Sure Cross® MultiHop Configuration Software

Instruction Manual

Original Instructions
150473 Rev. G
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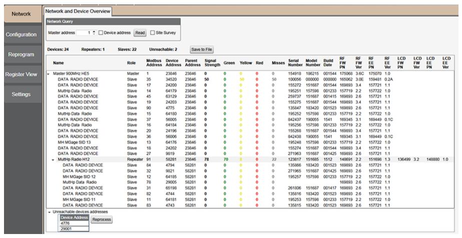
150473

Contents

1 MultiHop Configuration Software

Use Banner's MultiHop Configuration Software to view your MultiHop radio network and configure the radio and its I/O.



The software connects to a MultiHop master radio using one of four methods.

- Serial; using a USB to RS-485 (for RS-485 radios) or a USB to RS-232 (for RS-232 radios) converter cable.
- Modbus TCP; using an Ethernet connection to an Ethernet radio master.
- Serial DXM; using a USB cable to a DXM Controller to access a MultiHop master radio.
- TCP DXM: using an Ethernet connection to a DXM Controller to access a MultiHop master radio.

For MultiHop DX80DR* models, Banner recommends using BWA-UCT-900, an RS-485 to USB adapter cable with a wall plug that can power your 1 Watt MultiHop radio while you configure it. The adapter cable is not required when connecting to a DXM Controller.

Download the most recent software revision from the Wireless Reference Library on Banner Engineering's website: www.bannerengineering.com.

1.1 Installation

Use the MultiHop Configuration Tool to configure the radios within your MultiHop radio network. The MultiHop Configuration Tool uses a USB to RS-485 converter cable to connect a MultiHop radio to a USB connection on a computer.

Installing the Software—Before connecting the USB to RS-485 adapter cable, install the MultiHop Configuration software downloaded from the Banner Engineering website. To ensure a complete installation, verify you have an active Internet connection or .NET 4.5 (or higher) before installing the software.

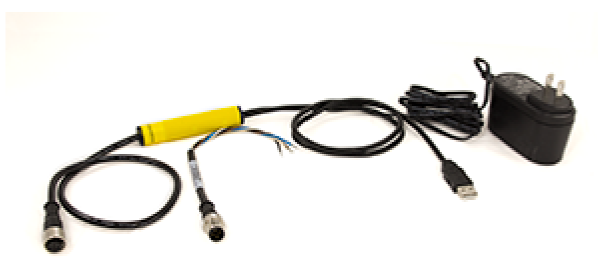


Figure 1. BWA-UCT-900 Adapter Cable

Figure 2. BWA-HW-026 Power Cable

Connecting the MultiHop Radio using the USB/Converter:

1. Complete the software installation.
2. Connect the USB end of the Banner USB converter to a USB port on the computer. The computer should recognize the Banner USB converter device.
3. Connect a Banner MultiHop radio to the Euro-style connector end of the USB converter. The MultiHop radio powers up. When using a third-party USB converter, manually wire the communication and power connections. Refer to Banner's MultiHop radio datasheet for the wiring pin-out configurations.
4. Launch the MultiHop Configuration Tool software.
5. Select the USB from the pull down list.
6. Use the **Device** > **Connection Settings** menu to select a port. The factory default baud rate is 19.2k, 1 stop bit, no parity.

Connecting to a MultiHop Radio using a DXM Controller:

1. Connect a USB cable from a USB port on the computer to the USB port on the DXM Controller.

2. For Ethernet, connect an Ethernet cable from the DXM Controller to an ethernet switch.
3. Cycle power on the DXM Controller after the Ethernet cable is attached to the DXM Controller.

For most of the MultiHop Configuration Tool screens, a grayed box represents a parameter read from the device, the control is inactive, or the software is reading a field. A white box represents parameters entered by the user.

1.2 Menu Bar

The **File** and **Device** menus select the basic file operations and communication configuration for the DX80 Gateway.

Access the **File** and **Device** menus from the menu bar.

File Menu

Exit—Closes the COMM port and exits the program. Any data that is not saved is lost.

Load—Loads a specific XML configuration file into the tool for editing. This XML configuration file is unique to the MultiHop Configuration Software and is not compatible with other configuration tool XML files.

New—Loads blank configuration settings into the tool.

Save—Saves the current settings in the configuration tool under the current XML file name. The program switches to Save As if there is no XML file name assigned.

Save As—Saves the current settings in the configuration tool to a new file name specified by the user.

Device Menu

Traffic Watcher—Views all serial data traffic between the host and the master radio. The Traffic Watcher logs file loads, error messages, and data transfers.

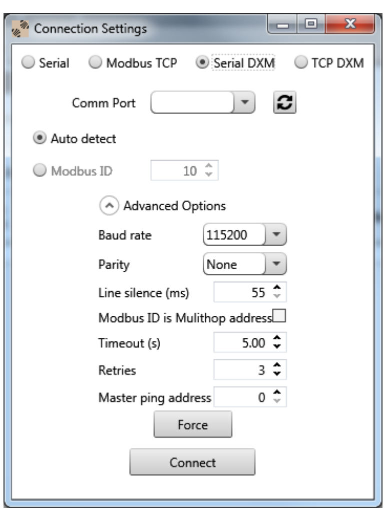
Connection Settings—Sets the COMM port to communicate with the master radio. There are four possible connection with the MultiHop Configuration Software.

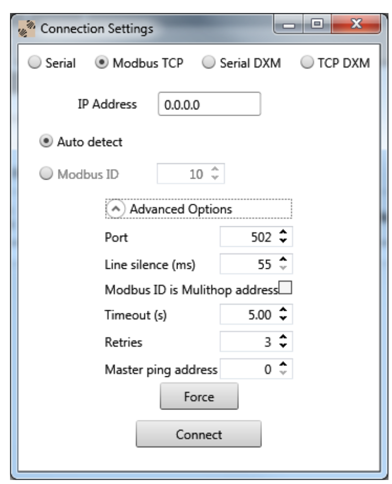
Serial—Direct connection to the master radio using a RS485 to USB converter cable.
Serial DXM—Connecting to a DXM internal ISM radio using USB
TCP DXM—Connecting to a DXM internal ISM radio using Ethernet; select the VPN checkbox only when your DXM is connected to the Internet via a cell modem

1.3 Connection Settings

The configuration software connects directly to a standalone Gateway or Master device by using the USB to RS-485 adapter cable. When using a DXM Controller, you may connect to the internal radio or any MultiHop radio attached to the DXM Controller, through the DXM Controller.

After the software launches, go to **Device** > **Connection Settings** to choose one of the four communication modes: **Serial**, **Modbus over TCP**, **Serial DXM**, or **TCP DXM**.





Basic Connection Settings

Comm Port / IP Address—Select the COMM port of the PC or, when using Ethernet, the IP address of the device. Click the refresh button to refresh the COMM ports on the PC.

Connect/Click to Cancel—Click to verify a radio is present by reading back the RF firmware. After a connection is in progress, this button changes to **Click to Cancel**.

Modbus ID—Modbus address ID of the radio.

Modbus TCP—Use when connecting to a standard DX80 Gateway or MultiHop master radio using an Ethernet connection. The IP address must be known to communicate with the device.

Serial—Use when directly connecting to a standard DX80 Gateway or MultiHop radio using the USB to RS-485 adapter cable.

Serial DXM—Use when configuring an internal radio of the DXM Controller using the USB connection on the DXM Controller.

TCP DXM—Use when configuring the internal radio of the DXM Controller using the Ethernet port. The standard DXM TCP port is 8844.

Advanced Connection Settings

Baud Rate (Serial only)—Defines the baud rate for the serial connection of the USB to RS-485 converter or DXM USB connection. Default of 19200 for the USB to RS-485 converter or 115k for the DXM USB connection.

Force—Click to have the software use the selected parameters and force a connection to a device without validating the device is present.

Line Silence—Specifies the wait time between two consecutive Modbus messages created by the DXM Controller. Too short of a wait time may cause external Modbus devices to miss or create errors on Modbus traffic. A typical setting should be 50 to 100 ms.

Master Ping—For most applications, leave the Master Ping set to 0. To communicate directly with a DXM baseboard, set the value to 2. Using Master Ping allows you to have multiple master radios on a single network. For more information about this advanced setting, contact Banner Engineering Corp and ask to speak to a Wireless applications engineer.

Parity (Serial only)—The default parity setting is None. Optional settings are Even or Odd.

Port (Ethernet only)—Defines the Ethernet port used when communicating via Modbus/TCP or to the DXM Controller. The default is 502.

Retries—The number of times the software resends Modbus messages before it errors out. The minimum number of retries is three.

Timeout—The time allowed for a Modbus message to complete. The default time out is 0.5 seconds for a serial connection and 5 second for a TCP connection. This may need to be extended for battery-powered devices or networks with communications paths that include multiple repeater devices.

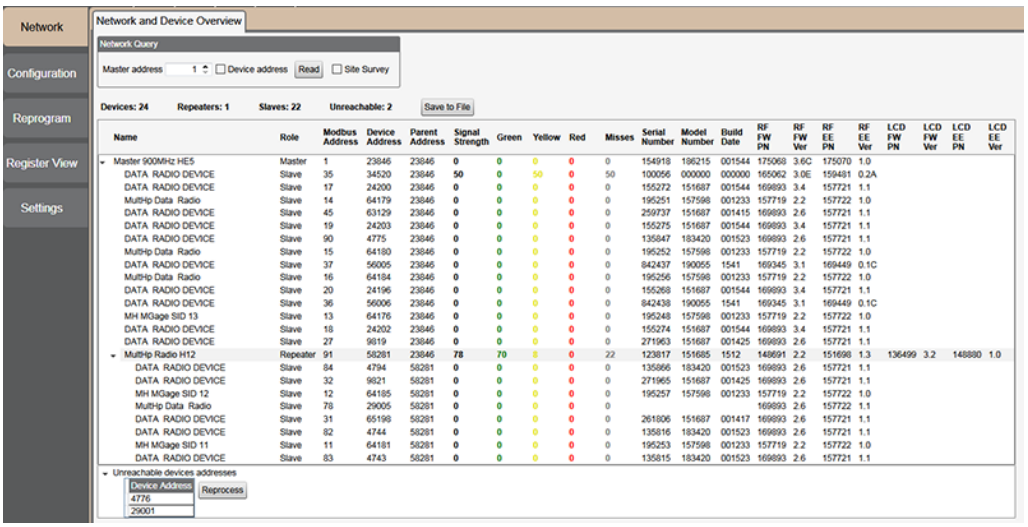
2 Software Screens

The following sections explain the function of each screen.

2.1 Network and Device Overview Screen

The **Network and Device Overview** screen displays an organized view of the MultiHop radio network, noting which devices are the master, repeaters, and slaves.

The network structure is indicated by the format of the list. MultiHop radios are indented to indicate which parent they are communicating with. In addition to displaying the structure of the data radio network, signal quality information is displayed in a color-coded format for easy viewing.



Device Address—The device address (DADR) is a unique number based on the device's serial number and is set by the factory. This address displays as part of the RUN menu's auto-loop display on the device's LCD screen while the radio is operating.

Device Role—The devices are listed as Master (only one per network), Repeater, or Slave. Set the device type using each radio's DIP switches.

Master—The master radio controls the overall timing of the network and is always a parent device for other MultiHop radios. The host system connects to this \master radio.
Repeater—When a MultiHop radio is set to repeater mode, it acts as both a parent and a child. The repeater receives data packets from its parent, then re-transmits the data packet to the children within the repeater’s network.
Slave—The slave radio is the end device of the data radio network. A MultiHop radio in slave mode does not re-transmit the data packet on the radio link.

Modbus Address—Set the MultiHop radio ID using the radio's rotary dials. Note that the MultiHop radio ID is also the Modbus Slave ID. The Modbus Address (Modbus ID) must be a unique number to access I/O point data on the radio device. For radio devices that do not have I/O and to not want to be individually accessed, a Modbus ID is not required.

Model Number—The model number is a 6-digit number used by the manufacturer to identify the device model of the radio.

Name—Use the name string to identify the radio device. The name is saved in the MultiHop device. Change the name using the **Configuration** screen.

Parent Address—The master radio and repeater radios act as a parent device to slave radios. The parent radio provides network timing and data routing to slave radios.

Radio (RF) and LCD Firmware (FW) and EEPROM (EE)—These parameters are set at the factory. You may be asked for this information if you call Banner Engineering for technical support. To update these programs, obtain the newest versions from the factory, then use the **Reprogram** screen to copy these files to your radio.

RF FW—Part number and version number for installed firmware of the radio microprocessor.
RF EE—Part number and version number for installed EEPROM of the radio microprocessor.
LCD FW—Part number and version number for installed firmware of the LCD microprocessor.
LCD EE—Part number and version number for installed EEPROM of the LCD microprocessor.

Save to File—Saves the information displayed on the screen (device name, type, address, etc) to a text file.

Serial Number—The serial number is a 6-digit, unique number that identifies that specific radio. No other radio will be assigned this number. Each Sure Cross radio uses its serial number to generate the device address that displays on the **Network and Device Overview** screen and the radio's LCD.

Signal Strength—The number of packets successfully transmitted, during a site survey, at the various signal strengths are represented by the "green," "yellow," and "red" delineations.

Green—a strong radio signal
Yellow—a good radio signal
Red—a marginal radio signal
Misses—represents the number of packets not received on their first transmission

Unreachable—The unreachable devices are radios the master radios has detected but was unable to locate them during the last scan. From the Unreachable drop-down list, select a device or range of devices and click **Reprocess**. The master radio will attempt to connect to and read this device.

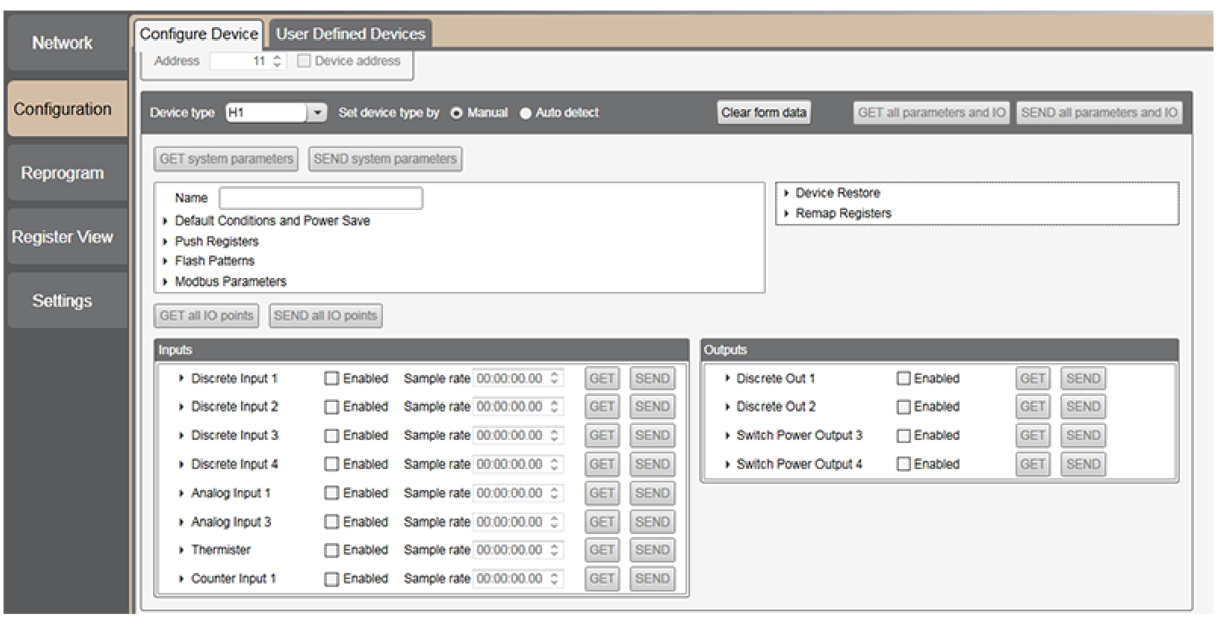
2.2 Configuration Screens

The **Configuration** main tab allows you to configure your device by defining device-level parameters and I/O parameters. Use the **User Defined Devices** screen to create a user-defined device for use in your radio network.

2.2.1 Configure Device Screen

Use the **Configure Device** screen to define the default conditions, push registers, flash patterns, Modbus parameters, device restore conditions, and to remap registers.

Enter the Modbus ID of the MultiHop radio you want to configure. To select a MultiHop radio by its unique device address (Not Modbus ID), select the Device Address checkbox and then enter the Device address.



Manual Mode—Select the **Manual Mode** checkbox and select the **Device Type** from the drop-down list. Selectable device types are:

H—M-H (no I/O) models
H1—M-H1 models (including SPRFs)
H2—M-H2 models (including SPRFs)
H3—M-H3 models (including SPRFs)
H4—M-H4 models (including SPRFs)
H5—M-H5 models (including SPRFs)
H6—M-H6 models (including SPRFs)
H12—M-H12 models (including SPRFs)
H14—M-H14 models (including SPRFs)
H1B—M-H1B Board Modules (including SPRFs)
DXM100x1—All DXM100x1 models
H2B—M-H2B Board Modules (including SPRFs)
DXM100x2—All DXM100x2 models
DC-LATCH—MultiHop DC-LATCH models
DXM150x1—All DXM150x1 models
HM—MultiHop M-GAGE models
DXM150x2—All DXM150x2 models
U—MultiHop Ultrasonic and Ultrasonic/Light models

To read the existing parameters, click **GET All Parameters**. To write changes to the selected device, click **SEND All Parameters**.

Reading Configuration Data from the MultiHop Radios

To read, or "get" configuration data from a MultiHop radio anywhere in the network, enter the MultiHop Modbus ID and click the appropriate **GET** button.

> **Note:** The MultiHop Modbus ID is assigned to each device using the rotary dials on the front of all MultiHop radios.

Name

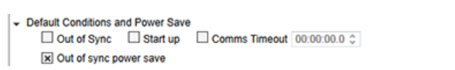
Assign a name to each device to it easier to track the device in the configuration software.

The **Name** must be less than 18 characters and contain only the standard alpha-numeric characters, the following standard ASCII characters: *, +, -, /, <, >, or a space.

After making any changes, click **SEND all parameters and IO** to write all the changes. The status bar at the bottom of the screen indicates the status of the process. Green (Communication Status Ready) indicates the process is complete. Red (error) indicates an error. Yellow (Getting Data) indicates the network is retrieving the requested data.

Default Conditions

Default conditions are the conditions under which outputs are sent to their defined default state. These conditions apply to all outputs.



When a radio is **Out of Sync**, it is not communicating with its parent radio. Selecting the Out of Sync condition sets all outputs (on this device) to their specific default values when this radio has lost its communication link with its parent radio. The default output values are selected under each of the output parameter sections of this screen.

Selecting **Start Up** sets this radio's outputs to their default values when this radio is powered up.

A **Comms Timeout** refers to the communication between the host system and the selected radio (which may be any radio within the network). Selecting Communication Timeout sets this radio's outputs to their selected default values when the host system has not communicated with this radio within the time specified. Set the communication timeout in seconds.

Selecting **Out of sync power save** sets the radio to low power mode if the radio is out of sync for more than 5 minutes. The radio wakes up every 5 minutes to search for a parent radio. This setting is recommended for battery-powered devices.

After making any changes, click **SEND all parameters and IO** to write all the changes. The status bar at the bottom of the screen indicates the status of the process. Green (Communication Status Ready) indicates the process is complete. Red (error) indicates an error. Yellow (Getting Data) indicates the network is retrieving the requested data.

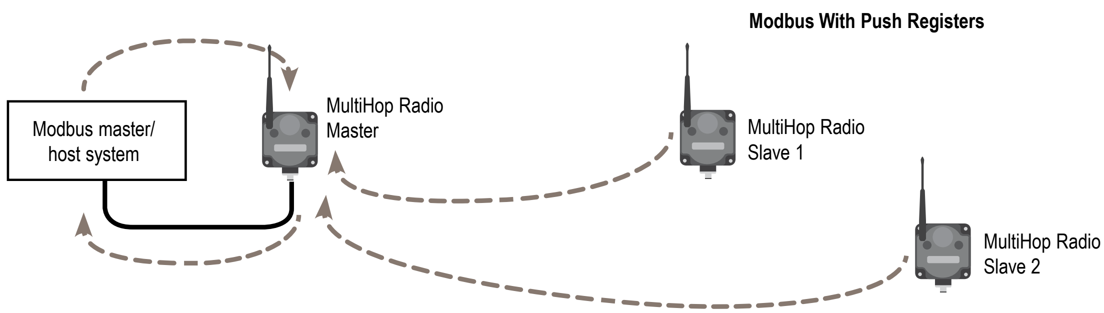
After the radio problems are resolved with the parent radio or communication with the host system has resumed, the host system is responsible for writing the operating output value.

Push Registers

Push registers automatically transmit register data from a MultiHop device back to the master MultiHop radio.

In the MultiHop system, every device is treated as a separate unit. In the Modbus protocol, every device is a Modbus slave device. To get I/O register information, a host system must interrogate each Modbus slave one at a time. This is the standard mode of operation of MultiHop devices and works well for most applications.

Push registers are a feature of the MultiHop system. The user can define up to four registers per MultiHop I/O device that transmit data to be stored at the master MultiHop data radio. This allows a host system to interrogate only the master device for I/O information without dealing with the latency of the wireless link.



Using the push registers is beneficial in applications where:

- End devices are battery powered with infrequent changes, but notification of changes wants to be immediate. Instead of a host continually polling a device for I/O changes, which consumes battery power, push registers transmit data back to the master device when it changes and/or on a periodic cycle.
- A host polling loop becomes impractical because of the time required to communicate with each remote device individually (large networks). The data changes are usually infrequent and the devices are typically battery powered. With large networks, push registers allow each end device to transmit data to the master when it changes and does not rely on the host request to initiate a transaction.

Using push registers is not beneficial in typical monitoring applications with periodic data requirements of a minute or longer.

A side benefit of using the push registers is the ability to use a device status register for each MultiHop device. With a push register interval defined, a **Master Sweep Interval** can be defined to verify the communication of each device pushing data back to the master device. During the master sweep interval, every device must communicate with the master device or the status register will be zero (missed communications).

06800s Push Registers

The following are the push register parameters for each radio. Push register values are stored on the radio master at registers 7909 through 7912, by MultiHop radio ID.

6831 Input Push Register 1

6832 Input Push Register 2, etc through 6850

For a slave or repeater, these define which registers to push to the master device. This allows a slave/repeater to send local input data back to the master without having to wait to be asked for the data.

The Modbus register value should be Modbus Register minus 40001. For example, to push register 40001, write a value of 40001 minus 40001, or 0. To push register 40002, write a value of 40002 minus 40001, or 1.

6871-6872 Push Register Report Interval

Push registers can report on a periodic interval or on change of state. The report interval establishes how often, in frames/slots, to push data to the master. 6871 is the high word and 6872 is the low word. This is typically a slave or repeater parameter.

Set a periodic interval using 40 millisecond units. For example, to set the report interval to 1 minute (60 seconds ÷ 0.040 seconds = 1500 units), write a 0 to register 46871 = 0 and write a 1500 to register 46872.

Enable change of state reporting by writing a 1 to register 43004 for input 1 or register 43024 for input 2. Other inputs have different configuration registers to enable change of state reporting.

6873-6874 Master Sweep (Health Heartbeat) Interval

Works in conjunction with each slave/repeater push register report interval (6871–6872) to create device status information in the master device. This allows the user to monitor the health of each device in the MultiHop network by defining how often the master should expect each repeater and slave to push register values back to the cached copies in local storage on the radio master.

This health check should be at least 10 frames longer than the push register report interval. Use the registers to set a periodic interval using 40 millisecond units.

For example, to set the master sweep interval to 1 minute (60 seconds ÷ 0.040 seconds = 1500 units), write a 0 to register 6873 = 0 and write a 1500 to register 6874; register 6873 is the high word and register 6874 is the low word.

Read the individual status registers for each Modbus slave device by sending a Modbus read command to the particular slave device at register 7904. For example, to read the status register of slave 24, send a Modbus read command to slave ID 24 register address 7904, the contents will be either 0 (bad) or 1 (good). The individual status data can be read by device address (not Modbus address) starting at Modbus register 12701. The master radio register 12701 holds the number of devices in the system. The following registers 12702+ contain the status information for those devices.

A bit-packed version of the status data is available starting at register 12981. The master radio register 12981 holds the number of device in the system, register 12982 holds the status bit fields for devices 0-15, 12983 holds the status bit fields for devices 16-31.

When dealing with device addresses, device order is based on the order they first sync to the master device. That ordered list is stored starting at Modbus registers 7001 in the master radio. Modbus register 7001 holds the count of the number of devices in the network, with the following registers 7002 and greater holding the device address of the MultiHop radio. The order of this list defines how the status bits or words are stored in the master radio.

6875 Report Interval Random Modulus

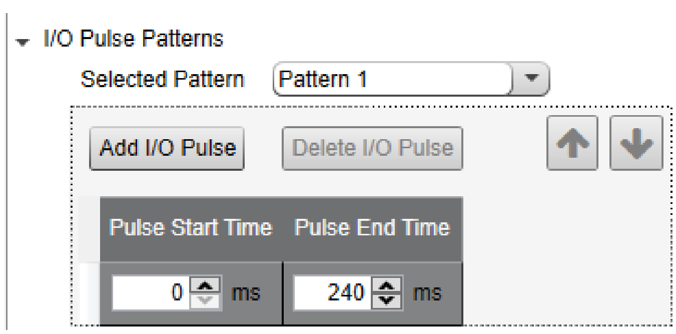
The Report Interval Modulus parameter provides an offset to the report interval between 0 and the report interval modulus to minimize the collisions that occur if multiple radios are reporting back at the same time to the radio master.

Enter this parameter as the number of 40 millisecond frames for the offset. A value of 5 represents 200 milliseconds, or 5 × 0.040 seconds.

For example, if the reporting interval is set to every minute and the report interval modulus is set to 3, the report interval will be every minute to a maximum of every minute + 120ms (3 × 40ms).

I/O Pulse Patterns

Setting the I/O pulse pattern establishes an on and off pattern that can be used for a discrete output or switch power.

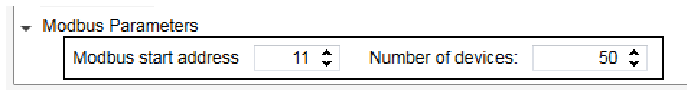


Define **I/O Pulse Patterns** by selecting specific timeslots to turn the output on or off. Although the pulse pattern was originally designed to turn on and off an indicator light, the pulse pattern can be set for any discrete output or switch power. Users may configure up to four different patterns per radio device. In the example shown, Pattern 1 is configured to turn on for the first 240 milliseconds within a 1280 millisecond range.

After making any changes, click **SEND all parameters and IO** to write all the changes. The status bar at the bottom of the screen indicates the status of the process. Green (Communication Status Ready) indicates the process is complete. Red (error) indicates an error. Yellow (Getting Data) indicates the network is retrieving the requested data.

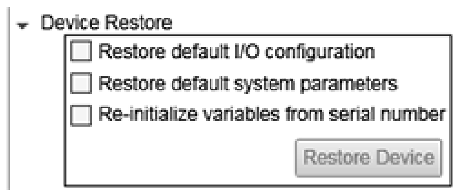
Modbus Parameters

Enter the first Modbus address and the total number of MultiHop devices in the network. These parameters only apply to the master MultiHop radio.



Device Restore

Use these commands to restore default settings to the selected device.

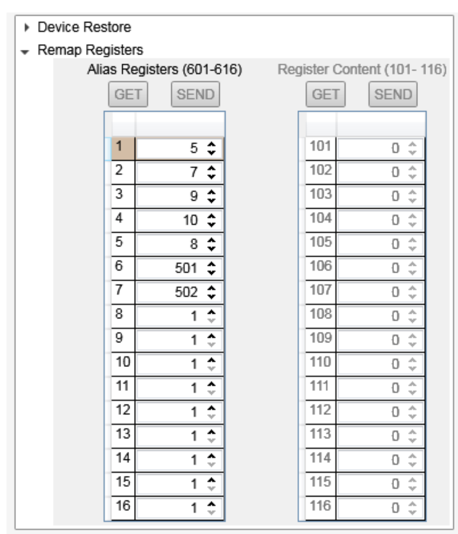


To restore default device parameters:

1. At the top of the screen, select a MultiHop device.
2. Click on **GET All Parameters** to get that device's I/O configuration.
3. In the **Device Restore** section, select the appropriate checkboxes.
    - **Restore Default I/O Configuration**. Restores default I/O configuration parameters to the values indicated in the device's datasheet, such as sample and report rates.
    - **Restore Default System Parameters**. Restore default system parameters, such as the radio configuration and binding code.
    - **Re-Initialize Variables from Serial Number**. Restores the default values of all variables calculated from the serial number. This is not typically recommended.
4. Click on **Restore Device** to restore the selected default values to your device.

Remap Registers or Register Aliasing

Use the **Remap Registers** section of the **Configure Device** screen to map registers to contiguous register locations to optimize Modbus read/write functions.



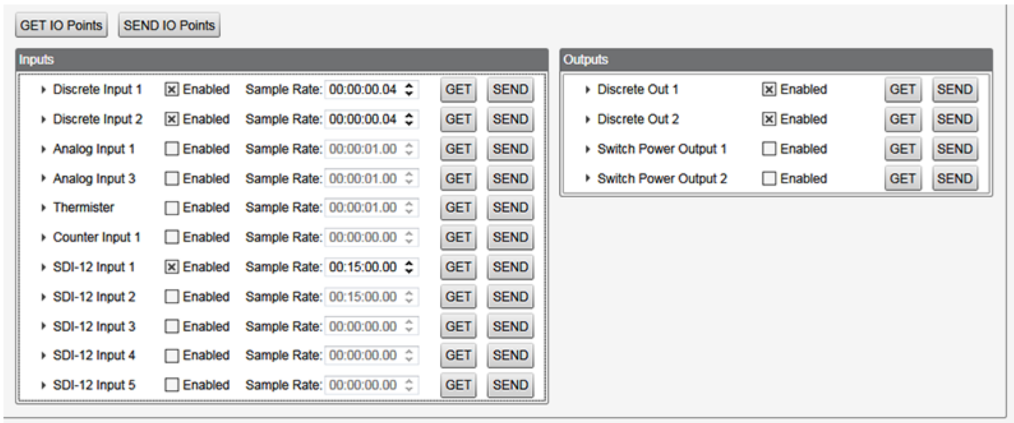
1. Verify the desired MultiHop Radio **Address** is selected in **Configuration Address**.
2. Click the arrow next to **Remap Registers**.

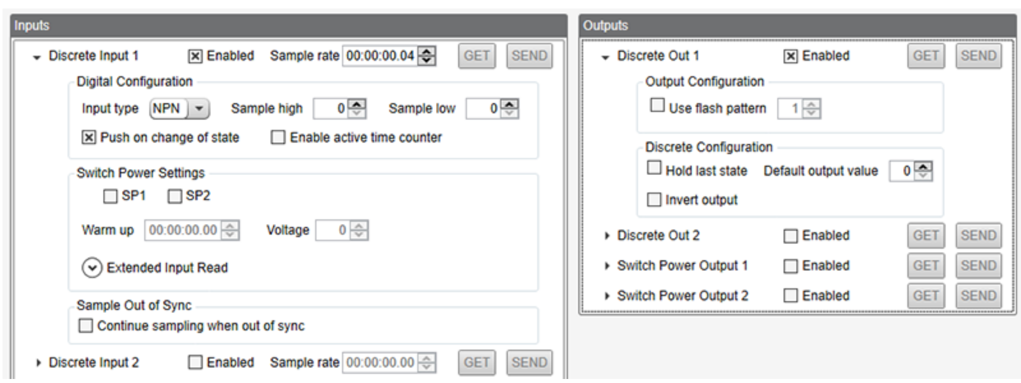
3. Fill in the source registers you would like to alias. The **Alias Registers** rows 1 through 16 are the user-defined entries of addresses of the registers to alias (rearrange). This alias table is stored in the MultiHop radio register addresses 601 through 616. In the example, source registers addresses 5, 7, 9, 10, 8, 501, and 502 are entered into the table.

The aliased **Register Contents** are in registers 101 through 116. For this example, when a host system reads Modbus registers 101 through 107 of the MultiHop radio, the register contents come from register 5, 7, 9, 10, 8, 501 and 502.

Get I/O Points

To configure the inputs and outputs for each MultiHop radio, enter the radio ID at the top of the screen and click **GET all parameters and IO**. All inputs and outputs available for the select device display on the screen.





Select the device you want to configure by using the drop-down list to select the device address. Click **GET all parameters and IO** to retrieve any existing configuration data from the device.

The following commands are general to the entire screen.

Address
: Select the address of the device you want to configure. Click **GET** to retrieve that device's information before making changes to it.

Enabled
: Turns on any specific I/O point. When unselected, the specific I/O point is disabled for the MultiHop radio device selected at the top of the screen

GET
: Click **GET all parameters and IO** to read all system and IO parameters from the radio. Click **GET system parameters** to read only the system parameters. Click **GET all IO points** to read only the IO point parameters. Click **GET** to read the parameters for that specific IO point.

Name
: Enter a name for the device. This name displays on the other configuration screens.

After making any changes, click one of the following to write the changes. The status bar at the bottom of the screen indicates the status of the process. Green (Communication Status Ready) indicates the process is complete. Red (error) indicates an error. Yellow (Getting Data) indicates the network is retrieving the requested data.

- **SEND all parameters and IO**—Writes all changes to all parameters and IO to the network
- **SEND system parameters**—Writes only the changes to the system parameters to the network
- **SEND all IO points**—Writes only the changes to the IO point parameters
- **SEND**—Writes the parameters only for that specific IO point

Inputs

The following parameters are used to configure the inputs.

The input parameters vary, depending on the enabled and available input types.

Input Configuration

Select **Enable** to turn on this input.

Sample Rate

The sample interval, or rate, defines how often the Sure Cross device samples the input. For battery-powered applications, setting a slower rate extends the battery life. Set the sample rate/interval in hours:minutes:seconds.

Analog Configuration

Enable push on change of state

Enables push registers for this input. When the discrete input changes state, the register value is pushed to the master radio if this register is configured to be a push register. For analog inputs, use the threshold and hysteresis parameters to define "on" and "off" points.

Enable register full scale

Turning Fullscale ON sets the entire register range of 0 through 65535 to represent the selected minimum through maximum input values. With Fullscale turned on, a register value of 0 represents the selected minimum value in microamps (for current inputs). A register value of 65535 represents the selected maximum value in microamps. For example, a register value of 0 is 0 and the register value of 65535 represents 20 mA (or 20,000 microamps). With Fullscale turned OFF, the register value represents unit-specific input readings. For units of current (mA), register values are stored as microAmps. Voltage values are stored as millivolts. A sensor reading of 15.53 mA is stored as 15530.

Counter Options

Counter type

Select the counter type: event or frequency. The **frequency counter** calculates the frequency of the input signal, in Hz. The **event counter** counts the total number of times an input signal changes to the high/ON/1 state. The frequency counter is typically used to measure flow rates, such as measuring the flow rate of items on a conveyor or the speed at which a windmill spins. The event counter can be used to measure the total operational cycles of a spinning shaft or the total number of items traveling down a conveyor.

Preset Value

Enter a number in the selection box and press the Set Value button to write a preset counter value to the register.

Digital Configuration

Configure the following parameters for discrete/digital inputs.

Continue sampling when out of sync (discrete)

Select to have the MultiHop device continue sampling the I/O even when the radio is out of sync with its parent radio. This is particularly valuable on counter inputs.

Enable active time counter (Discrete)

Select the checkbox to have the device count the length of time the discrete input is held high.

Input type (Discrete)

Select either NPN or PNP discrete input types.

Sample High and Sample Low

For analog inputs, the sample high parameter defines the number of consecutive samples the input signal must be above the threshold before a signal is considered active. Sample low defines the number of consecutive samples the input signal must be below the threshold minus hysteresis before a signal is considered deactivated. The sample high and sample low parameters are used to avoid unwanted input transitions.

Sample Out of Sync

When a device is not in sync with the wireless network, it will not sample its I/O points. If **Continue Sampling When Out of Sync** is selected, the device continues to sample the I/O when the device is out of sync. This may be useful for counter applications when the network is powered down often.

SDI-12 Configuration

SDI-12 Input—Manually edit the result register parameters.

Address—Enter the device ID for the SDI-12 device.
Command—Select the command type that applies to your SDI-12 sensor.
Registers—Enable each used registers and set the Register Options that apply to your SDI-12 sensor.

Signal Conditioning

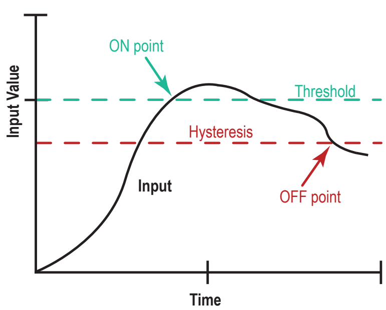
Delta

The delta parameter defines the change required between sample points of an analog input before the analog input reports a new value. To turn off this option, set the Delta value to 0. To use the delta function, the push registers must be defined.

Hysteresis and Threshold (Analog)

Threshold and hysteresis work together to establish the ON and OFF points of an analog input. The threshold defines a trigger point or reporting threshold (ON point) for a sensor input. Setting a threshold establishes an ON point. Hysteresis defines how far below the threshold the analog input is required to be before the input is considered OFF. A typical hysteresis value is 10% to 20% of the unit's range.

In the example shown, the input is considered on at 15 mA. To consider the input off at 13 mA, set the hysteresis to 2 mA. The input will be considered off when the value is 2 mA less than the threshold.



Median Filter

When the median filter is turned on, three samples are taken for each analog sensor reading. The high and low values are discarded and the middle value is used as the analog value. Set to zero (0) to turn off the median filter. Set to one (1) to turn on the median filter.

Sample High and Sample Low

For analog inputs, the sample high parameter defines the number of consecutive samples the input signal must be above the threshold before a signal is considered active. Sample low defines the number of consecutive samples the input signal must be below the threshold minus hysteresis before a signal is considered deactivated. The sample high and sample low parameters are used to avoid unwanted input transitions.

Tau Filter

Set to zero (0) to turn off the tau filter. Set to 1 (weakest filter) through 6 (strongest filter) to turn on the tau filter. (In the DX80 products, the Low Pass Filter is a combination of the median filter and the tau filter.)

Switch Power Settings

Configure the following parameters for the switch power settings (inputs).

Enabled

Associates I/O switch power functions to a specific input. Do not use these parameters to configure continuous, or device-level, switch power. Select one of the available switch power (SP) checkboxes to link that switch power to the input you're currently configuring.

Voltage and Warm-Up

Select the desired voltage and warm-up time. The voltage setting establishes the voltage of the switch power. The warmup time is the length of time the switch power must be on before the device can sample the input.

Extended Input Read Settings

Use the Extended Input Read parameter to link multiple input sampling times together when all devices are powered by the same Switch Power. For battery-powered devices, this uses less energy and prolongs battery life. Define the Sample Rate, Warm-up time, and Voltage parameters for the first input. These parameters for follow-on linked inputs are ignored. Click on the **Extended Input Read** arrow to select the additional inputs to read when the switch power is active.

For example, set the Sample Rate, Warm-Up time, and Voltage for Universal Input 1. Select SP1 to power Universal Input 1. By selecting Extended Input Read for 2 and 3, the device will also read inputs 2 and 3 when it reads input 1.

Temperature Settings

Enable full scale (Temperature)

Turning Fullscale OFF sets the register range of 0x8000 (–32767) through 0x7FFF (+32768) to represent the range of input values. With Fullscale turned OFF, a register value of 1450 represents 72.5 degrees (register values = temperature × 20). With Fullscale turned ON, users can specify the register minimum and maximum range of values. These min/max values are represented in the register as 0 (min) and 65535 (max).

Temperature resolution

Select high to store temperatures values in the registers as the measured temperature × 20. Set to low to store temperature values in tenths of a degree (measured temp × 10).

For example, if the measured temperature is 20.5 degrees, turning temperature scaling to high stores the temperature value as 410 while use low resolution stores the temperature as 205.

Units

Select either Celsius or Fahrenheit for your temperature readings.

Outputs

The following parameters are used to configure the outputs, including the switch power outputs.

The output parameters vary, depending on the enabled and available output types. To begin configuring your outputs, **Enable** the output.

Discrete Output

Default Output Value

Select the default output value. When the selected default condition occurs and Hold Last State parameter is set to OFF, this output is set to the selected default output value (e.g. out of sync, communication timeout, start up).

Hold Last State

Retains its last value during the selected default condition (out of sync, communication timeout, start up).

Use I/O Pulse Pattern

To use a programmed pulse pattern, select **Use I/O pulse pattern**, then select the appropriate pattern from the drop-down list. Define the patterns in the Device Parameters section of this screen.

Switch Power Output

When linking a switch power output to a specific input, select the **Enable** checkbox and set the **Enable default state** to OFF. Use the settings for the specific input to link the switch power output and set the voltage and warm-up time.

For continuous switch power, set the voltage on this screen and set the default state to ON. Verify the default "start-up" conditions are set in the device parameters screens.

Enable default state
When enabled, this switch power output remains on during the selected default condition (e.g. out of sync, communication timeout, start up). When disabled, the switch power cycles off during the selected default condition.

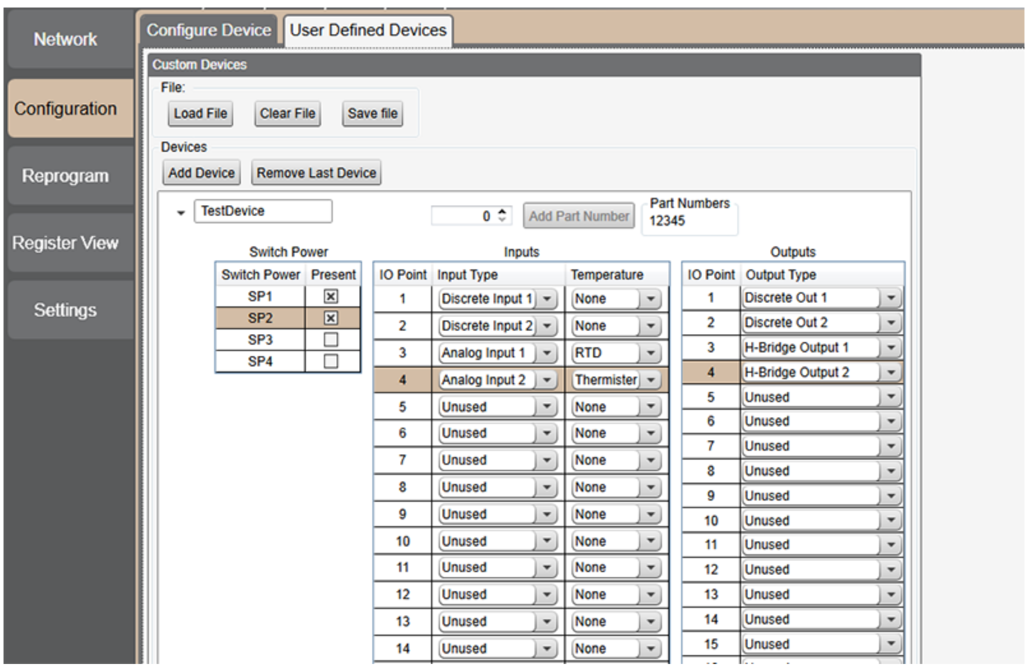
Hold Last Voltage
When set, the switch power output retains its last value during the selected default condition (e.g. out of sync, communication timeout, start up).

Use I/O Pulse Pattern
To use a programmed pulse pattern, select **Use I/O pulse pattern**, then select the appropriate pattern from the drop-down list. Define the patterns in the Device Parameters section of this screen.

Voltage
To set a voltage for the switch power output, select a value. When configured for continuous voltage output, this switch power output no longer cycles on, warms up the sensors, then cycles back down. Because the output voltage remains constant, continuous voltage is typically used with solar power installations.

2.2.2 User Defined Devices Screen

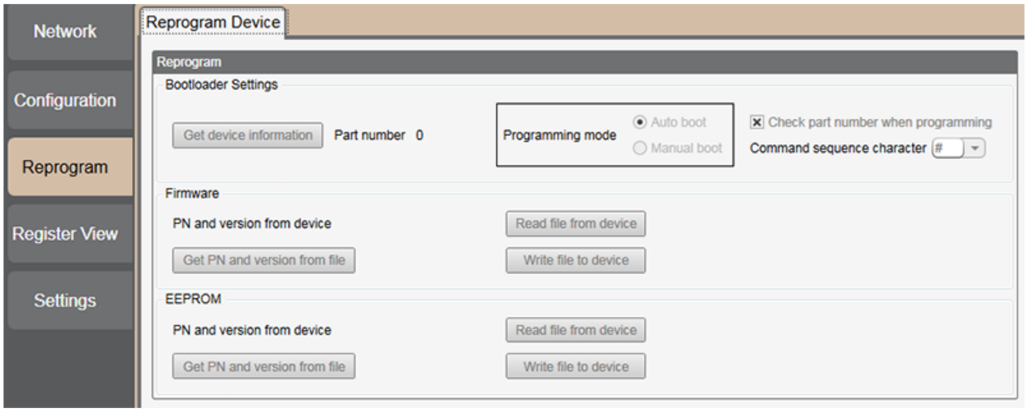
If your device does not appear in the Device type drop-down list, it is a user-defined device. Use the **User Defined Devices** screen to define the device or to upload a configuration file specific to your device. This is particularly useful for special, non-standard MultiHop devices.



2.3 Reprogram Device Screen

Use the **Reprogram Device** screen to update the firmware and EEPROM files.

Before updating the program files, verify you are using RS-485 to communicate with the MultiHop radio. The **Reprogram Device** screen only works when the M-Hx models are in RS-485 communication mode. The communication model is selectable using jumpers for the M-H model, but is hardwired to RS-485 for the M-Hx models.



Auto Boot

Lets the configuration tool manage the boot loading process. This is the recommended setting. See Update Firmware Using Auto Boot on p. 27.

Manual Boot

Requires the user to manually perform the beginning of the boot load process. With the device turned off, start the boot load process by clicking **Write file to device** with all the appropriate parameters defined. Turn on the power to the MultiHop device within 15 seconds, and the device should go into boot mode. Manual mode was created to deal with varying startup timing with USB ports. See Update Firmware Using Manual Boot on p. 27.

Check part number when programming

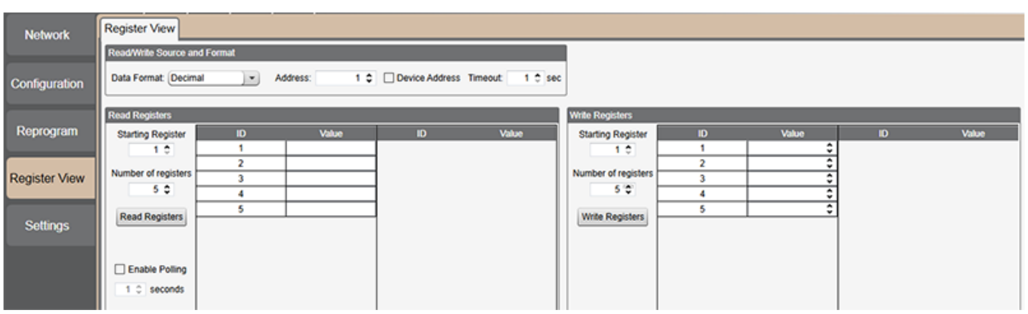
Select **Check part number when programming** to have the Configuration Tool automatically verify the firmware or EEPROM file features match the features of your radio. For example, selecting this option allows the Configuration Tool to verify you aren't trying to write the firmware or EEPROM for an I/O radio to a data radio that does not have I/O.

Command sequence character

AT command delimiter. Most MultiHop radios require the # character. The % character is used for the DXM Controller I/O board.

2.4 Register View Screen

Use the **Register View** screen to read and write register contents when operating in Modbus mode.

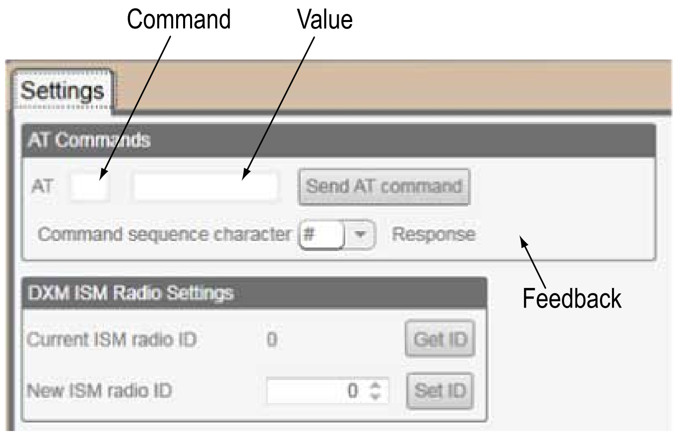


The values stored in the selected registers displays on the screen.

2.5 Settings Screen

Use the **Settings** screen to send AT commands to the MultiHop radio when using the RS-485 to USB adapter cable (not over a TCP connection) or to set the ISM radio ID of the MultiHop radio within a DXM Controller.

AT Commands are control commands that access system parameters. This feature is **only for advanced users**. Do not use these commands unless you understand the intended operation. See Send AT Commands on p. 25.



To assign a **New ISM radio ID** to a MultiHop radio within a DXM Controller, enter the new radio id and click **Set ID**.

3 Configuration Instructions

3.1 Conduct a MultiHop Site Survey

To conduce a MultiHop site survey using the configuration software, use the **Network** > **Network and Device Overview** screen.

To conduct a signal strength analysis, or site survey, follow these instructions.

1. On the MultiHop Configuration Software, go to the **Network** > **Network and Device Overview** screen.
2. Select the master radio's ID from the drop-down list.
3. Initiate a site survey analysis.
   - To analyze the entire network, select **Site survey**, then click **Read**.
   - To analyze an individual radio, highlight the line of the device then right-click and select site survey.

   Depending on the size of your network, analyzing the signal strength and displaying the network structure may take a few minutes (about 15 seconds per radio.)
4. Read Interpreting the MultiHop Site Survey Results on p. 19 for detailed instructions about interpreting your results.

Signal Strength—The number of packets successfully transmitted, during a site survey, at the various signal strengths are represented by the "green," "yellow," and "red" delineations.

Green—a strong radio signal
Yellow—a good radio signal
Red—a marginal radio signal
Misses—represents the number of packets not received on their first transmission

3.1.1 Interpreting the MultiHop Site Survey Results

Site survey mode works by having two radios (one child and one parent) repeatedly exchange data packets. For every round-trip exchange of data, the child data radio keeps track of the weaker of the two paths. Both units report the statistics as a percentage on their LCD display.

The reports consists of sorting the data into one of four categories: Green, Yellow, Red, or Missed Packets.

- Green indicates strong signal,
- Yellow is less strong but still robust,
- Red means the packet was received but has a margin of less than 15 dB, and
- A missed packet means the data did not arrive or contained a checksum error. (During normal operation, missed packets are re-tried until they are received without errors. During a site survey, missed packets are not re-tried.)

For applications with only a few hops, the system can tolerate up to 40% missed packets without serious degradation, but situations with more missed packets should be reviewed for proper antenna selection and placement, cabling, and transmit power levels. If your application includes many hops, modify the installation and antenna placement to reduce the missed packet count.

Any radio can initiate a site survey. Other radios on the same network ID remain synchronized to the network, but are blocked from sending data while the site survey is running. In installations with multiple child radios, the site survey analyzes the signal strength between the selected child and its parent radio only. Disable site survey on one radio before initiating it from another.

Radios in site survey mode have a solid green LED for the duration of the site survey and the LCD display scrolls the results. Because the statistics represent the lesser of the round-trip results, one person can ascertain the link quality from either device.

3.1.2 Improving Your Site Survey Results within a MultiHop Network

If a repeater radio is available in the network but is not being used, enable the forced routing function on the radio with a weak signal to force it to use a nearby radio with a stronger signal strength. Reference the Banner Engineering document titled *Forced Routing Method* for more information.

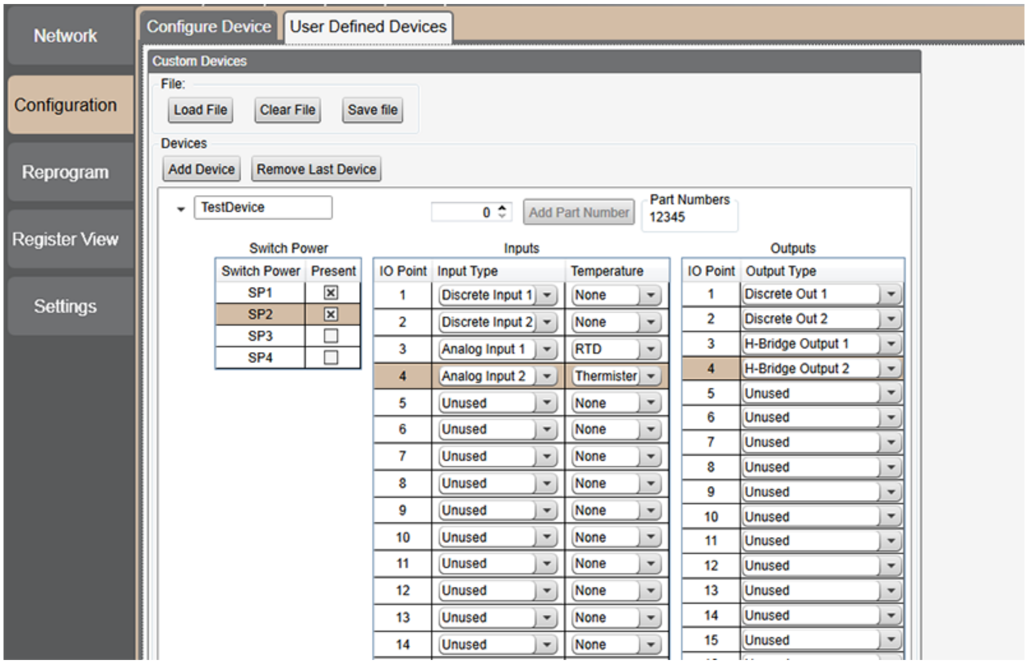
If you cannot use forced routing or add a repeater radio to the network, use a 8 dBi omni-direction antenna or a 10 dBd directional antenna.

We also recommend raising the radio units to a higher elevation, either by physically moving the devices or installing the antenna(s) remotely at a higher position. Additional antenna cables are available from Banner Engineering if needed.

The absent of signals may also be due to the distance between the master (main) and slave (remote) radios. If this is the case, please contact Banner Engineering for further assistance.

3.2 Configure a User-Defined Device

To configure a device that does not appear in the **Device type** drop-down list, use the **Configuration** > **User Defined Devices** screen.

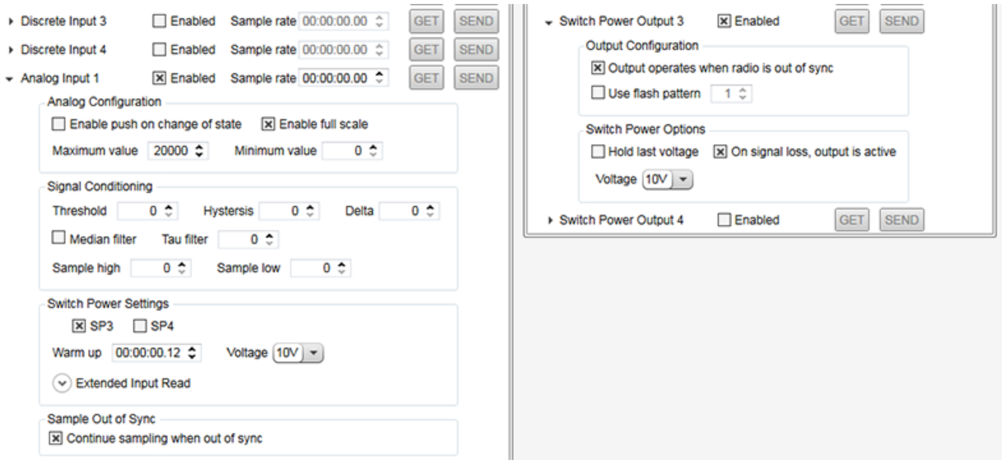


1. Name your new device template. In the example shown, we have named our template TestDevice.
2. Enter the part number of your device and click **Add Part Number**.
3. If your device includes switch power outputs, select the switch power outputs that are active.
4. Define each input and output type.
5. Click **Save File** to save the file to your hard drive.
6. Click **Load File** to load the file to your device.

3.3 Inputs and Outputs

3.3.1 Configure the Switch Power Output

To operate the switch power (SP) terminals as switch power that cycles on for a specific length of time then cycles off to conserve power, enable the desired SP terminal and set the voltage and warm-up time for the specific input associated with the switch power. Follow these steps to associate SP3 to Analog IN 1.



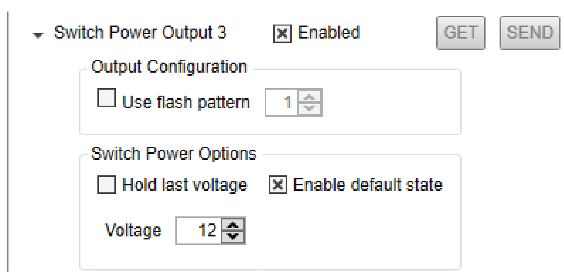
1. Go to the Analog IN 1 section of the **Configuration** > **Configure Device** screen and select the **Enabled** checkbox.
2. Select the **SP3** checkbox to enable switch power 3 to power analog IN 1.
3. Set the voltage and warm-up time according to the sensor's needs.
4. Use the **Switch Power Output 3** section to enable the switch power.
5. Set the appropriate Output Configuration and Switch Power Option.

3.3.2 Configure Device-Level Switch Power

Use device-level switch power to configure voltage output through the switch power terminals. If switch power is defined for use in any input point, switch power cannot be defined for device-level use.

Device-level switch power is configured using the Outputs pane of the I/O parameters.

1. In the MultiHop Configuration Tool, go to the **Configuration** > **Configure Device** screen.
2. Enter the **Device ID** and **Device type**.
3. Click **GET all parameters and I/O** to retrieve the configuration parameters from the device.
4. On the Output side of the screen, click the arrow next to the **Switch Power Output** to display the parameters.
5. Enable the switch power.
6. Define the **Voltage** and select a flash pattern if applicable.
7. Click **SEND** to send the settings to the radio.
8. After sending any changes to the radio, cycle the power to activate the changes.

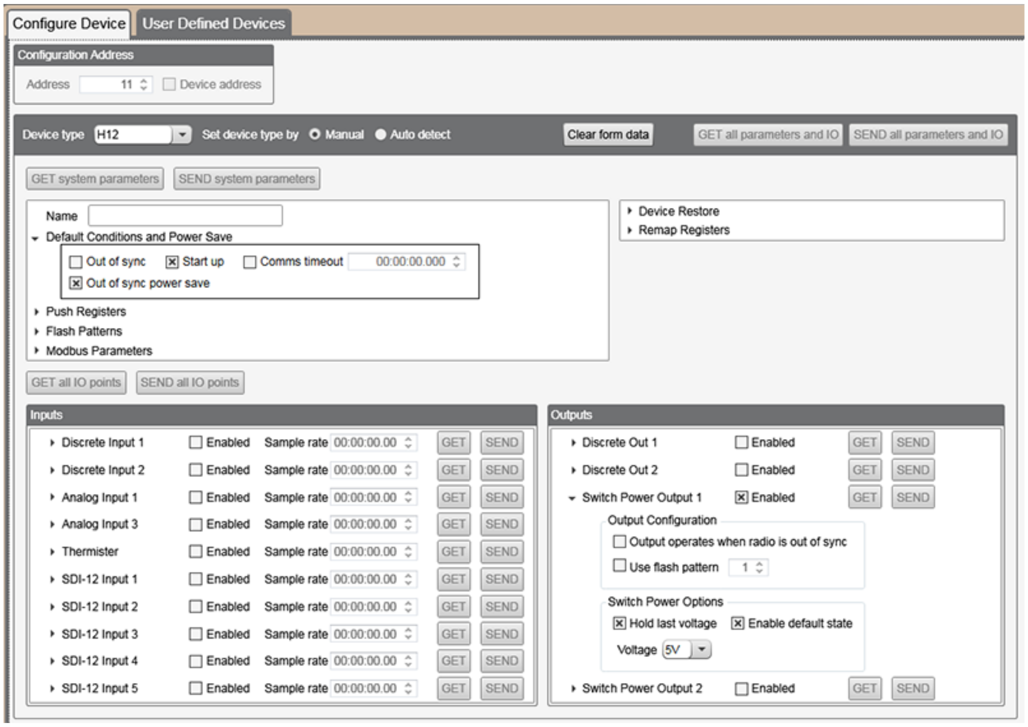


3.3.3 Configure Switch Power for Continuous Voltage

To configure the Switch Power output to supply continuous voltage to a sensor using the configuration software, follow these steps.

On your computer, launch the MultiHop Configuration Software. Select the appropriate COM connection to the computer.

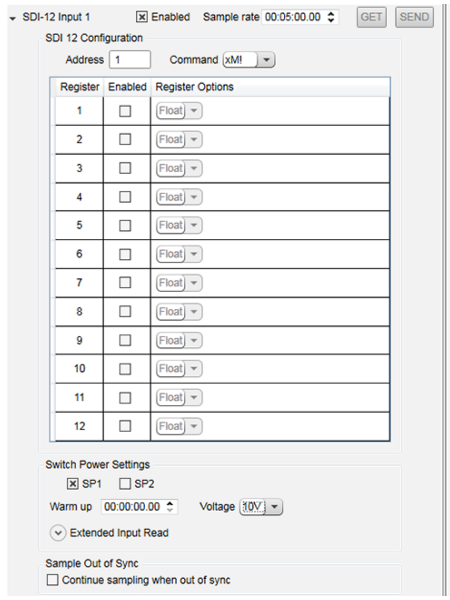
This example sets up switch power 1 to supply continuous power. Note that only one switch power output can be configured to supply continuous power, and no input can be defined to use switch power.



1. On the **Configuration** > **Configure Device** screen, enter the ID of the MultiHop radio that will be assigned a continuous power output and click **GET all parameters and I/O**.
   The configuration of that MultiHop radio is read from the radio and displayed on the screen.
2. Select the **Switch Power Output** and enable it.
3. Select **Enable default state**.
4. Use the drop-down list and select a value for the **Voltage**.
5. Click **SEND**.
6. Under the **Default Conditions and Power Save** settings, select **Start Up**.
   This configures the enabled and configured Switch Power terminal to output continuous voltage as soon as the radio powers up.
7. Click **SEND system parameters** or **SEND all parameters and IO** to send the new settings to the wireless network device.
8. Cycle power to the radio.
   This continuous switch power configuration will activate after the power is cycled.

3.3.4 Configure the SDI-12 Inputs

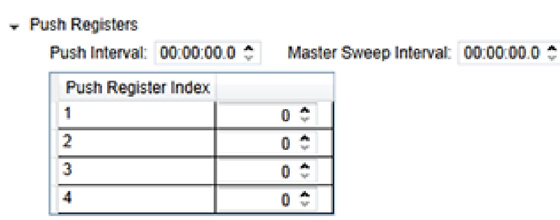
To configure the SDI-12 inputs for use with an Acclima or Decagon 5TE SDI-12 sensor, follow these steps.



1. Select the **Enable** checkbox to enable the SDI-12 input.
2. Select an **Sample Interval** (sample rate), in hours:minutes:seconds.
3. Select the **Address** (device ID) for the SDI-12 device. The sample screenshot shows the configuration for SDI-12 device 1.
4. Under the **Switch Power Settings**, select either 1 or 2 to have SP1 or SP2 power your SDI-12 device.
5. Enter the appropriate **Voltage** needed to power your sensor.
6. Select a **Warm-Up** time, in hours:minutes:seconds. This is the amount of time your sensor requires power before an accurate reading can take place. Refer to your SDI-12 documentation for this value.
7. If you want your SDI-12 device to continue sampling when the MultiHop radio has lost its radio connection to its parent radio, select the **Enable Input Out-of-Sync** checkbox.
8. Enable each register that you need and select the appropriate register option from the drop-down list.
9. Click on the **Send** button to send this configuration to the selected MultiHop device.

3.4 Push Registers

3.4.1 Configure the Push Registers



Up to four push registers may be defined for each MultiHop radio. For most applications, input registers are mapped to the push registers, but other registers may be configured as push registers, such as the battery read voltage. To configure a register as a push register:

1. On the MultiHop Configuration Tool, go to the **Configuration** > **Configure Device** screen.
2. Select the desired MultiHop Radio ID number at the top of the screen.
3. Click the arrow next to **Push Registers** to display the push registers parameters.
4. Use the **Registers** drop-down list to select the input for that radio that will be a push register.
5. Enter a **Push Interval** or **Master Sweep Interval** value.
6. Click **Send** to write the settings to the radio.

The status bar at the bottom of the screen indicates when the process is complete by listing the Communication Status as Ready, with a green light. Errors display as a red light and a brief explanation of the error status. A yellow status light and a description of Getting Data indicate the network is retrieving the requested data from the selected MultiHop radio.

Push Interval

Enter a value in seconds to define how often the push register values are transmitted back to local registers on the radio master.

Master Sweep Interval (Radio master only)

Enter a value in seconds to define how often the master should expect each repeater and slave to push register values back to the cached copies in local storage on the radio master. The Master Sweep Interval is only set on the radio master and should always be greater than the push interval defined for the other radios. When the radio master does not receive a push register value within the Master Sweep Interval, the status register for that MultiHop radio is set to indicate there has been no communication from that radio.

3.4.2 Reading Push Registers

To read the push register data from the master device, send a Modbus read command to **the remote slave ID for registers 47909-47912** (push registers 1-4). The master device intercepts the Modbus command to the remote slave (because of the register addresses) and substitutes the local cached register values.

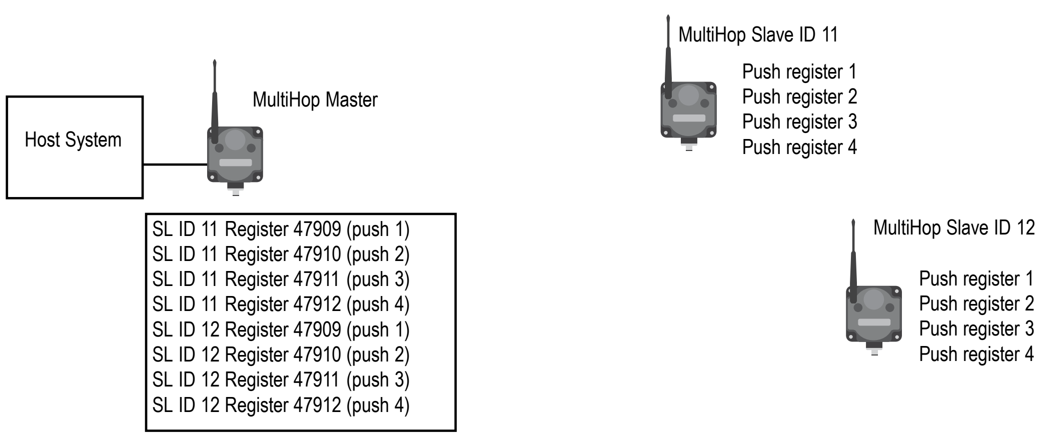
Read the status register for a MultiHop device the same as reading the push registers: the host sends a Modbus read command to the remote slave ID and register 47904. To use the status register for each MultiHop device, the master sweep interval must be defined using the MultiHop Configuration tool.

A status register value of zero indicates no device; a value of one (1) indicates the device has reported.

3.4.3 Example Push Registers

When the Modbus master/host system needs I/O data, it queries the MultiHop radio master. The radio master “intercepts” the request and sends the data to the Modbus master/host system without having to wirelessly request the data from the MultiHop radio slave. This allows a host system to interrogate only the radio master for I/O information and avoid the latency of the wireless link.

For example, when the host system requests the contents of a particular MultiHop radio slave’s registers 47909 through 47912, the radio master “intercepts” the request and pulls the appropriate values from its stored registers.



3.4.4 Using Change of State and Push Registers

Push registers are typically defined to send back register data at specific time intervals. Change of state data can also be defined to send to the radio master. As with any push register data, the data is not guaranteed to be delivered to the radio master because the message is not acknowledged from end to end.

The factory default for message retries is set to eight. With really poor links, the data may not be received. We recommend also having a periodic reporting time defined when using change of state.

3.5 Read Registers

Use the **Register View** screen to read registers.

1. On the **Register View** screen, select the MultiHop Radio ID of the desired radio.
2. Under **Data Format**, select how to display the registers values, either decimal or hexadecimal.
3. Under **Read Registers**, select the starting register and the number of registers from that starting point to read. In the sample screen shown, register 1 and the 5 following registers will be read and displayed on the screen.
4. Select **Enable Polling** and enter a polling frequency in seconds.
5. Click **Read Registers**.
   The status bar at the bottom of the screen indicates when the process is complete by displaying a communication status of "Ready" and an green "light."

3.6 Write to Registers

Use the **Register View** screen to write to selected registers.

1. On the **Register View** screen, select the MultiHop Radio ID of the desired radio.
2. Under **Write Registers**, select the starting register and the number of registers from that starting point to read.
3. Enter in the values, in hex, to be written to each register.
4. Click **Write Registers** to send these changes to the radio.
   The status bar at the bottom of the screen indicates when the process is complete by displaying a communication status of "Ready" and a green "light."

3.7 Send AT Commands

To send AT commands to the MultiHop radio, use the **Settings** screen.

1. Enter the command in the first field, just to the right of the **AT**.
2. Enter the value in the second field, near the **Send AT command** button.
3. Click **Send AT command.** The status bar at the bottom of the screen indicates **Ready** when the process is complete. When the AT command was successfully sent to the radio, the feedback field displays **OK**.

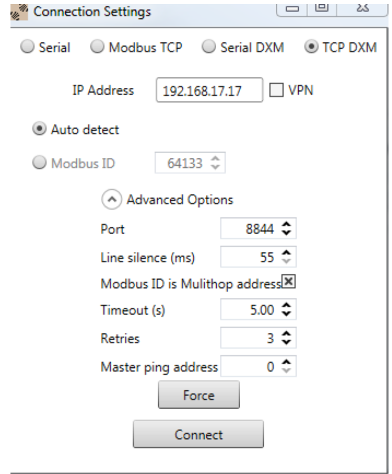
3.8 Using the MultiHop Configuration Software with the MultiHop Ethernet Radio

The MultiHop Configuration Software can be used with the Ethernet Data Radios to examine the network topology, conduct a site survey, or adjust parameter settings.

The MultiHop Configuration Software must be set up to communicate through the Ethernet connection by using the IP address of the master MultiHop Ethernet Data Radio. To use the MultiHop Configuration Software with the MultiHop Ethernet Data Radio, the computer must be plugged into the same wired network as the master radio.

The default IP address of the Ethernet radios is 192.168.17.17. After connecting, set the software's addressing mode to use the device address of the Ethernet radio.

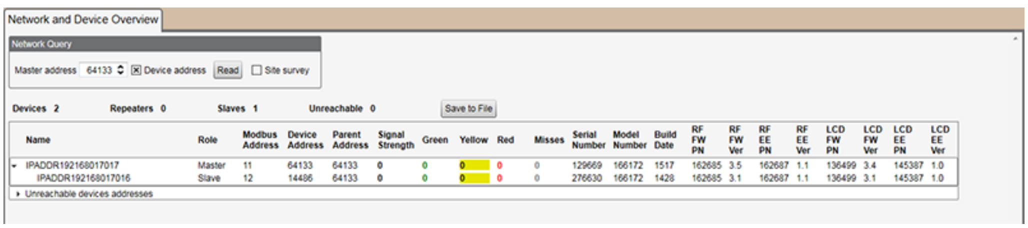
1. Launch the MultiHop Configuration Software.
2. Go to the **Device** > **Connection Settings** menu.
3. Select **TCP DXM** and enter the IP address of the master Ethernet radio. Communications timeout and communication retry parameters can also be adjusted on this page.
4. Click **Connect**.
5. Go to the **Network** > **Network and Device Overview** screen.
6. Enter the Maser Device address into the **Device address** field. From the LCD menu, the device address is shown as (DADR).
7. Click **Read** to view the wireless network.



To conduct a signal strength analysis, or site survey, select **Site survey**, then click **Read**. Depending on the size of your network, analyzing the signal strength and displaying the network structure may take a few minutes (about 15 seconds per radio.)

To run site survey on a individual radio, highlight the line of the device then right click.

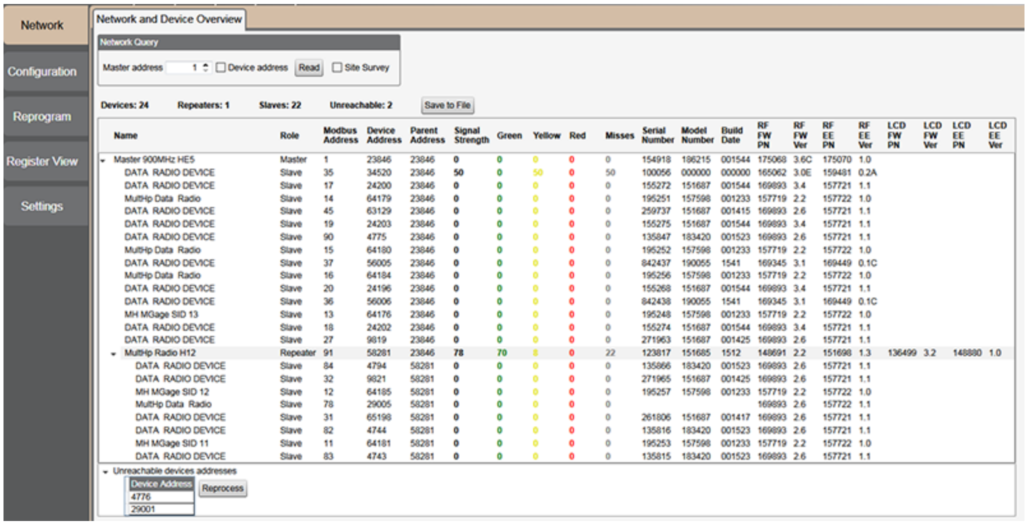
Depending upon the radio link quality, the retry count and timeout parameters may need to be adjusted. Those parameters are found under the **Device** > **Connection Settings** menu.



4 Product Support

4.1 View Device Factory Information

Use the **Network** > **Network and Device Overview** screen to view the device's factory information.



1. To view the factory information for all models within your network, such as model and serial numbers, select the master radio's ID and click **Read**.
2. To view the factory information for a specific device, click on the device name and select from the context-sensitive menu.

4.2 Update Firmware Using Auto Boot

Update firmware or EEPROM files from the **Program** > **Reprogram Device** screen.

To write a new version of the firmware or EEPROM files to the device using **Auto Boot** mode, follow these instructions. Do not attempt any other work on the computer while updating program files to a MultiHop radio as this may corrupt the programming process.

1. Click **Write File to Device**.
2. Select the new file from your hard drive.
3. A dialogue box pops up to verify you want to overwrite the configuration file already on the data radio. Click on **OK** to continue or **Cancel** to cancel the write process.
4. The Communication Status display at the bottom of the screen indicates when the configuration tool has finished writing the file out to the radio. When the status is "Ready," the process is complete. If there are errors during the programming process, use manual mode to update the files.

To save your firmware or EEPROM files to your hard drive using **Auto Boot** mode, select a location and file name on your computer.

4.3 Update Firmware Using Manual Boot

Update firmware or EEPROM files from the **Program** > **Reprogram Device** screen.

To write a new version of the firmware or EEPROM files to the selected device using **Manual Boot** mode, follow these instructions. Do not attempt any other work on the computer while updating program files to a MultiHop radio as this may corrupt the programming process.

1. Cycle power to the radio by disconnecting then reconnecting the power to the radio.
   The firmware version will be read when the radio reboots.
2. After the radio reboots, browse to the firmware file location on your hard drive. Select the appropriate files.

3. Click **Write File to Device** for the firmware, then click **OK** on the pop-up box to start the process.
4. Immediately cycle power to the MultiHop radio.
5. Complete the same steps for the EEPROM if necessary.

To save your firmware or EEPROM files to your hard drive using **Manual Boot** mode:

1. Cycle power to the radio by disconnecting then reconnecting the power to the radio. The firmware version will be read when the radio reboots.
2. After the radio reboots, browse to the firmware file location on your hard drive. Select the appropriate files.
3. Click **Write File to Device** for the firmware, then click **OK** on the pop-up box to start the process.
4. Immediately cycle power to the MultiHop radio.
5. Complete the same steps for the EEPROM if necessary.

4.4 Contact Us

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5 Glossary of Wireless Terminology

This definitions list contains a library of common definitions and glossary terms specific to the Wireless products.

active threshold An active threshold is a trigger point or reporting threshold for an analog input.

a/d converter An analog to digital converter converts varying sinusoidal signals from instruments into binary code for a computer.

address mode The Sure Cross® wireless devices may use one of two types of addressing modes: rotary dial addressing or extended addressing. In **rotary dial** address mode, the left rotary dial establishes the network ID (NID) and the right rotary dial sets the device address. **Extended** address mode uses a security code to "bind" Nodes to a specific Gateway. Bound Nodes can only send and receive information from the Gateway they are bound to.

antenna Antennas transmit radio signals by converting radio frequency electrical currents into electromagnetic waves. Antennas receive the signals by converting the electromagnetic waves back into radio frequency electrical currents.

attenuation Attenuation is the radio signal loss occurring as signals travel through the medium. Radio signal attenuation may also be referred to as free space loss. The higher the frequency, the faster the signal strength decreases. For example, 2.4 GHz signals attenuate faster than 900 MHz signals.

baseline filter (M-GAGE) Under normal conditions, the ambient magnetic field fluctuates. When the magnetic field readings drift below a threshold setting, the baseline or drift filter uses an algorithm to slowly match the radio device's baseline to the ambient magnetic field.

binding (DX80 star networks) Binding Nodes to a Gateway ensures the Nodes only exchange data with the Gateway they are bound to. After a Gateway enters binding mode, the Gateway automatically generates and transmits a unique extended addressing (XADR), or binding, code to all Nodes within range that are also in binding mode. The extended addressing (binding) code defines the network, and all radios within a network must use the same code.

After binding your Nodes to the Gateway, make note of the binding code displayed under the ***DVCFG** > **XADR** menu on the Gateway's LCD. Knowing the binding code prevents having to re-bind all Nodes if the Gateway is ever replaced.

binding (MultiHop networks) Binding MultiHop radios ensures all MultiHop radios within a network communicate only with other radios within the same network. The MultiHop radio master automatically generates a unique binding code when the radio master enters binding mode. This code is then transmitted to all radios within range that are also in binding mode. After a repeater/slave is bound, the repeater/slave radio accepts data only from the master to which it is bound. The binding code defines the network, and all radios within a network must use the same binding code.

After binding your MultiHop radios to the master radio, make note of the binding code displayed under the ***DVCFG** > **-BIND** menu on the LCD. Knowing the binding code prevents having to re-bind all radios if the master is ever replaced.

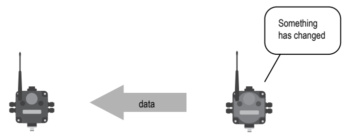
binding (serial data radio networks) Binding the serial data radios ensures all radios within a network communicate only with the other radios within the same network. The serial data radio master automatically generates a unique binding code when the radio master enters binding mode. This code is transmitted to all radios within range that are also in binding mode. After a repeater/slave is bound, the repeater/slave radio accepts data only from the master to which it is bound. The binding code defines the network, and all radios within a network must use the same binding code.

bit packing i/o Bit packing uses a single register, or range of contiguous registers, to represent I/O values. This allows you to read or write multiple I/O values with a single Modbus message.

booster (boost voltage) A booster is an electronic circuit that increases a battery-level voltage input (3.6V) to a sensor operating voltage output (5 to 20 V).

CE The CE mark on a product or machine establishes its compliance with all relevant European Union (EU) Directives and the associated safety standards.

change of state Change of state reporting is a report initiated by the Node when a change to the sensor's input state is detected. If the input does not change, nothing is reported to the Gateway.



channel A channel may be either a path for communications or a range of radio frequencies used by a transceiver during communication.

collision A collision is a situation in which two or more transmissions are competing to communicate on a system that can only handle one transmission at a time. This may also be referred to as a data collision.

collocated networks To prevent interference between collocated wireless networks, assign each wireless network a different Network ID. The Network ID is a unique identifier assigned to each wireless network using the rotary dials on the Gateway.

contention architecture Contention architecture is a wireless communication architecture that allows all network devices access to the communications channel at the same time. This may lead to transmission collisions.

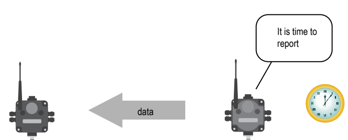
counter - event The event counter counts the total number of times an input signal changes to the high/ON/1 state. The counter increments on the falling edge of an input signal when the signal level crosses the threshold.

Event counters can be used to measure the total operational cycles of a spinning shaft or the total number of items traveling down a conveyor.

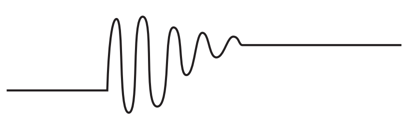
counter - frequency The frequency counter calculates the frequency of the input signal, in Hz.

Frequency counters can be used to measure flow rates, such as measuring the flow rate of items on a conveyor or the speed at which a windmill spins.

cyclic reporting Cyclic reporting is when the Gateway polls the Node at user-defined intervals.

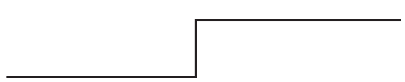


debounce When a signal changes state using a mechanical switch or relay, the signal can oscillate briefly before stabilizing to the new state. The debounce filter examines the signal's transitions to determine the signal's state.



The signal oscillates between states after a mechanical switch or relay activates.

Without a debounce filter, the signal is interpreted to change state multiple times.



With a debounce filter, the signal is interpreted to change state only once.

The factory default setting is to activate the input filtering to compensate for unclean state transitions.

decibel A decibel is a logarithmic ratio between a specific value and a base value of the same unit of measure. With respect to radio power, dBm is a ratio of power relative to 1 milliWatt. According to the following equation, 1 mW corresponds to 0 dBm.

Equation: $PmW = 10^{x/10}$ where x is the transmitted power in dBm, or $dBm = 10 \log(PmW)$

Another decibel rating, dBi, is defined as an antenna's forward gain compared to an idealized isotropic antenna. Typically, dBm = dBi = dBd + 2.15 where dBi refers to an isotropic decibel, dBd is a dipole decibel, and dBm is relative to milliwatts.

deep sleep mode Potted Puck models, potted M-GAGE models: Some battery-powered M-GAGE radios ship in a "deep sleep" mode to conserve battery power. While in "deep sleep" mode, the M-GAGE does not attempt to transmit to a parent radio and remains in "deep sleep" until an LED light at the receiving window wakes it up. M-GAGEs that ship in "deep sleep" mode are typically the potted M-GAGEs that require an LED Optical Commissioning Device to configure the M-GAGE.

Wireless Q45 Sensors: If the Wireless Q45 Sensor fails to communicate with the Gateway for more than 5 minutes, it enters **sleep mode**. The radio continues to search for the Gateway at a slower rate and the LEDs do not blink. To wake up the sensor, press any button. After the Q45 wakes up, it will do a fast rate search for the Gateway for five more minutes.

default output conditions/ triggers Default output conditions/triggers are the conditions that drive outputs to defined states. Example default output conditions include when radios are out of sync, when a device cycles power, or during a host communication timeout.

Device Power Up—Power-up events occur every time the device is powered up.

Out of Sync—Out-of-sync events occur when the radio is out of sync with its master radio.

Host Link Failure—Host link failure is when the defined timeout period has elapsed with no communications between the host system (or Modbus master device) and the DX80 Gateway, typically about four seconds. These events trigger when a host link failure has been detected.

Node Link Failure—Node link failures are determined by the polling interval or the out-of-sync timing. When a Node detects a communications failure with the Gateway and the Node Link Failure flag is set, the output points are set to the user-defined states and the inputs are frozen.

Gateway Link Failure—Gateway link failures are determined by three global parameters: Polling Interval, Maximum Missed Message Count and Re-link Count. When the Node's Gateway Link Failure flag is set and the Gateway determines a timeout condition exists for a Node, any outputs linked from the failing Node are set to the user-defined default state.

default output value Default output values are specific values written to output registers. For discrete outputs, this is a 1 (on) or 0 (off) value. For analog outputs the value can be any valid register value. When a default condition occurs, these default output values are written to the output register.

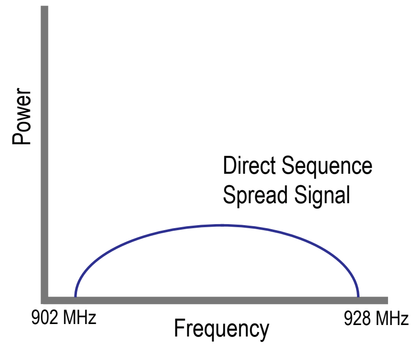
delta The delta parameter defines the change required between sample points of an analog input before the analog input reports a new value. To turn off this option, set the Delta value to 0.

determinism A deterministic system defines how network endpoints behave during the loss of communications. The network identifies when the communications link is lost and sets relevant outputs to user-defined conditions. Once the radio signal is re-established, the network returns to normal operation.

device, node, or radio address/ID (DX80 Networks) The Node address is a unique identifier for each wireless device on a network and is set using the rotary dials. For the DX80 networks, Gateways are identified as device 0. Nodes are assigned addresses (NADR) from 01 to 47 using the rotary dials.

directional antenna A direction antenna, or Yagi, is an antenna that focuses the majority of the signal energy in one specific direction.

Direct Sequence Spread Spectrum (DSSS) Direct Sequence Spread Spectrum is a method for generating spread spectrum transmissions where the transmitted signal is sent at a much higher frequency than the original signal, spreading the energy over a much wider band. The receiver is able to de-spread the transmission and filter the original message. DSSS is useful for sending large amounts of data in low to medium interference environments.



DX83 Ethernet Bridge — The Ethernet Bridge acts as a communications bridge between the Modbus RTU network (Gateway) and Modbus/TCP or EtherNet/IP host systems and includes the ability to configure the network using a Web browser interface.

effective isotropic radiated power (EIRP) — The EIRP is the effective power found in the main lobe of a transmitter antenna, relative to a 0 dB radiator. EIRP is usually equal to the antenna gain (in dBi) plus the power into that antenna (in dBm).

Ethernet — Ethernet is an access method for computer network (Local Area Networks) communications, defined by IEEE as the 802 standard.

EtherNet/IP™ — EtherNet/IP is Allen-Bradley's DeviceNet running over Ethernet hardware.

extended address mode — Using extended address mode isolates networks from one another by assigning a unique code, the extended address code, to all devices in a particular network. Only devices sharing the extended address code can exchange data. The extended address code is derived from the Gateway's serial number, but the code can be customized using the manual binding procedure.

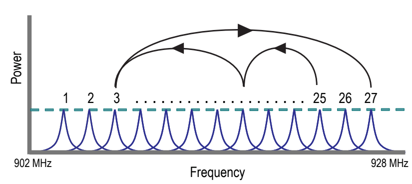
flash pattern — Flash patterns are established by selecting timeslots to turn the output on or off. While originally the flash pattern was designed to turn on and off an indicator light, the flash pattern can be set for any discrete output or switch power output.

***Flex*Power** — Banner's *Flex*Power® technology allows for a true wireless solution by allowing the device to operate using either 10 to 30 V dc, 3.6 V lithium D cell batteries, or solar power. This unique power management system can operate a *Flex*Power Node and an optimized sensing device for up to 5 years on a single lithium D cell.

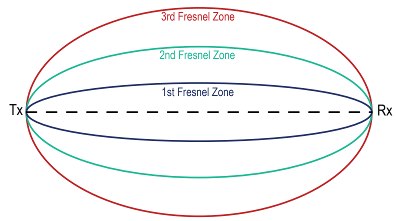
free space loss (FSL) — The radio signal loss occurring as the signal radiates through free space. Free Space Loss = 20 Log (4(3.1416)d/λ) where d is in meters. Remembering that $\lambda f = c = 300 \times 10^6$ m/s, the equations reduce down to:

For the 900 MHz radio band: FSL = 31.5 + 20 Log d (where d is in meters).
For the 2.4 GHz radio band: FSL = 40 + 20 Log d (where d is in meters.)

Frequency Hopping Spread Spectrum (FHSS) — Frequency Hopping Spread Spectrum (FHSS) is a method for generating spread spectrum transmissions where the signal is switched between different frequency channels in a pseudo-random sequence known by both the transmitter and the receiver. FHSS is useful for sending small packets of data in a high interference environment.



Fresnel zone — Fresnel zones are the three-dimensional elliptical zones of radio signals between the transmitter and receiver. Because the signal strength is strongest in the first zone and decreases in each successive zone, obstacles within the first Fresnel zone cause the greatest amount of destructive interference.



gain Gain represents how well the antenna focuses the signal power. A 3 dB gain increase doubles the effective transmitting power while every 6 dB increase doubles the distance the signal travels. Increasing the gain sacrifices the vertical height of the signal for horizontal distance increases. The signal is 'squashed' down to concentrate the signal strength along the horizontal plane.

gateway A gateway is a general network device that connects two different networks.

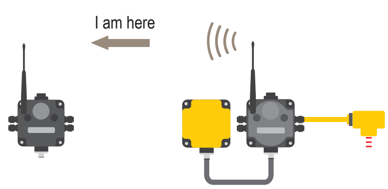
Gateway A Sure Cross® Gateway is the wireless sensor network master device used to control network timing and schedule communication traffic. Similar to how a gateway device on a wired network acts as a "portal" between networks, the Sure Cross Gateway acts as the portal between the wireless network and the central control process. Every wireless I/O sensor network requires one Gateway device. Every Sure Cross device is a transceiver, meaning it can transmit and receive data.

GatewayPro The GatewayPro combines the standard Gateway and the DX83 Ethernet Bridge into one device.

ground loop Ground loops are grounds within a system that are not at the same potential. Ground loops can damage electrical systems.

ground plane A ground plane is an electrically conductive plate that acts as a 'mirror' for the antenna, effectively doubling the length of the antenna. When using a 1/4 wave antenna, the ground plane acts to 'double' the antenna length to a 1/2 wave antenna.

heartbeat mode In heartbeat mode, the Nodes send "heartbeat" messages to the Gateway at specific intervals to indicate the radio link is active. The heartbeat is always initiated by the Node and is used only to verify radio communications. Using the Nodes to notify the Gateway that the radio link is active instead of having the Gateway "poll" the Nodes saves energy and increases battery life.



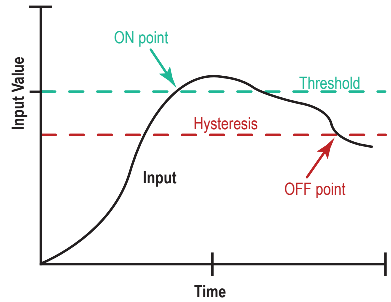
hibernation/ storage mode While in **storage mode**, the radio does not operate. All Sure Cross® radios powered from an integrated battery ship from the factory in storage mode to conserve the battery. To wake the device, press and hold button 1 for 5 seconds. To put any *Flex*Power® or integrated battery Sure Cross radio into storage mode, press and hold button 1 for 5 seconds. The radio is in storage mode when the LEDs stop blinking, but in some models, the LCD remains on for an additional minute after the radio enters storage mode. After a device has entered storage mode, you must wait 1 minute before waking it.

For the Wireless Q45 and Q120 Sensors: While in **storage mode**, the MultiHop Radio's radio does not operate. The MultiHop Radio ships from the factory in storage mode to conserve the battery. To wake the device, press and hold the binding button (inside the housing on the radio board) for five seconds. To put any MultiHop Radio into storage mode, press and hold the binding button for five seconds. The MultiHop Radio is in storage mode when the LEDs stop blinking.

hop As a verb, hopping is the act of changing from one frequency to another. As a noun, a hop is the device to device transmission link, such as from the Master device to the Slave device.

hop table A hop table is a precalculated, pseudo-random list of frequencies used by both the transmitter and receiver of a radio to create a hopping sequence.

hysteresis Hysteresis defines how far below the active threshold (ON point) an analog input is required to be before the input is considered OFF. A typical hysteresis value is 10% to 20% of the unit's range. For more specific details, see *Threshold*.



Industrial, Scientific, and Medical Band (ISM) The ISM, or Industrial, Scientific, and Medical band, is the part of the radio spectrum that does not require a license for use. The Sure Cross radios operate in the ISM band.

latency A network's latency is the maximum delay between transmission and reception of a data signal.

lightning arrestor Also called a lightning suppressor, surge suppressor, or coaxial surge protection, lightning arrestors are used in remote antenna installations to protect the radio equipment from damage resulting from a lightning strike. Lightning arrestors are typically mounted close to the ground to minimize the grounding distance.

line of sight Line of sight is the unobstructed path between radio antennas.

link failures A **Host Link Failure** occurs when the defined timeout period, typically about four seconds, elapses with no communication between the host system (or Modbus master device) and the DX80 Gateway.

A **Gateway Link Failure** refers to the radio link between a Node and the Gateway and is determined by three global parameters: Polling Interval, Maximum Missed Message Count, and Re-link Count. When the Node’s Gateway Link Failure flag is set and the Gateway determines a timeout condition exists for a Node, any outputs linked from the failing Node are set to the user-defined default state.

A **Node Link Failure** is determined by the polling interval or the out-of-sync timing. When a Node detects a communications failure with the Gateway and the Node Link Failure flag is selected, the output points are set to the user-defined states and the inputs are frozen.

local and non-local registers Local registers are registers specific to the device in question. When discussing a Gateway, the Gateway's local registers include the registers specific to the Gateway in addition to all the Nodes' registers that are stored in the Gateway. Non-local, or remote, registers refer to registers on other Modbus slave devices, such as other MultiHop slave radios or third-party Modbus devices.

master/slave relationship The master/slave relationships is the model for a communication protocol between devices or processes in which one device initiates commands (master) and other devices respond (slave). The Sure Cross network is a master/slave network with the Gateway acting as the master device to the Nodes, which are the slave devices. A PC can also be a master device to a wireless sensor network. See *star networks*.

maximum bad count The maximum bad count refers to a user-established maximum count of consecutive failed polling attempts before the Gateway considers the radio (RF) link to have failed.

maximum misses The maximum misses is the number of consecutive polling messages the Node fails to respond to. For more information, see Polling Rate and Maximum Misses.

median filter When the median filter is turned on, three samples are taken for each analog sensor reading. The high and low values are discarded and the middle value is used as the analog value. Set to zero (0) to turn off the median filter. Set to one (1) to turn on the median filter.

Modbus	Modbus is a master-slave communications protocol typically used for industrial applications.
Modbus/TCP	Modbus/TCP is an open standard protocol very similar to Modbus RTU except that it uses standard Internet communication protocols.
MultiHop	MultiHop networks are made up of one master radio and many repeater and slave radios. The MultiHop networks are self-forming and self-healing networks constructed around a parent-child communication relationship. A MultiHop Radio is either a master radio, a repeater radio, or a slave radio. The master radio controls the overall timing of the network and is always the parent device for other MultiHop radios. The host system connects to this master radio. Repeater radios extend the range of the wireless network and slave radios are the end point of the wireless network. For more information, refer to the *Sure Cross MultiHop Radios Instruction Manual* (p/n 151317).
multipath fade	Obstructions in the radio path reflect or scatter the transmitted signal, causing multiple copies of a signal to reach the receiver through different paths. Multipath fade is the signal degradation caused by these obstructions.
network ID	The Network ID (NID) is a unique identifier you assign to each wireless network to minimizes the chances of two collocated networks interfering with each other. Assigning different NIDs to different networks improves collocation performance in dense installations.
node	A node is any communications point within a network.
Node	Nodes are remote I/O slave devices within Banner's wireless sensor networks. Sensors and other devices connect to the Node's inputs or outputs, allowing the Node to collect sensor data and wirelessly transmit it to the Gateway. Every Sure Cross device is a transceiver, meaning it can transmit and receive data.
noise	Noise is any unwanted electromagnetic disturbances from within the RF equipment, especially the receiver. Noise is more of a concern when signal levels are low.
omni-directional antenna	Omni-directional antennas transmit and receive radio signals equally in all directions.
out of sync/link loss (loss of radio signal)	The Sure Cross wireless devices use a deterministic link time-out method to address RF link interruption or failure. When a radio link fails, all pertinent wired outputs are sent to the selected default value/state until the link is recovered, ensuring that disruptions in the communications link result in predictable system behavior. Following a time-out, all outputs linked to the Node in question are set to 0, 1, or hold the last stable state depending on the value selected.
path loss	Path loss describes attenuation as a function of the wavelength of the operating frequency and the distance between the transmitter and receiver.
path loss (or link loss) calculations	Link loss calculations determine the capabilities of a radio system by calculating the total gain or loss for a system. If the total gain/loss is within a specific range, the radio signal will be received by the radio. **Total Gain = Effective output + Free space loss + Total received power** . Because the transmitter and receiver gains are positive numbers and the free space loss is a larger negative number, the total gain of a system should be negative. A link loss calculation may also be called a link budget calculation.
peer to peer network	Peer-to-peer is a model for a communication protocol in which any device in the network can send or receive data. Any device can act as a Master to initiate communication.
polling interval/ rate	The Gateway communicates with, or polls, each Node to determine if the radio link is active. The polling rate defines how often the Gateway communicates with each Node. Polling is always initiated by the Gateway and only verifies radio signal communications.

polling interval/ rate and maximum misses	The Gateway communicates with, or polls, each Node to determine if the radio link is active. The polling rate, or interval, defines how often the Gateway communicates with each Node. Polling is always initiated by the Gateway and only verifies radio signal communications. Nodes that fail to respond are counted against the 'Maximum Misses' for that Node. If the 'Maximum Misses' is exceeded for any

Node, the Gateway generates an RF timeout error in the Modbus I/O register 8 of the appropriate Node. The 'Maximum Misses' is defined as the number of consecutive polling messages that the Node fails to respond to.

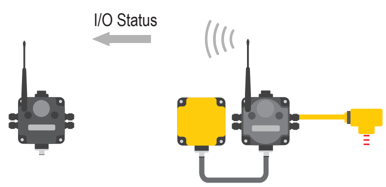
radiation pattern An antenna's radiation pattern is the area over which the antenna broadcasts an easily received signal. The radiation pattern/shape changes based on the antenna type and gain.

re-link count The re-link count is the number of completed polling messages the Gateway receives from a Node before a lost RF link is considered re-established and normal operation resumes.

remote antenna A remote antenna installation is any antenna not mounted directly to the Sure Cross wireless device, especially when coaxial cable is used. Always properly install and ground surge suppressors in remote antenna systems.

repeater radio A repeater radio extends the transmission range of a wireless network. Repeaters are typically used in long-distance transmission.

report interval/ rate The report rate defines how often the Node communicates the I/O status to the Gateway. For *Flex*Power® applications, setting the report rate to a slower rate extends the battery life.



Change of state reporting sets the system to report only when the value crosses the threshold setting.

rotary dial address mode See: *address mode*

Received Signal Strength Indicator (RSSI) An RSSI is the measurement of the strength of received signals in a wireless environment. See *Site Survey*.

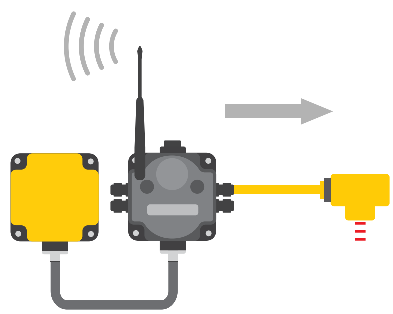
resistance temperature detector (RTD) An RTD is a temperature measurement device that measures the electrical resistance across a pure metal. The most commonly used metal is platinum because of its temperature range, accuracy, and stability.

RTDs are used for higher precision applications or for longer wire runs because RTDs can compensate for wire length. In industrial applications, RTDs are not generally used at temperatures above 660° C. Though RTDs are more accurate, they are slower to respond and have a smaller temperature range than thermocouples.

sample high/ sample low (analog I/O) For analog inputs, the sample high parameter defines the number of consecutive samples the input signal must be above the threshold before a signal is considered active. Sample low defines the number of consecutive samples the input signal must be below the threshold minus hysteresis before a signal is considered deactivated. The sample high and sample low parameters are used to avoid unwanted input transitions.

sample high/ sample low (discrete I/O) For discrete inputs, the sample high parameter defines the number of consecutive samples the input signal must be high before a signal is considered active. Sample low defines the number of consecutive samples the input signal must be low before a signal is considered low. The sample high and sample low parameters are used to create a filter to avoid unwanted input transitions. The default value is 0, which disables this feature. The value range is 1 through 255.

sample interval/ rate The sample interval, or rate, defines how often the Sure Cross device samples the input. For battery-powered applications, setting a slower rate extends the battery life.



sample on demand
Sample on demand allows a host system to send a Modbus command to any register and require the inputs to immediately sample the sensor and report readings back to the host system. Sampling on demand can be used between the normal periodic reporting.

To use the Sample on Demand feature requires using a host-controlled system capable of sending Modbus commands to the master radio.

signal-to-noise ratio (SNR)
The signal-to-noise ratio is the ratio of the signal to any background noise or noise generated by the medium. In radio terms, it a ratio of the transmitted radio signal to the noise generated by any electromagnetic equipment, in particular the radio receiver. The weaker the radio signal, the more of an influence noise has on radio performance. Like gain, the signal-to-noise ratio is measured in decibels.

The equations for calculating SNR are:

SNR = 20 × log (Vs/Vn) where Vs is the signal voltage and Vn is the noise voltage;

SNR = 20 × log (As/An) where As is the signal amplitude and An is the noise amplitude; or

SNR = 10 × log (Ps/Pn) where Ps is the signal power and Pn is the noise power.

single-point ground
All grounds within a system are made to a single ground to avoid creating ground loops.

site survey
Conducting a site survey, also known as a radio signal strength indication (RSSI), analyzes the radio communications link between the Gateway (or master radio) and any Node (or slave radio) within the network by analyzing the radio signal strength of received data packets and reporting the number of missed packets that required a retry.

slave ID
The slave ID is an identifying number used for devices within a Modbus system. By default, Gateways are set to Modbus Slave ID 1. When using more than one Modbus slave, assign each slave a unique ID number.

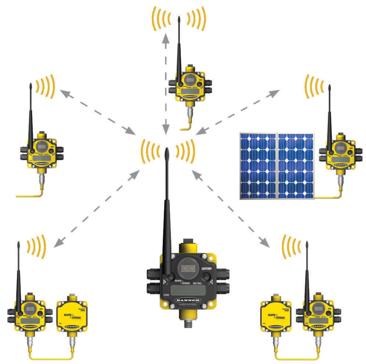
sleep mode
During normal operation, the Sure Cross radio devices enter sleep mode after 15 minutes of operation. The radio continues to function, but the LCD goes blank. To wake the device, press any button.

slow scan mode
(All internal battery models)In slow scan mode, the radio wakes up every 15 minutes to search for its parent radio. If a parent or master radio is not found, the radio goes back to sleep for another 15 minutes.

SMA connector
An SMA connector (SubMiniature version A) is a 50 ohm impedance connector used for coaxial RF connections and developed in the 1960s. An SMA connector is typically used between the radio and the antenna.

spread spectrum
Spread spectrum is a technique in which the transmitter sends (or spreads) a signal over a wide range of frequencies. The receiver then concentrates the frequencies to recover the information. The Sure Cross radio devices use a version of spread spectrum technology called Frequency Hop Spread Spectrum.

star networks
A star topology network is a point to multipoint network that places the network master radio in a center or hub position. Slave radios only transmit messages to the master radio, not to each other. These network layouts can be very flexible and typically operate relatively quickly. Slave radios acknowledge receipt of messages transmitted from the master radio.



For more information on Banner's star network products, refer to the *Sure Cross Performance DX80 Wireless I/O Network Instruction Manual* (p/n 132607)

switch power
Efficient power management technology enables some *Flex*Power devices to include an internal power output supply, called switch power (SP), that briefly steps up to power sensors (ideally, 4 to 20 mA loop-powered sensors). The warmup time denotes how long the sensor must be powered before a reliable reading can be taken. After the warmup time has passed, the input reads the sensor, then the switched power shuts off to prolong battery life.

system operating margin (fade margin)
The system operating margin, or fade margin, is the difference between the received signal level (in dBm) and the receiver sensitivity (also in dBm) required for reliable reception. It is recommended that the receiver sensitivity be more than 10 dBm less than the received signal level. For example, if the signal is about –65 dB after traveling through the air and the radio receiver is rated for -85 dB, the operating margin is 20 dB — an excellent margin.

tau filter
Set to zero (0) to turn off the tau filter. Set to 1 (weakest filter) through 6 (strongest filter) to turn on the tau filter. (In the DX80 products, the Low Pass Filter is a combination of the median filter and the tau filter.)

TCP/IP
TCP/IP stands for Transfer Control Protocol / Internet Protocol and describe several layers in the OSI model that control the transfer and addressing of information.

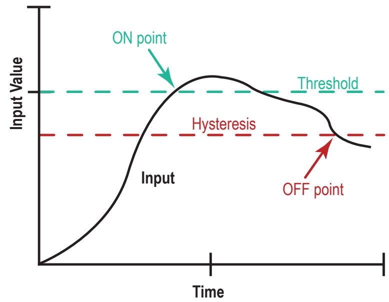
time-division multiple access (TDMA)
TDMA is a wireless network communication architecture that provides a given slot of time for each device on the network, providing a guaranteed opportunity for each device to transmit to the wireless network master device.

thermistor
A thermistor is a temperature-sensitive resistor that changes resistance based on temperature fluctuation.

thermocouple
A thermocouple is a temperature measuring device consisting of two dissimilar metals joined together so that the difference in voltage can be measured. Voltage changes in proportion to temperature, therefore the voltage difference indicates a temperature difference.

The different “types” of thermocouples use different metal pairs for accuracy over different temperature ranges. Thermocouples are inexpensive, relatively interchangeable, have standard connectors, and have a wide temperature range of operation. They can be susceptible to noise, with the wire length affecting accuracy. Thermocouples are best suited for applications with large temperature ranges, not for measuring small temperature changes over small ranges.

threshold and hysteresis
Threshold and hysteresis work together to establish the ON and OFF points of an analog input. The threshold defines a trigger point or reporting threshold (ON point) for a sensor input. Setting a threshold establishes an ON point. Hysteresis defines how far below the threshold the analog input is required to be before the input is considered OFF. A typical hysteresis value is 10% to 20% of the unit’s range.



In the example shown, the input is considered on at 15 mA. To consider the input off at 13 mA, set the hysteresis to 2 mA. The input will be considered off when the value is 2 mA less than the threshold.

Setting threshold and hysteresis points prevents inputs from oscillating between 'on' and 'off' when the input remains close to the threshold point.

timeout interval The Timeout Interval is the total elapsed time before the system flags an error condition. This is a calculated value from Polling Interval (sec) × Maximum Misses.

topology Topology is the pattern of interconnection between devices in a communication network. Some examples include point to point, bus, ring, tree, mesh, and star configurations.

transceiver A transceiver includes both a transmitter and receiver in one housing and shares circuitry; abbreviated as RxTx.

wireless sensor network (WSN) A wireless sensor network is a network of low-power electronic devices that combine sensing and processing ability. The devices use radio waves to communicate to a gateway device, connecting remote areas to the central control process.

Yagi Yagi is the name commonly given to directional antennas. The full name of the antenna is a Yagi-Uda antenna, named for the developers Shintaro Uda and Hidetsugu Yagi, both of Tohoku Imperial University in Sendai, Japan. Yagi antennas may also be called beam antennas or directional antennas.

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