seconds).
2. Right-click the Base Station Com X, e.g., Com 42.
3. Click Configure.
4. Click Configure Base Station and the Configuration window opens.
5. Click the Buttons tab.
6. Click the Button B1 Short Press drop-down box and select Start Low Duty Cycle.
7. Click the Button B1 Long Press drop-down box and select Wake/Stop Node.
8. Uncheck both Broadcast checkboxes in the Button B1 frame.
9. Enter the Node address, e.g. 257, in both of the Node textboxes in the Button B1 frame.
10. Click Apply. Click OK.
11. Close Node Commander.
12. Disconnect the base station USB cable from the host.
13. Connect power to the back panel header of the base station.
14. For purposes of this demonstration, leave your DAQ connected to the base station so that you can observe the analog output from the base station.
15. Press B1 with a SHORT press and observe the Status LED.
16. Now observe the traces in your DAQ and you will see that Low Duty Cycle has started.
17. Press B1 with a LONG press and observe the Status LED.
18. Now observe the traces in your DAQ and you will see that Low Duty Cycle has ceased.







Button Paring Function

A special function of the B1 and B2 Buttons is the 'Button Pairing' function. The function is called by simultaneous pressing of B1 and B2. This function allows the user to put the base station in Node Discovery mode and pair the node with the base station. This function has two pairing modes:

- If Analog Pairing is enabled, the simultaneous pressing of B1 and B2 will "permanently" pair a node's channels to the analog out channels on the base station. The node channels will be paired 1 to 1 with the base station analog output channels and the channel scaling (standard bits mode, floating point mode, etc.) will remain as previously configured. By permanently, we mean that the node address will be captured and written to non-volatile memory in the base station. This node address will survive power cycling and remain as the Analog Pairing configuration on the base station until otherwise changed.
- If Analog Pairing is disabled, the simultaneous pressing of B1 and B2 will "temporarily" pair a node address to the buttons. For example, if a B1 short press originally started all wireless nodes in LDC mode and we pair the base station with node 271 (with analog pairing disabled), the B1 short press will only start node 271 in LDC mode until the base station power is cycled. At that point, the button configurations will return to the original configuration.
- Node/base station pairing can be stopped either by pairing a node or by pressing any button. The green LED will illuminate continuously (solid) when not in pairing mode.
- In this special function, the base station automatically changes its radio channel (frequency) to that of the node.

Status LED

The WSDA®-Base-101 has a Status LED on the front panel that indicates the current activity state of the base station. **Table 4** describes the various the LED state and its meaning.

LED State	Activity
Solid **Green** LED	The base station is powered and idle.
Blinking **Blue** LED every 1 second	The base station is beaconing.
Blinking **Red** LED	The base station has received a beacon from another base station.
Green LED turns on and stays on	B1 or B2 button is held down.
Red LED blinks once	B1 or B2 button is held down momentarily
Green LED blinks rapidly	B1 and B2 buttons are held down momentarily.

Table 4. *LED Activity*

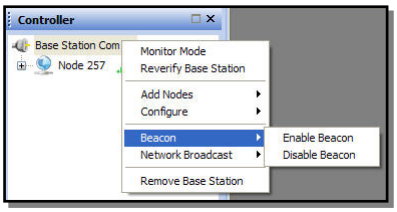
Beaconing

The WSDA®-Base-101 provides system-wide clock synchronization to the wireless nodes it is operating in **Synchronized Sampling (both Continuous and Burst modes)**. We refer to this function as the base station 'beacon', or 'beaconing'. The base station broadcasts a special data packet containing the base station's current UTC time (Coordinated Universal Time) to all nodes every second (1 Hz). The time stamp is pulled from the base station's real time clock (RTC) and updates each node's real time clock. The continuous synchronization beacon coupled with the accuracy of the base station and nodes' real time clocks (+/-3 ppm drift) provides a node to node synchronization of +/-32 microseconds.

- The base station transmits the beacon only on its current radio channel (frequency). This requires any wireless node to be on the same radio channel in order to receive the beacon. Nodes on other radio channels will not receive the beacon.
- The base station uses the node broadcast address 65535 when it transmits the beacon. All wireless nodes respond to this special broadcast address.
- Node Commander® polls the Windows OS for the host time and updates the base station RTC each time it sends the **Synchronized Sampling** command. Assuming the host computer is being updated via a UTC time server (Internet, etc.), and given the nature of the Windows OS, the base station RTC time will be accurate vis-à-vis UTC within +/1 second.
- The wireless nodes only utilize the beacon when they are actually performing **Synchronized Sampling**. They do utilize it at any other time. Therefore it is recommended that you keep the beacon disabled when not performing **Synchronized Sampling**. This will conserve battery, minimize radio interference, etc.
- The beaconing function is not available for **Armed Datalogging, Datalogging, Streaming** and **Low Duty Cycle** data collection modes.
- The current UTC time contained in the beacon has a resolution of 1 second. The time does not contain a sub-second value.
- Beaconing is indicated by the base station Status LED as a blue blip every one second.
- Beaconing is enabled in Node Commander® by clicking Enable Beacon. It is also automatically enabled when you click Start Sampling in the Synchronized Sampling window.
- Beaconing is disabled in Node Commander® by clicking Disable Beacon or clicking Stop Node. It is also automatically disabled when you click Synchronized Sampling and Synchronized Sampling window opens.

Node Commander®
Enable and Disable the Beacon

1. Right-click the Base Station Com X, e.g. Com 42.
2. Click Beacon.
3. Click Enable Beacon or click Disable Beacon.



Power

USB

The WSDA®-Base-101 normally receives its power through the USB connection with the host computer. The USB specifications provide *for a 5 volt supply on a single wire from which USB connected USB devices may draw power with no more than 5.25 volts and no less than 4.75 volts (5 volts +/-5%) between the positive and negative bus power lines.* The host computer must adhere to these specifications.

Auxiliary

The WSDA®-Base-101 can also be powered through the header on the back panel. This is particularly useful when the WSDA®-Base-101 is deployed in stand-alone operation without benefit of the USB connection to a host computer. Any external power source including free-standing power supply, batteries, etc. may be used if the supply meets the supply voltage and power consumption requirements. The supply voltage must range from +3.6 volts DC to +13.0 volts DC. Under-voltage will result in improper operation or no operation. Over-voltage may result in over-heating or damage to the device. Power from the auxiliary source should be wired to pin 1 and ground from the auxiliary source should be wired to pin 2 on the header, as shown in **Table 1**.

WARNING: Do not exceed +13.0 volts DC when powering the WSDA®-Base-101 through its auxiliary power connector. Severe damage may occur to the WSDA®-Base-101.

Power consumption

Table 5 shows the current draw of the WSDA®-Base-101 in different operating modes.

Configurations/operations	Current draw
Idle	45.7 mA
Broadcast Stop	91.6 mA
8 active node channels operating at 256 Hz Low Duty Cycle with analog outputs active	65.6 mA
1 active node channel operating at 256 Hz Low Duty Cycle with analog outputs active	62.1 mA
8 active node channels operating at 256 Hz Synchronized Sampling (analog outputs not active	62.6 mA

Table 5. *Power Consumption*

Upgrade Base Station Firmware

From time to time, MicroStrain makes improvements to the firmware on-board the WSDA®-Base-101. MicroStrain Support Engineers will provide you with a bootloader program, the new firmware version and instructions to upgrade your base station without having to return it to the factory.

Radio Operation

Frequencies and Channels

The WSDA®-Base-101 employs a 2.4 GHz IEEE 802.15.4 compliant radio transceiver for wireless communication with MicroStrain wireless nodes. The radio is a direct-sequence spread spectrum radio and can be configured to operate on any of 16 separate frequencies ranging from 2.405 GHz to 2.480 GHz. Following the 802.15.4 standard, the MicroStrain Wireless Sensor Networks family of base stations and nodes alias these frequencies as channel 11 through channel 26 and the WSDA®-Base-101 default setting is 2.475 GHz (channel 25), as shown in **Table 6**.

Frequency	Channel Designation	Frequency	Channel Designation
2.405 GHz	11	2.445 GHz	19
2.410 GHz	12	2.450 GHz	20
2.415 GHz	13	2.455 GHz	21
2.420 GHz	14	2.460 GHz	22
2.425 GHz	15	2.465 GHz	23
2.430 GHz	16	2.470 GHz	24
2.435 GHz	17	2.475 GHz	25 (default)
2.440 GHz	18	2.480 GHz	26

Table 6. *Radio Frequencies and Channel Designation*

Node Commander®
Change Base Station Radio Frequency

1. *Right-click Base Station Com X.*
2. *Click Configure.*
3. *Click Frequency.*
4. *Click Channel, e.g. 24 (2.470 GHz).*

Antenna Positioning

The base station enclosure can be mounted in any position, and, in general, the antenna mast itself should always be rotated to the vertical (pointed up to the sky). However, there are environments where communications will improve if the antenna mast is pointed in other directions. The Node Range Test function in Node Commander® will aid you in determining the best pointing position.

Node Commander®
Range Test the Node

1. *Right-click Node X.*
2. *Click Communicate.*
3. *Click Range Test and the Short Packet Range Test window will appear.*
4. *Move the antenna position and observe the Good Pings and Signal Strength.*

Communication Range vs. Transmit Power

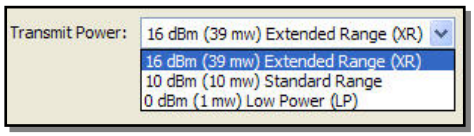
MicroStrain's mXRS™ wireless nodes and the WSDA®-Base-101 have a user-settable radio transmit power level function. This function has a two-fold purpose. On the one hand, the function provides a method to conserve power consumption on either the internal rechargeable batteries in the wireless nodes OR any external batteries (either rechargeable or non-rechargeable) that may be deployed to power the nodes or the base station. On the other hand, the function allows the user to stay within radio transmission power restrictions in certain countries or other conditions. Users will normally want to select the power level that insures robust communication between base station and node, is within any restrictions, AND at the same time, conserves battery life.

The mXRS™ wireless nodes and the WSDA®-Base-101 can be set to operate at the following transmit power levels. We recommended that you match levels of the nodes with the base station.

- 16 dBm (39 mW) Extended Power yielding range up to 2 kilometers
- 10 dBm (10 mW) Standard Power yielding range up to 1 kilometer
- 0 dBm (1 mW) Low Power yielding range up to 70 meters

Node Commander®
Set Transmit Power Level on Node

1. Right-click Node X.
2. Click Configure.
3. Click Configure Node and the Configuration window appears.
4. Click the RF tab.
5. Click the Transmit Power Level drop-down.
6. Click the desired power level.
7. Click Apply.



Please ask your MicroStrain Support Engineer for further help characterizing the range versus transmit power requirements for your particular application.

Radio Interference

The WSDA®-Base-101 and the wireless nodes it is serving may experience radio performance problems in the 2.4 GHz band as a result of the many other devices that share this license free zone. If you suspect that other devices in the immediate area might be interfering with the communication between base station and nodes, try selecting a different channel for the base station and nodes. As indicated above in the *Frequencies and Channels* section, the base station and nodes can be set to operate on any of 16 different frequencies within the band.

Radio Certification

FCC (United States) Certification

The WSDA®-Base-101 complies with Part 15 of the FCC rules and regulations. Compliance with the labeling requirements, FCC notices and antenna usage guidelines is required. In order to operate under MicroStrain's FCC Certification, OEMs/integrators must comply with the following regulations:

Labeling Requirements

The WSDA®-Base-101 is labeled with its FCC ID number XJQMSLINK0001. If this FCC ID is not visible when the module is installed inside another device, the outside of the device into which the module is installed must also display the following label referring to the enclosed module:

Contains FCC ID: XJQMSLINK0001
This device complies with Part 15 of the FCC Rules.
Operation is subject to the following two conditions:

(1) this device may not cause harmful interference and
(2) this device must accept any interference received, including interference that may cause undesired operation.

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures: 1) re-orient or relocate the receiving antenna, 2) increase the separation between the equipment and receiver, 3) connect equipment and receiver to outlets on different circuits, and/or 4) consult the dealer or an experienced radio/TV technician for help.

FCC-approved Antennas

This device has been designed and tested to operate with the antennas listed below:

- Antenna Factor (ANT-2.4-CW-RCS-SMA)

Important Notes

- The WSDA®-Base-101 has been certified by the FCC for use with other products without any further certification (as per FCC section 2.1091). Modifications not expressly approved by MicroStrain could void the user's authority to operate the equipment.
- If the WSDA®-Base-101 is integrated with an unintentional radiator, the OEM/integrator is responsible for testing compliance of the unintentional radiator (FCC section 15.107 & 15.109) before declaring compliance of their final product to Part 15 of the FCC Rules.
- If using the WSDA®-Base-101 in portable applications (module antenna is less than 20cm from the human body during device operation), the integrator or end user is responsible for passing additional SAR (Specific Absorption Rate) testing based on FCC rules 2.1091 and FCC Guidelines for Human Exposure to Radio Frequency Electromagnetic Fields, OET Bulletin and Supplement C. The testing results will be submitted to the FCC for approval prior to selling the integrated unit. The required SAR testing measures emissions from the module and how they affect the person.

IC (Industry Canada) Certification

The WSDA®-Base-101 is labeled with its IC ID number. If this IC ID is not visible when the module is installed inside another device, then the outside of the device into which the module is installed must also display the following label referring to the enclosed module.

Contains Model: WSDA®-Base-101, IC: 8505A-MSLINK0001

Integrator is responsible for its product to comply with IC ICES-003 & FCC Part 15, Sub. B - Unintentional Radiators. ICES-003 is the same as FCC Part 15 Sub. B and Industry Canada accepts FCC test report or CISPR 22 test report for compliance with ICES-003.

Transmitter Antennas

This device has been designed to operate with the antennas listed below:

- Antenna Factor (ANT-2.4-CW-RCS-SMA)

Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes : (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Dimensional Drawing

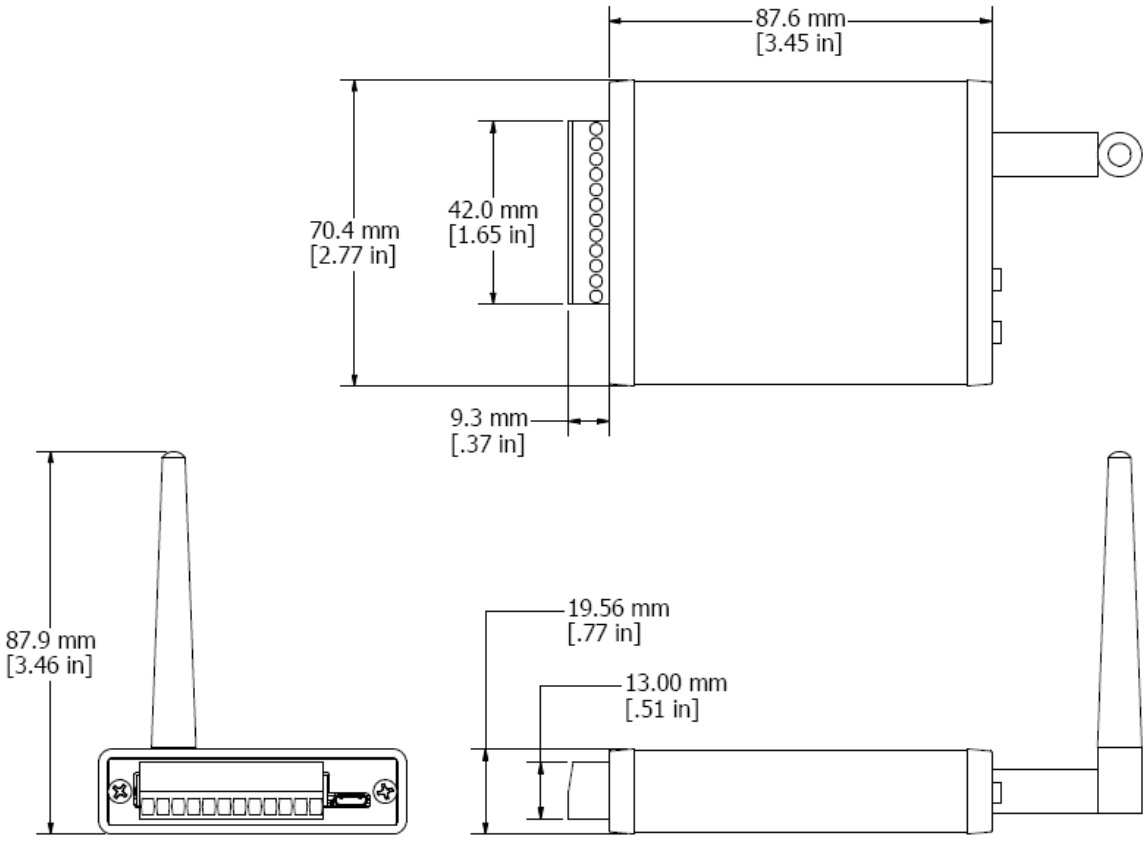


Figure 9. *WSDA®-Base-101 Dimensions*

Enclosure

The WSDA®-Base-101 enclosure is made of black-anodized aluminum with 4 rubber foot pads for desktop mounting.

The WSDA®-Base-101 is designed to be operated within a temperature range of -30° C to +70° C.

WARNING: The WSDA®-Base-101 should not be disassembled by the user. Damage not covered by warranty may result.