Using the KAM / WSI / 104

The KAM/WSI/104 module contains a base station, or gateway, licensed from LORD Corporation (microstrain.com) for communicating with a wireless sensor network using the LXRS protocol. The module collects node data for transmission over the Acra KAM-500 backplane in packetized format and/or mapped analog channel format.

This paper discusses the following topics:

54.1 Introduction

LXRS uses a star network topology for bi-directional communication between one gateway and multiple wireless sensor nodes. All nodes communicate directly to the gateway using assigned time-division-multiplexing (TDM) slots, and each network operates on a designated frequency channel within the 2.4 GHz license-free ISM band. (See "54.8 References" on page 12 - LORD technical note link.)

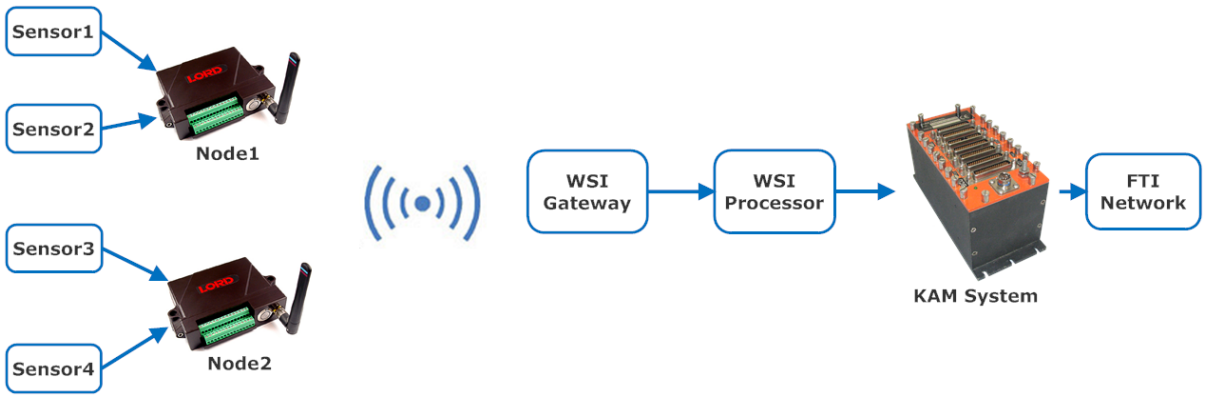


Figure 54-1: LXRS network topology

Setting up the wireless sensor network requires two steps.

1. Set up the KAM/WSI/104 in DAS Studio 3.
2. Set up the wireless nodes using SensorConnect.

This document contains instructions on how to set up the KAM/WSI/104.

54.1.1 Required software

DAS Studio 3 - contact Curtiss-Wright support (acra-support@curtisswright.com)

SensorConnect (http://www.microstrain.com/software)

54.1.2 Required hardware and cables

KAM/WSI/104: Wireless sensor module

KAD/BCU/140: Ethernet controller

ACC/CON/051: USB to 19 way cable

Wireless sensors (nodes) compatible with LXRS protocol

54.2 Network planning

Before programming the KAM/WSI/104, plan your wireless sampling network.

SensorCloud Sensing Wireless Network Calculator (https://sensorcloud.com/pricing?onlyCalc=true; requires Google Chrome browser) is recommended for planning. It estimates the bandwidth required for various combinations of nodes and channels and sampling rates.

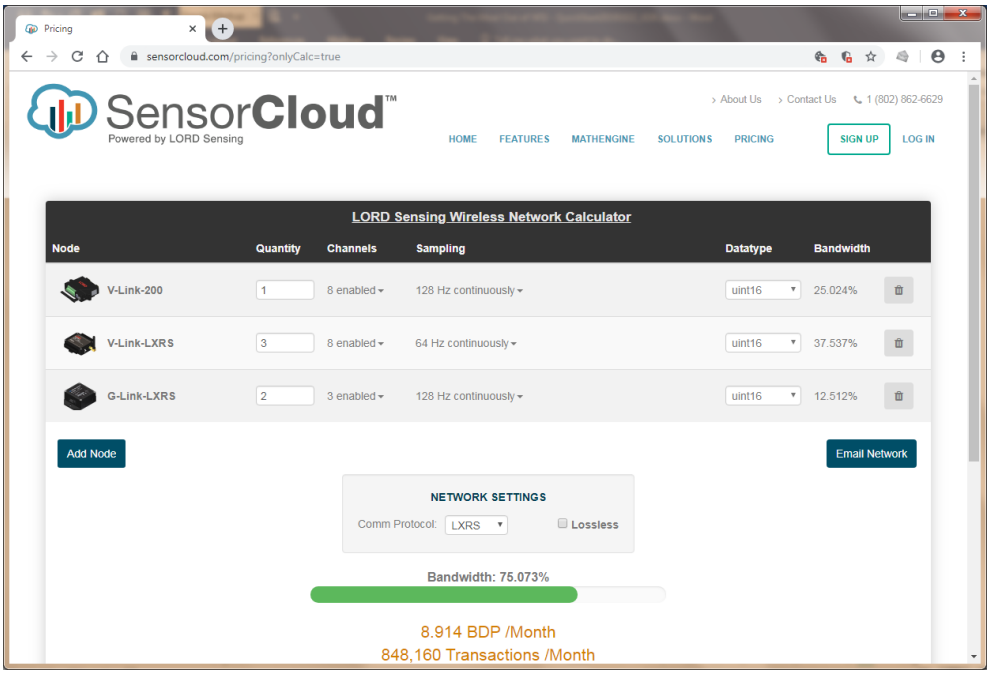


Figure 54-2: SensorCloud Sensing Wireless Network Calculator

The KAM/WSI/104 uses Synchronized Sampling Mode, LXRS Protocol, and 16-bit data words. Lossless mode is recommended. Use these settings when planning the network.

It is also possible to set up a live network using SensorConnect, before programming the KAM/WSI/104, to see what configurations are allowed by the software through experimentation (see “54.4 Talking to the gateway” on page 5). Once you have set up one working network, it is easy to tweak and experiment with settings.

The node IDs and sampling rates is required for both KAM/WSI/104 programming (“54.3.1 Analog channel mapping” on page 3) and network setup (“54.4.3 Setting up the network” on page 5).

54.3 Programming the KAM/WSI/104

The KAM/WSI/104 must be programmed with DAS Studio 3. (The PC requires an Ethernet connection to the KAD/BCU/140 for programming.)

DAS Studio 3 is used to create a configuration, which contains the various elements which make up your data acquisition system. You then use this configuration file to manage and program these elements. To see how hardware is represented in the DAS Studio 3 graphical user interface, see Figure 1 in the *DAS Studio 3 User Manual*.

To begin, open DAS Studio 3 and create a task with the KAD/BCU/140 and a KAM/WSI/104.

The KAM/WSI/104 can handle incoming node data in two ways:

1. It can map specific node channels to placeable analog parameters.
2. It can packetize node data into streams.

Analog parameters are easier to display and view but have specific requirements to match the sampling rate with the incoming data rate. Packetizers have no sampling rate restrictions but can produce varying length packets.

Both approaches can be used in combination, for any node, up to the channel count limits.

Save, verify, and program the Acra KAM-500 system when the task file is configured to your requirements.

54.3.1 Analog channel mapping

The KAM/WSI/104 can support up to 31 placeable parameters, each a 16-bit word with mapping to a remote node and channel. These appear to the Acra KAM-500 backplane as Analog channels 0 to 30.

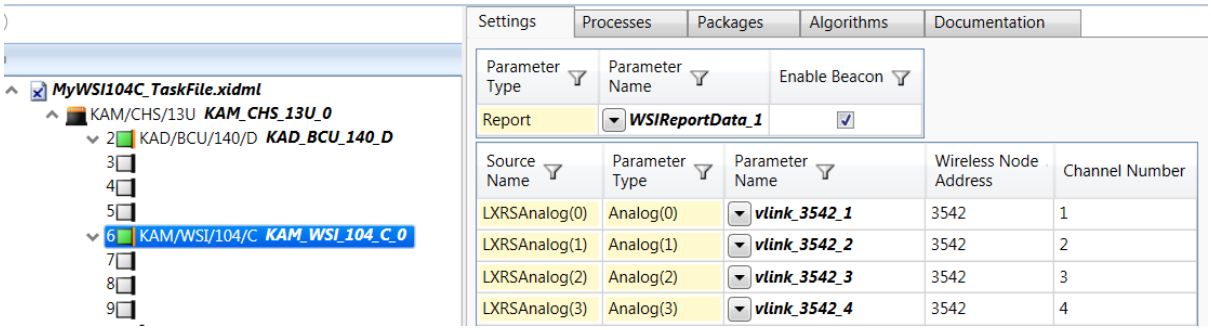


Figure 54-3: KAM/WSI/104C Settings tab

Enter both the wireless node address and the channel number to create a mapping to a parameter. Rename the parameter to suit. (Including the node ID and channel number in the name, as in example above for node *vlink #3542*, may be a useful viewing aid.) Leave unused parameters as address 65535.

As shown in the following figure, the wireless node address (also known as node ID) is visible in SensorConnect and printed on the node label as part of the serial number. (In the serial number format XXXX-YYYYY, the YYYYY is the node ID.) The channel number corresponds to the input ports on the node.

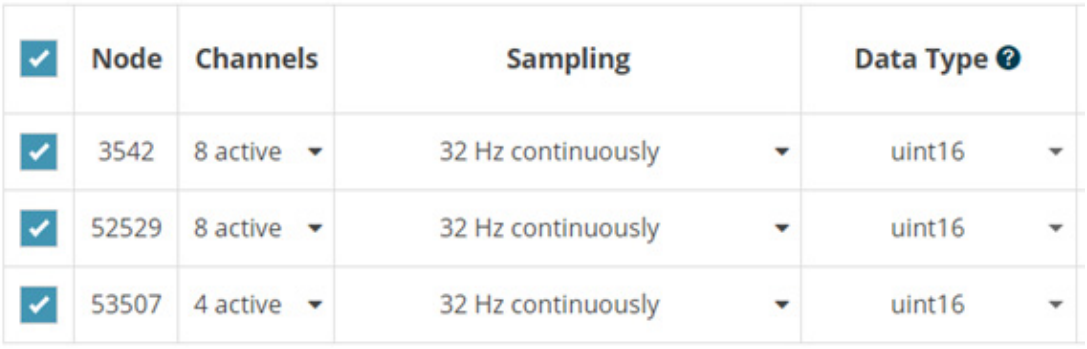


Figure 54-4: SensorConnect network setup showing Node ID and 32Hz sampling rate

You can now place these parameters in PCM or Ethernet or any standard Curtiss-Wright output format. Refer to the “Package Generator” chapter of the *DAS Studio 3 User Manual*.

When placing the parameters in a package, ensure that the sampling rate for the parameter on the KAM-500 backplane matches the sampling rate for the data source. It must be the same rate as is assigned to the node in SensorConnect (see the previous screen). This example uses 32 Hz for both the parameter sampling rate and the node sampling rate. The sampling rate for the parameter can be doubled by doubling the number of occurrences in the package.

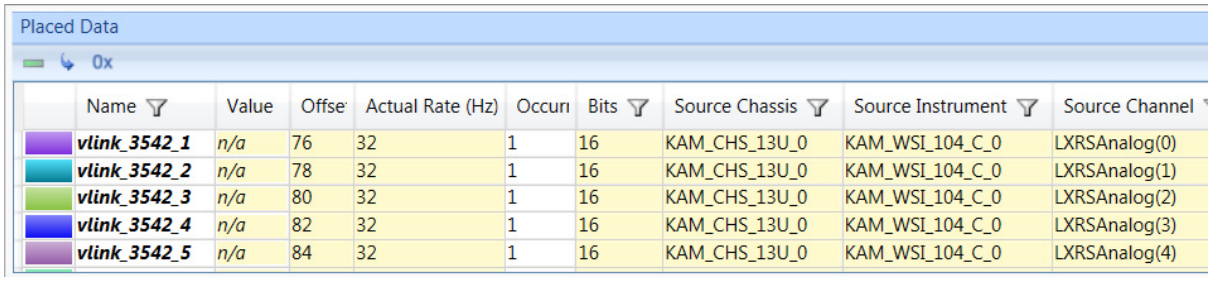


Figure 54-5: Placed Data pane in a KAD/BCU/140 Package tab in DAS Studio 3

Inactive (*dead*) nodes or invalid mappings have their placed data replaced with a constant value, 0xDEAD.

54.3.2 Packetizer

The packetizer supports both IENA and INET-X formats, but it cannot mix formats.

There is a unique packetizer stream for *LXRS RAW* packets. If enabled, this stream fires on every data packet received from the gateway, from any connected node, whether or not it is mapped to any stream or parameter. The contents are the data packet with a wrapper, following the *LXRS RAW* format in the *KAM/WSI/104* data sheet. These can be decoded in Wireshark using an *LXRS* dissector; contact Curtiss-Wright support (acra-support@curtisswright.com) for details.

Packetizer

Source Name	Packetizer Format	Stream Id	IENA Type	IENA Key	Packetization Enabled	IENA-M Param ID	Packetization Sink
LXRSRaw	iNET-X	ABCD0A9A	N/A	0	☑	0	All

Figure 54-6: LXRS Raw packetizer settings in DAS Studio 3

The *LXRS Node* packetizer streams reformat the received data from a matching node into *Analog Packetizer* format, described in the *KAM/WSI/104* data sheet.

LXRS Node packetizers require a unique iNET-X stream ID (or IENA key) and a node ID (Wireless Node Address). The same node ID cannot be used for two different streams; it must be a 1:1 mapping between streams and nodes. The **Packetization Enabled** check box must be selected for streams to be active.

Source Name	Packetizer Format	Stream Id	IENA Type	Packetization Enabled	IENA Key	Wireless Node Address	Packetization Sink
LXRSNode(0)	iNET-X	dc52940	N/A	☑	0	52940	All
LXRSNode(1)	iNET-X	dc03542	N/A	☑	0	3542	All
LXRSNode(2)	iNET-X	dc52529	N/A	☑	0	52529	All

Figure 54-7: LXRS Node packetizer settings in DAS Studio 3

DAS Studio 3 assigns a destination IP unique to the stream after verification. These can be edited in the Packages tab of the KAD/BCU/140. Note the *Sub Type* and *DataType* identifying the streams.

Package Properties

Name	Rate (Hz)	Type	Sub Type	Stream ID	Source IPA	Source UDP Port	Destination MAC	Destination IPA	Destination UDP Port	DataType
KADBCU140D01ut100	64	INet-X	Placed	D000	000.000.000.000	1023	01-00-5E-00-00-01	235.0.0.1	1023	n\a
KAMWSI104C_ABCD0A9A	576	INet-X	Parser aligned	ABCD0A9A	192.168.28.1	1023	01-00-5E-00-00-02	235.0.0.2	8010	LXRSRaw
KAMWSI104C_DC03542	640	INet-X	Parser aligned	0dc03542	192.168.28.1	1023	01-00-5E-00-00-0B	235.0.0.11	8010	LXRSNode
KAMWSI104C_DC52529	640	INet-X	Parser aligned	0dc52529	192.168.28.1	1023	01-00-5E-00-00-0C	235.0.0.12	8010	LXRSNode

Figure 54-8: DAS Studio 3 Package tab showing the packetizer packet automatically added after verification

54.3.3 Report and Beacon

The Enable Beacon check box next to the Report parameter is enabled by default. It is recommended to keep the beacon enabled, as the beacon allows the nodes to detect the base station. The beacon is sent at 1-second intervals and contains a timestamp from the KAM-500 which the nodes use to synchronize their clocks with the KAM-500.

The Beacon status does not affect the contents of the Report parameter word. The Report flags are defined in the KAM/WSI/104 data sheet. The Report also contains a count of currently active nodes.

Parameter Type	Parameter Name	Enable Beacon
Report	***WSIReportData_1***	☑

Figure 54-9: Report parameter and Beacon setting in DAS Studio 3

54.4 Talking to the gateway

For this procedure, you need a PC with SensorConnect installed and the USB cable (ACC/CON/051) supplied with the KAM/WSI/104 module.

54.4.1 SensorConnect

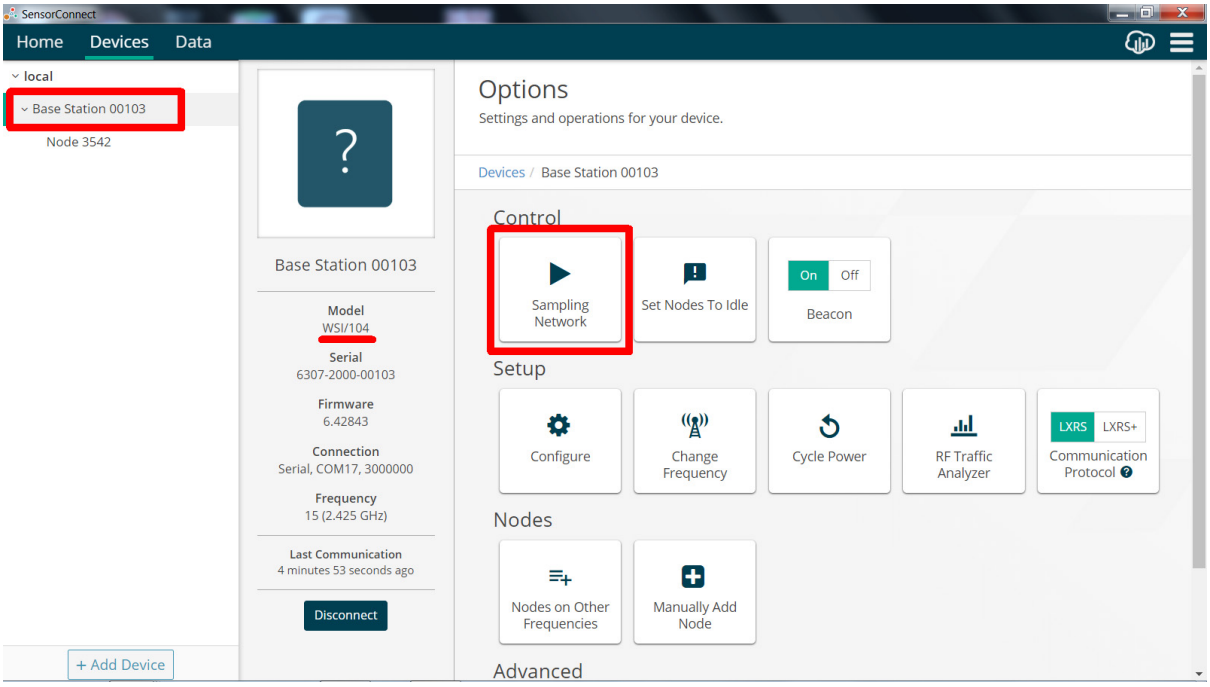
SensorConnect is Windows-compatible software from LORD (MicroStrain) for communicating to a base station over USB.

It is available from https://www.microstrain.com/software/sensorconnect.

Download and install SensorConnect to a PC.

54.4.2 Communication

1. Connect the USB cable to the KAM/WSI/104 top block and to the PC.
2. Power up the KAM-500 chassis and start SensorConnect.
3. The first run of SensorConnect creates a default data depository, visible under the **Home** tab. This stores base station and network configurations. (Refer to SensorConnect documentation if you want to change the data depository or save location.)
4. Click the **Devices** tab.
5. In SensorConnect, the KAM/WSI/104 appears as a Base Station, model **WSI/104**.



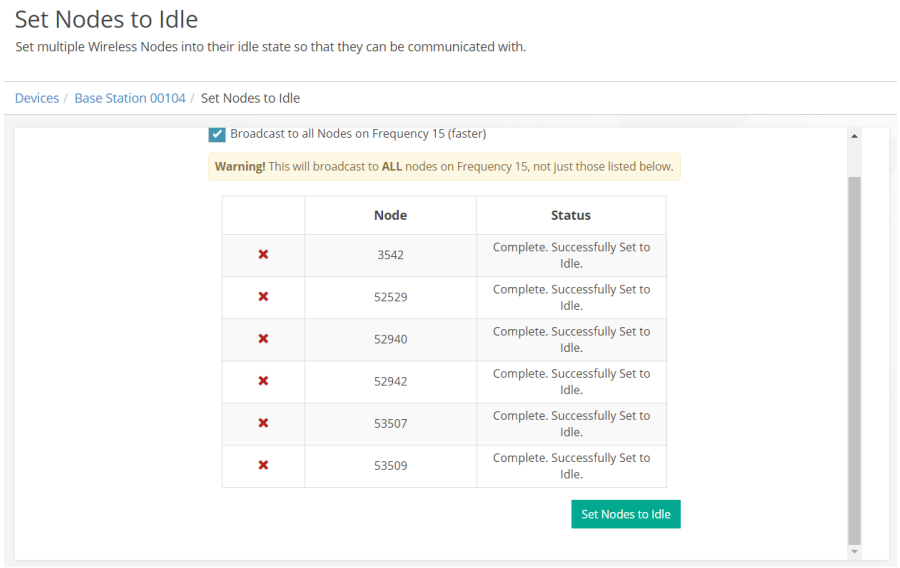
6. Power up the remote node(s). After a few seconds (assuming factory default settings) Series 200 nodes appear in the SensorConnect device list. Older nodes such as VLink-LXRS need to be put into idle mode to be recognized; this is easily done by toggling the node's power switch rapidly off and on twice.

   Nodes that don't show up automatically can be checked using the **Manually Add Node** command and entering the ID; they are added if they respond to a ping request sent as part of this procedure. Refer to the SensorConnect user guide for more details.

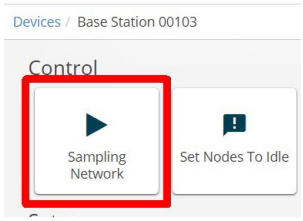
54.4.3 Setting up the network

This section covers setting up the nodes to form a sampling network. Settings can be sent to each node individually, however it is faster to use the base station menu and the **Sampling Network** button to set up multiple nodes on the same screen.

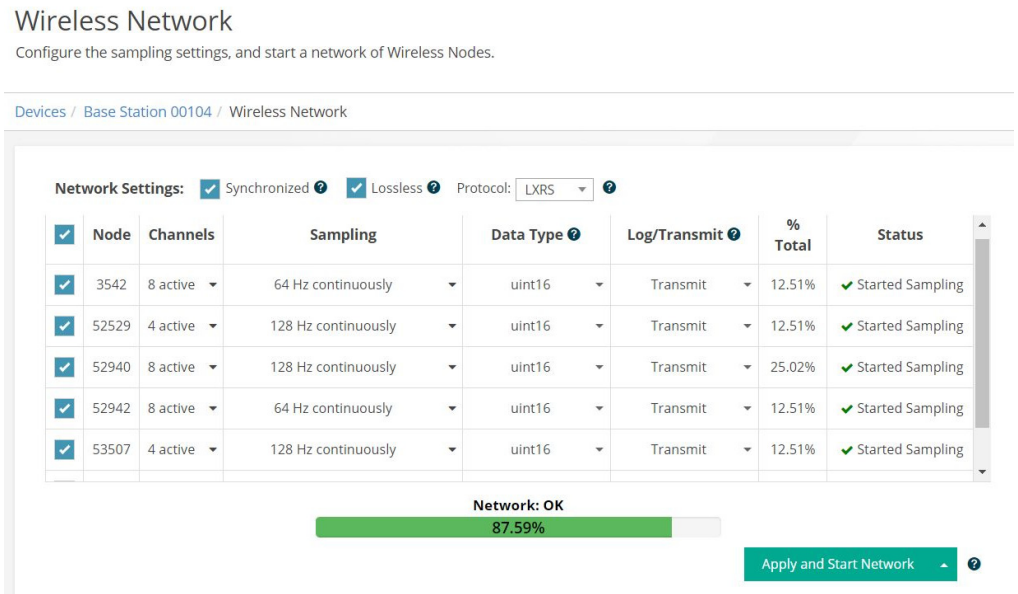
1. Click **Set Nodes To Idle** to set all nodes into their idle state.
   Nodes in idle mode respond to setup commands.



2. Click the base station **Sampling Network** control.



The **Wireless Network** screen appears.



3. Set the sampling frequency for each node to match the sampling rate in the KAM/WSI/104 task file.
   a. The supported **Network Settings** are [Synchronized=TRUE, Lossless=TRUE, Protocol=**LXRS**].
   b. The supported settings for nodes are [Data Type=**uint16**, Log/Transmit=**Transmit**].
   c. **Channels** and **Sampling** are drop-down menus that can be customized per node.
   d. Total bandwidth requirement must be < 100%. The **Apply** button is disabled if the total bandwidth requirement exceeds 100%.

Channels that are mapped to KAM/WSI/104 placed parameters must be active to transmit the data. Inactive channels are replaced by placeholder value 0xDEAD.

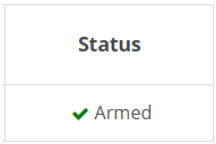
54.4.4 Starting the network with backplane controller as time source

The base station sends out *beacon* packets to synchronize the nodes to its time source. It is possible to start an ad-hoc network immediately by clicking **Apply and Start Network** while SensorConnect is running on the PC, however it will start with timestamps based on the PC clock. (After the USB cable is unplugged, it can take a minute or two for the network to resynchronize to the KAM-500 backplane controller timebase.) The following procedure starts the network with the KAM-500 backplane controller as time source instead of the PC.

1. After setting up the synchronized sampling network, click the **Apply and Start Network** drop-down menu and then select **Apply and Arm Nodes**.

   The node status indicates **Armed** when the command is received.

2. Power down the KAM-500 and unplug the USB cables.
   (SensorConnect can be powered down at this stage.)
3. Power up the KAM-500.
   About a minute after startup, the nodes synchronize to the KAM-500 beacon and start transmitting data.

NOTE: SensorConnect turns on and off the beacon as required when arming the network, as does the KAM/WSI/104 when rebooted. There is a Beacon button in SensorConnect base station menu but there shouldn't be any need to use it.

54.4.5 Viewing data in SensorConnect

SensorConnect has a Data tab that can display live node data in widgets and dashboards. This can be useful for verifying incoming data at the gateway, independently of its path through the KAM-500 system. This live display is only possible while the USB cable is connected. Once this connection is removed, you cannot view the signal in SensorConnect.

For more on this and the Data Depository tab, refer to the SensorConnect built-in help and documentation.

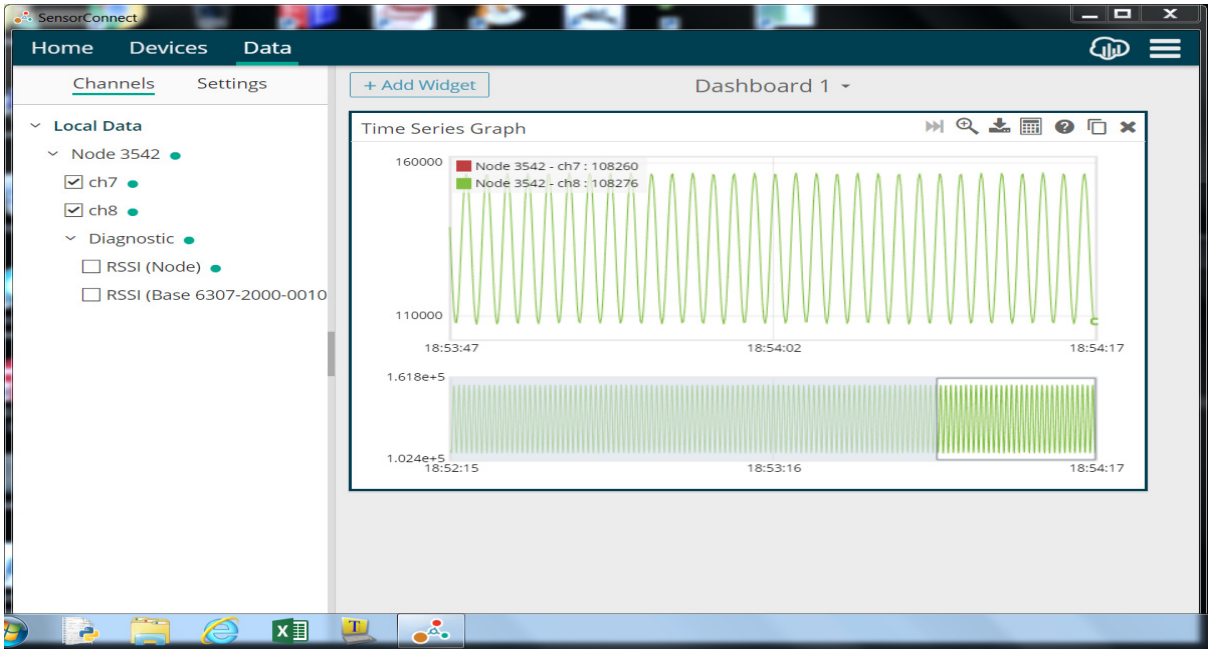


Figure 54-10: SensorConnect Data tab

54.5 Timestamping and latency

Incoming data for mapped analog channels is buffered by the KAM/WSI/104. The buffers are slightly larger than one second in depth and the data has a fixed one-second latency (based on sampling rate) between receipt from the gateway and output as a placed parameter.

If the received data rate is less than the outgoing data rate—due to radio network packet losses or under sampling—the under filled buffer does not have valid data for its entire length.

If incoming data is more than one second old, it is not recognized as old data and is still placed in the buffers. This is a known issue.

The latency is only relevant to placed analog parameters. The packetizers transmit a packet immediately when a message is received and processed.

The nodes operate on a UTC internal clock with node-to-node synchronization of 50 µs and synchronized to the base station beacon packets. When a node sends a data packet, the timestamp corresponds to the time of the first sample in the packet. IENA packetizers use the UTC timestamp provided by the node. iNET-X packetizers use a PTP timestamp so leap seconds (defined in the backplane controller setup) are added to the node timestamp. This *first sample* timestamp is regardless of network transport time, packet length, or retries required.

54.6 LED behavior

As an aid to debugging and bench testing, the KAM/WSI/104 has a mode LED (D1) and an activity LED (D5) on the motherboard. They are not visible when all chassis slots are covered by lids or modules.

When the USB connection to the PC is active, D1 is red.

When there is a node detected on the network, D1 is green.

When neither of these is true, and the module is polling for nodes, D1 is blue.

When the gateway is actively receiving node data samples, D5 is green and flickering.

There are also LEDs on the gateway board that follow D1 behavior.

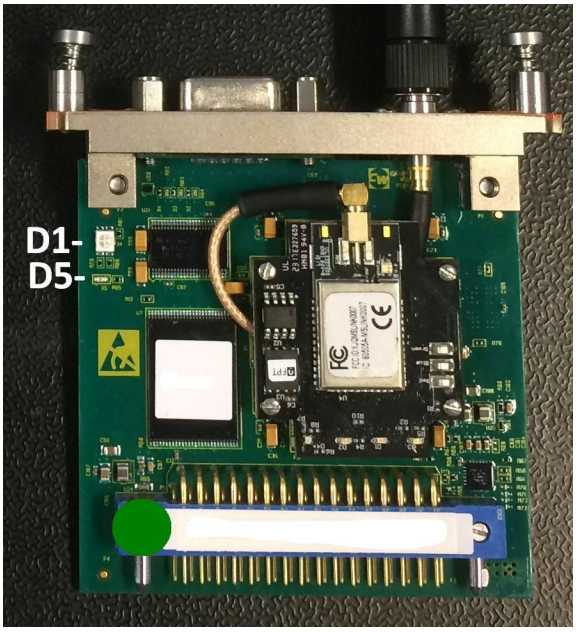


Figure 54-11: KAM/WSI/104 LED location

54.7 Wireless network tips

LXRS network behavior is covered in more detail in LORD documentation.

54.7.1 Radio interference and lossless mode

Under noisy RF environments, packets can be lost. When the network is in lossless mode, unacknowledged packets are buffered by the node and retransmitted until acknowledged. This can compensate for the odd missed packet with no visible effects in the packetized or placed data sequence.

Even with lossless mode, under poor conditions some packets may be delayed and arrive too late to be placed in the correct latency buffer, and corrupt the placed data feed. Packetized streams are not affected by delays.

Under extremely poor conditions the node buffering itself may fill up causing the oldest data in the node to be lost permanently. (See “54.8 References” on page 12 - LORD technical note link.)

Under good conditions with no need for retransmission, there is very little network delay and the delay has near-deterministic timing.

54.7.2 LXRS vs LXRS+ protocol

Some newer nodes support both the LXRS and LXRS+ protocol. The LXRS protocol has greater range whereas the LXRS+ protocol supports higher speeds. (See “54.8 References” on page 12 - LORD technical note 8401-0084 link.) The KAM/WSI/104 only supports the LXRS protocol at this time.

Figure 54-12: Communication protocol button

54.7.3 Frequencies

There are 14 available frequency channels between 2.405 and 2.470 GHz. Wireless nodes and the gateway must be on the same frequency channel to communicate. (See “54.8 References” on page 12 - LORD user manual link.)

This guide assumes the factory default (channel 15) is used for all nodes and the base station. It is possible to set up or migrate the entire network to another available frequency using the SensorConnect *Change Frequency* utility.

One strategy to mitigate noise is to move to a less noisy channel. SensorConnect has an *RF Traffic Analyzer* utility for monitoring the available frequencies to help determine which ones are noisy and should be avoided.

Figure 54-13: Change Frequency and RF Traffic Analyzer utilities

Two KAM/WSI/104 base stations can operate with overlapping range (even in the same chassis) if they are on different frequencies.

NOTE: In this case, the limit of 24 WSI packetizers per chassis applies and must be split between the base stations.

54.7.4 Transmit Power

Both the nodes and the base station have adjustable transmit power settings.

Transmit Power can range from 0 to 20 dBm. Higher transmit power normally helps with communication but can reduce battery life of the nodes, and may affect other electronic devices by adding to EMI. The default power setting is 10 dBm.

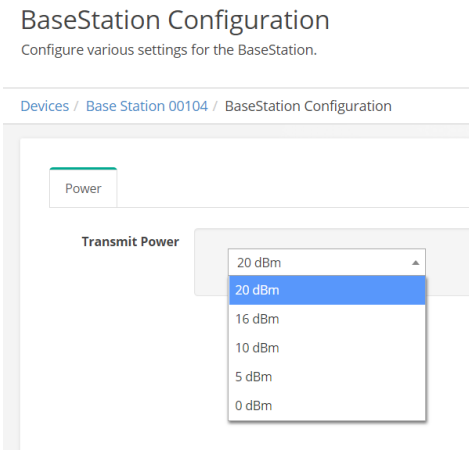


Figure 54-14: Transmit Power range

Range testing and received signal strength indicators (RSSI) are available through the Node menu in SensorConnect, as shown in the following figure.

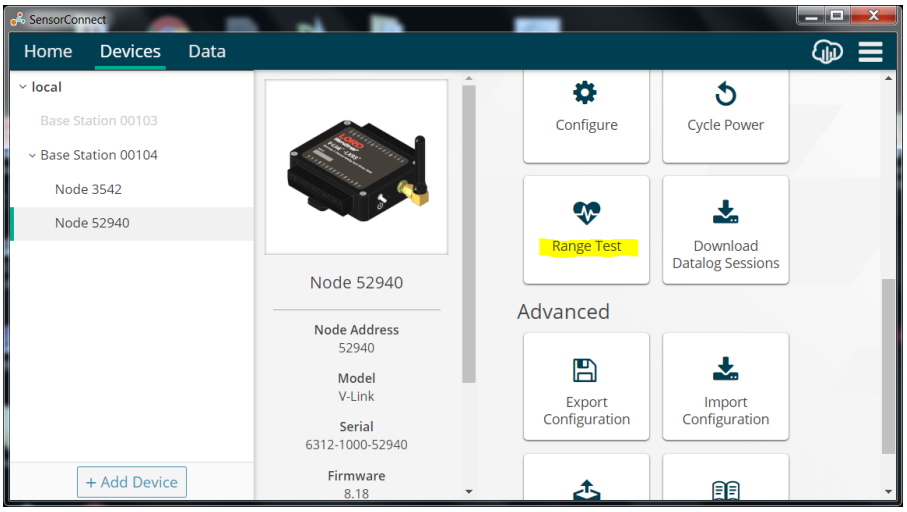


Figure 54-15: Range Test control

RSSI data from nodes is also available on the SensorConnect Data tab and in LXRS RAW data.

54.7.5 Node configuration

Node configuration is done through the Configure command on the Node menu. The Power tab allows setting the transmit power level and the default power-up and power-off behaviors. For Analog nodes the Hardware tab allows changes to the range and gain of the input amplifiers. Refer to node data sheets for limits and other details.

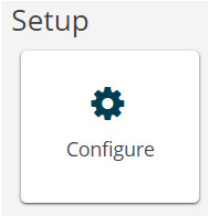


Figure 54-16: Node configuration control

The following figure shows the Power tab of the Wireless Node Configuration control panel.

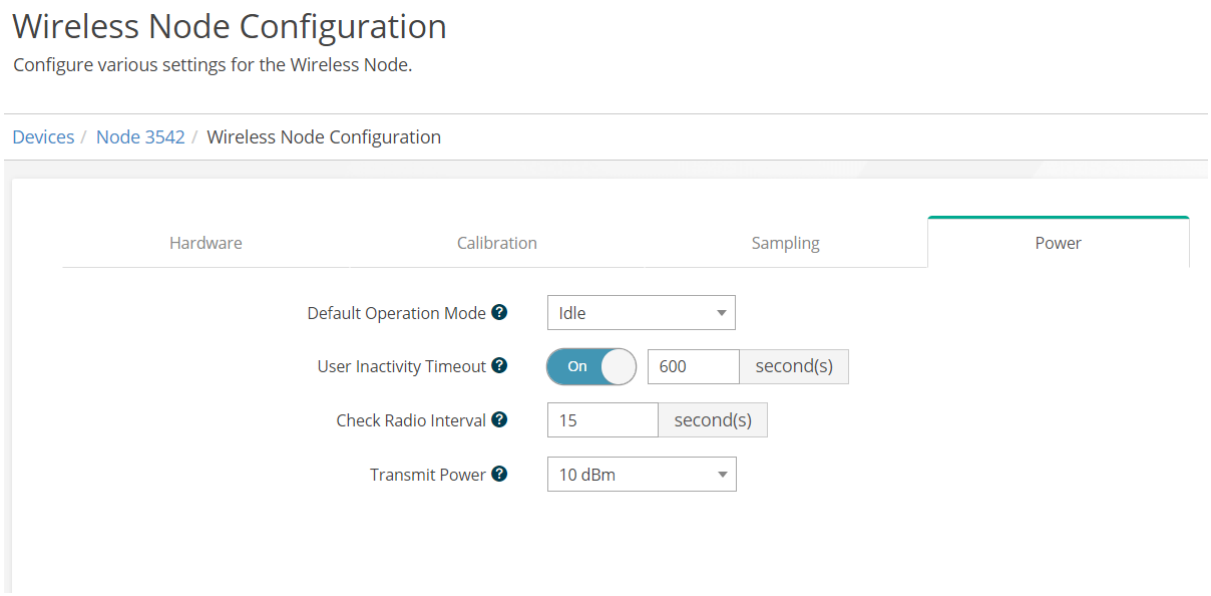


Figure 54-17: Wireless Node Configuration Power tab

54.7.6 Antenna location and orientation

Range is maximized by having line-of-sight between antennas, and decreases when line-of-sight is blocked by metalwork, cables and backshells—especially shielded cables going to the KAM-500 chassis.

54.8 References

LORD technical note 8401-0084 *LXRS® and LXRS+ Wireless Sensor Protocol*

https://www.microstrain.com/sites/default/files/tech_note_-_lxrs_and_lxrs_8401-0084_0.pdf

LORD user manual *WSDA®-200-USB Wireless USB Base Station*

https://www.microstrain.com/wireless/WSDA-200-USB

SensorConnect screenshots taken from version 10.4.9.

https://www.microstrain.com/software/sensorconnect

DAS Studio screenshots taken from version 3.4.11.

acra-support@curtisswright.com