

Sure Cross[®] MultiHop Radios

Instruction Manual

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151317

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1 MultiHop Radio Overview

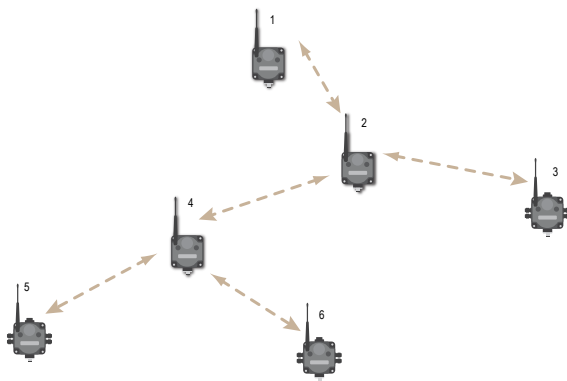
MultiHop networks are made up of one master radio and many repeater and slave radios.

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 wireless network.
- The repeater radios extend the range of the wireless network.
- The slave radios are the end point of the wireless network.

At the root of the wireless network is the master radio. All repeater or slave radios within range of the master radio connect as children of the master radio, which serves as their parent. After repeater radios synchronize to the master radio, additional radios within range of the repeater can join the network. The radios that synchronize to the repeater radio form the same parent/child relationship the repeater has with the master radio: the repeater is the parent and the new radios are children of the repeater. The network formation continues to build the hierarchical structure until all MultiHop radios connect to a parent radio. A MultiHop radio can only have one designated parent radio. If a radio loses synchronization to the wireless network it may reconnect to the network through a different parent radio.

For the simple example network shown below, the following relationships exist:



- Radio 1 is the master radio and is parent to radio 2 (repeater).
- Radio 2 (repeater) is child to radio 1 (master), but is parent to radios 3 (slave) and 4 (repeater).
- Radio 4 (repeater) is child to radio 2 (repeater), but is parent to radios 5 and 6 (both slaves).

On the LCD of each device, the parent device address (PADR) and local device address (DADR) are shown.

MultiHop Master Radio. Within a network of MultiHop data radios, there is only one master 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.

MultiHop Repeater Radio. 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. The incoming packet of information is re-transmitted on both the radio link and the local serial link.

MultiHop Slave Radio. The slave radio is the end device of the MultiHop radio network. A radio in slave mode does not re-transmit the data packet on the radio link, only on the local serial (wired) bus.

1.1 MultiHop Application Modes

The MultiHop radios operate in Modbus mode or transparent mode. Use the internal DIP switches to select the mode of operation. All MultiHop radios within a wireless network must be in the same mode.

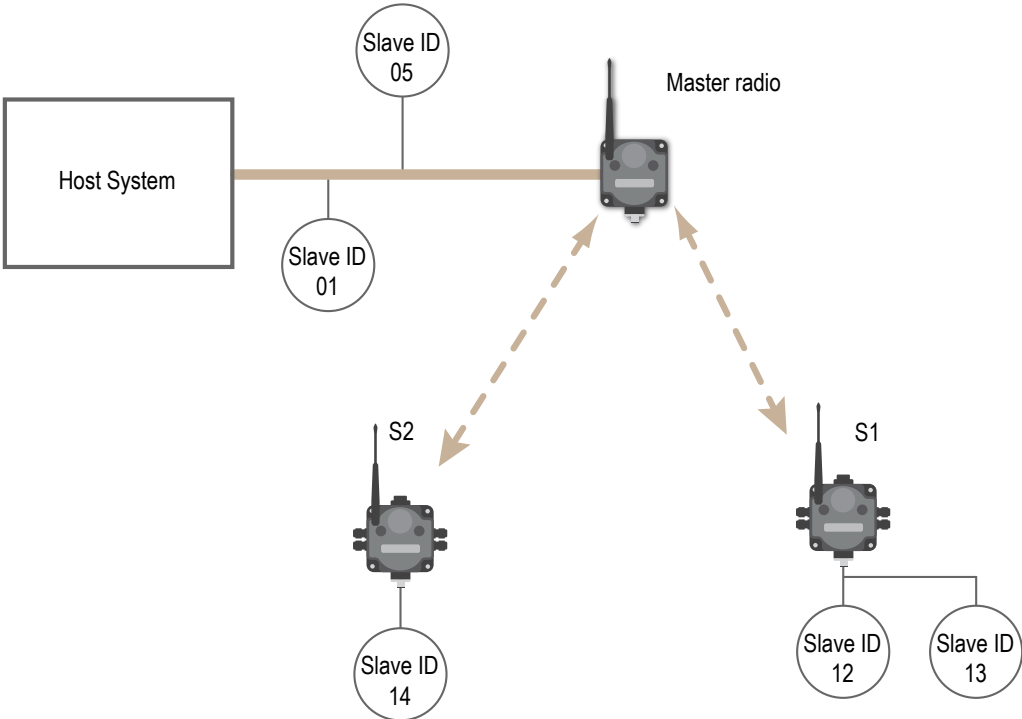
1.1.1 Modbus Mode

Modbus application mode provides additional functionality to optimize RF packet routing performance and allows register-based access and configuration of various parameters on the MultiHop radio. Modbus application mode requires that the system host device be running a Modbus master program and that the master radio is connected directly to the host.

Packet Routing—In Modbus application mode, the master radio first discovers all connected Modbus slaves in the network, then uses the Modbus slave ID contained in the incoming Modbus message to wirelessly route the packet only to the radio attached to the target Modbus slave. The packet is then passed via the radio's serial interface to the Modbus device where it is processed. This is entirely transparent to the user. Direct packet by packet routing offers an advantage over broadcast addressing with MultiHop paths because each hop in the path can be retried independently in the event of a packet error. This results in significantly more reliable packet delivery over MultiHop paths.

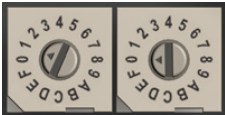
Modbus Slave IDs 01 through 10 are reserved for slaves directly connected to the host (local I/O). As such, polling messages addressed to these devices are not relayed over the wireless link. Use Modbus Slaves IDs 11 through 60 for remote Modbus slaves — devices serially connected to a data radio — allowing a maximum of 50 attached devices.

Shown is a basic wireless network operating in Modbus application mode. Slave devices may be any Modbus slaves, including Banner's DX85 Modbus RTU Remote I/O devices or DX80 Gateways.



MultiHop Radio Registers and Radio IDs—The Modbus application mode also enables the host to access a radio’s internal Modbus registers to access radio configuration and status information.

To enable access of a radio’s internal Modbus registers, the radio itself must be assigned a Modbus Slave ID, or MultiHop Radio ID, using the rotary dials on the front of the device. The left rotary dial acts as the tens unit while the right rotary dial acts as the ones unit. To set the slave ID to 12, set the left dial to 1 and the right dial to 2.



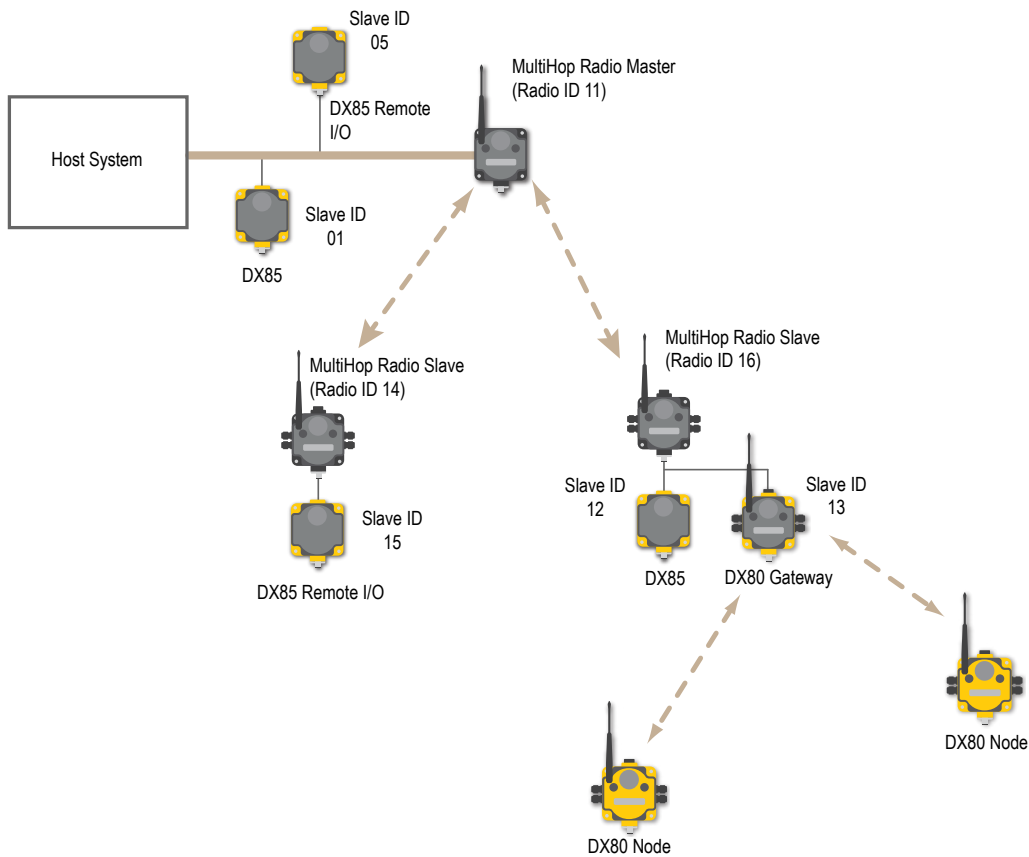
When a Modbus message is received by the radio, the packet’s slave ID is compared to its own rotary dial address. If it matches, the radio accesses its internal Modbus registers. If it does not match, the radio delivers the packet to the serial interface thereby interrogating a connected Modbus slave. The range of acceptable Modbus Slave/MultiHop Radio IDs is from 11 to 60; a Slave ID setting of 0xFF disables access to the MultiHop radio’s internal registers but still delivers addressed messages to Modbus slaves that are serially connected to the radio. Detailed information about the contents and functions of the radio’s Modbus registers is provided in table 2.

All MultiHop Radio internal registers are defined as 16-bit holding registers (4xxxx). To access the internal registers, set the radio to operate in Modbus mode (using the DIP switches) and set a valid MultiHop Radio ID (11 through 60).

*Note: The radio’s rotary dial address must not be a duplicate of an attached Modbus slave ID.

- Rotary dial positions 11 through 60—Valid wireless Modbus Slave IDs or MultiHop Radio IDs
- Rotary dial position FF—Devices set to FF are not directly addressed by the Modbus host system but can deliver the message to the serially connected Modbus slaves

This example host system is connected to three hardwired devices: DX85 Remote I/O Modbus slave 01, DX85 Remote I/O Modbus slave 05, and the master MultiHop Radio. Host messages for Modbus slaves 01 through 10 are ignored by the master radio. Messages for Modbus Slaves or MultiHop Radios 11 through 60 are sent out the wireless network.



1.1.2 Transparent Mode

Use transparent mode for communication protocols other than Modbus.

In transparent mode, the MultiHop radio packetizes data received from the hardwired serial connection and transmits the packet to all radios within range. Because the recipient is not known, there is no acknowledgement of sent messages.

A wireless system by definition is a lossy link. It is up to the host system protocol to guarantee the data integrity. For reliable packet transmission, follow all rules for packet size and inter-character timing listed in the specifications and allow sufficient time between packets to avoid overloading the MultiHop radio network. The time between packets varies based on the size of the network.

Example: Force a Single Route in Transparent Mode

Use the Destination Address parameter to create a single end-to-end route while in transparent mode. Set the Destination Address parameter using the LCD menu system on the MultiHop radios (*DVCFG > DEST) or write to Modbus register 46403.

For a MultiHop master radio at 54321, a repeater radio at 43210, and a slave radio at 32109, follow these instructions.

1. Set the destination address on the MultiHop radio master to 32109.
2. Set the destination address on the MultiHop radio slave to 54321.

Now routing retries and acknowledgements take affect.

For more information about Transparent Mode and forced routing, see [Forced Routing with MultiHop Radios](#) on p. 57.

2 Radio Features



- 1 Rotary Dials. Set the Modbus Slave ID when operating in Modbus mode. (Not used on the Ethernet Data Radio.)
- 2 Push Button 1. Single-click to advance across all top-level data radio menus. Single-click to move down interactive menus, once a top-level menu is chosen. (See MultiHop Radio Menu System.)
- 3 Push Button 2. Double-click to select a menu and to enter manual scrolling mode. Double-click to move up one level at a time. Triple click to enter binding mode.
- 4 LED 1 and 2. Provide real-time feedback to the user regarding RF link status, serial communications activity, and the error state.
- 5 LCD Display. Six-character display provides run mode user information such as the number of packets sent and received. This display allows the user to conduct a site survey.
- 6 5-pin M12 Euro-style Quick-disconnect Port. The Euro-style power is used for serial connections and power. (Not available on the Ethernet Data Radio.)

2.1 Dimensions

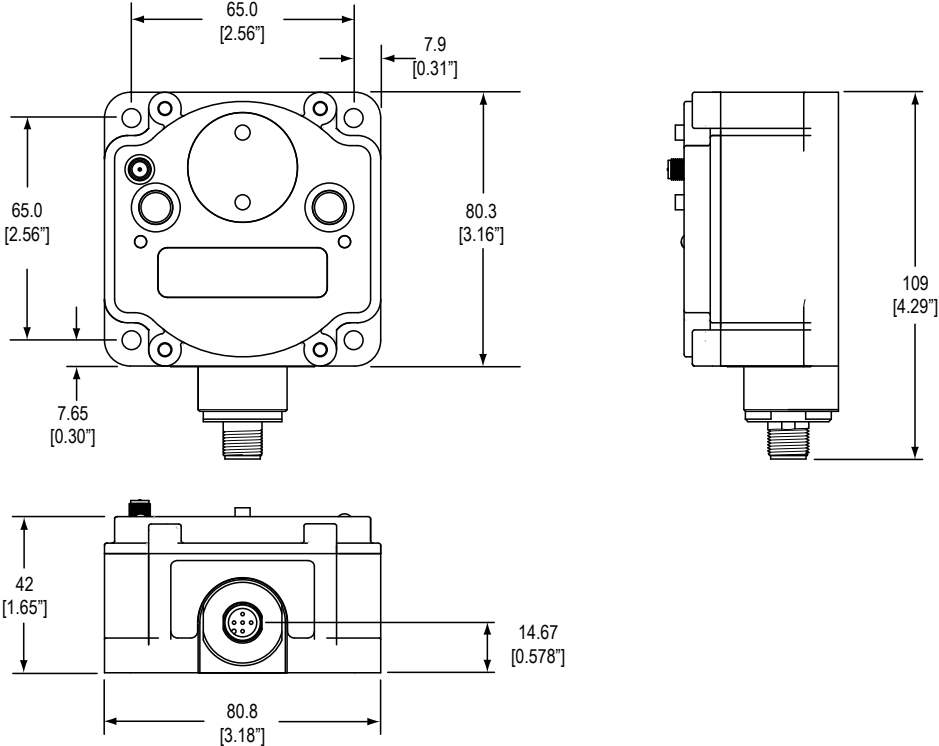


Figure 1. MultiHop Radio, Low Profile Housing

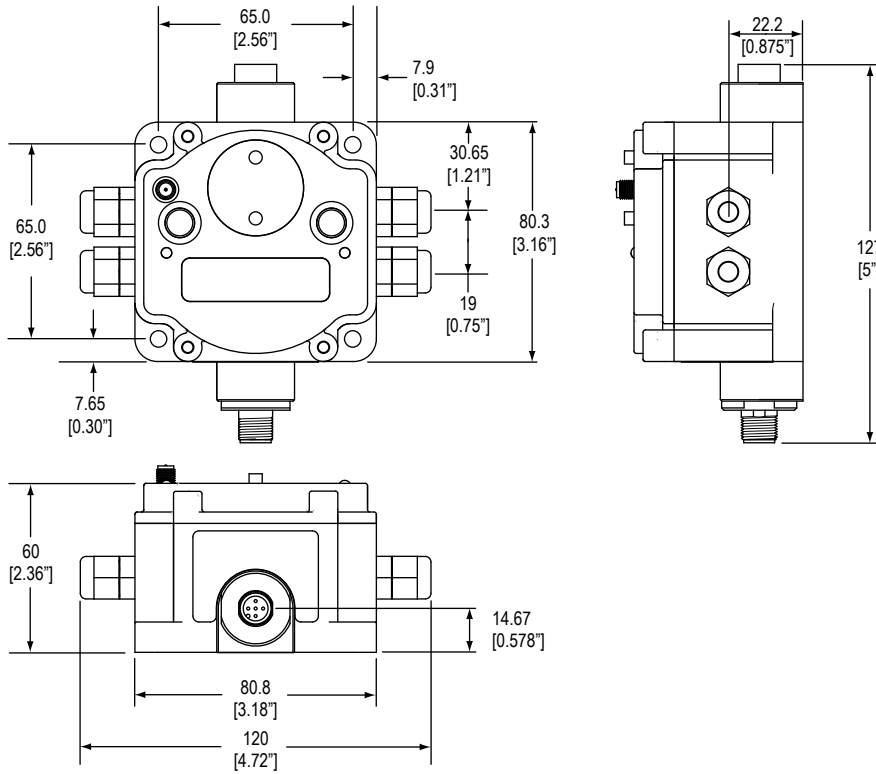


Figure 2. MultiHop Radio with I/O

2.2 DX80...E Housings

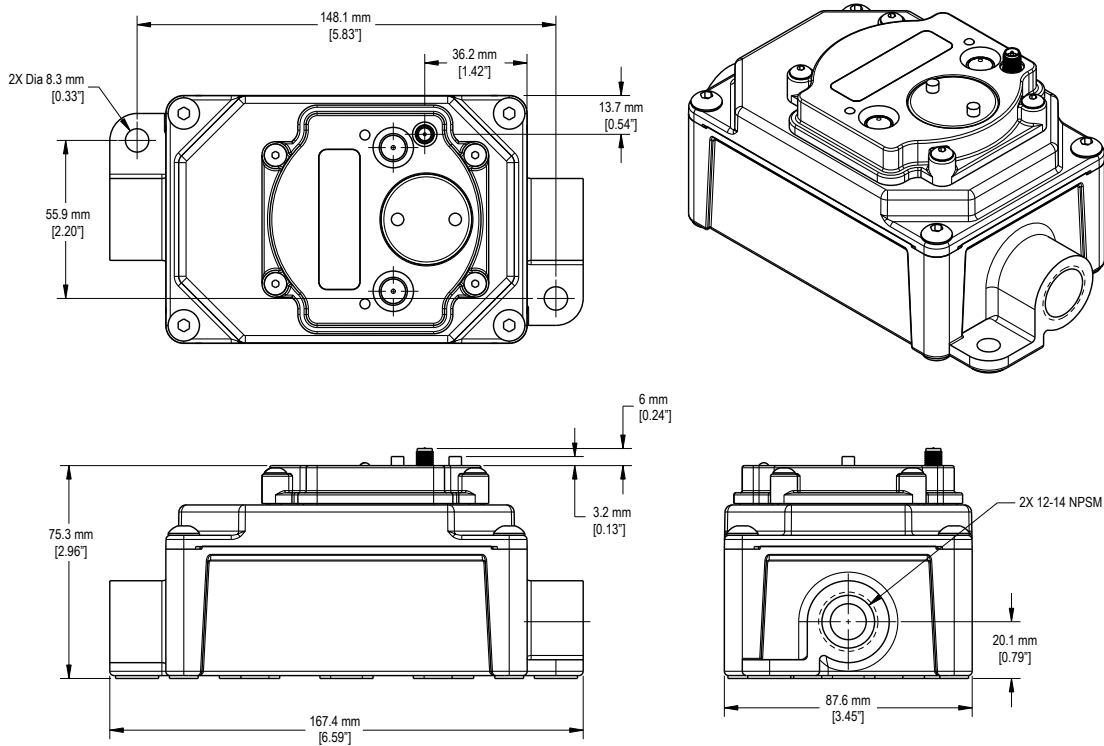


Figure 3. DX80...E Housing

3 Setting Up Your MultiHop Network

To set up and install your wireless MultiHop network, follow these steps:

1. If your radios have DIP switches, configure the DIP switches of all devices. For DIP switch configurations, refer to the product's datasheet.
2. Connect the sensors to the MultiHop radios if applicable. For available I/O, refer to the product's datasheet.
3. Apply power to all devices.
4. If your MultiHop radio has rotary dials, set the MultiHop Radio (Slave) ID. If your MultiHop radio has no rotary dials, continue to the next step.
5. Form the wireless network by binding the slave and repeater radios to the master radio.
6. Observe the LED behavior to verify the devices are communicating with each other.
7. Configure any I/O points to use the sensors connected to the Sure Cross devices.
8. Conduct a site survey between the MultiHop radios.
9. Install your wireless sensor network components.

For additional information, refer to one of the following documents:

- MultiHop Data Radio Quick Start Guide: [152653](#)
- MultiHop Register Guide: [155289](#)

3.1 Configure the MultiHop Radios

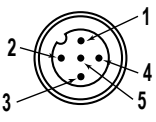
Before configuring the devices, disconnect the power to all MultiHop radios.

MultiHop Radios use the master device identification number to form groups of radios that communicate with each other. Follow the procedure outlined below for binding radios to a particular master radio.

1. Access the DIP switches by removing the four screws that mount the cover to the bottom housing.
2. Remove the cover from the housing without damaging the ribbon cable or the pins the cable plugs into.
3. Using the master/repeater/slave DIP switches, set one unit to be the master radio. By default, the MultiHop radios ship from the factory configured to be repeater radios.
4. Using the same DIP switches, set the other data radios to be repeaters or slaves.
5. Set any additional DIP switches now. (See the DIP Switches section in the data sheet for the positions and descriptions.) By default, the MultiHop radios ship from the factory in Modbus mode. If you need the radio to be in Transparent mode, configure that DIP switch now.
6. Apply power to the MultiHop radios to activate the DIP switch changes.

3.1.1 Apply Power to the Radio

Connecting power to the communication pins will cause permanent damage. For *FlexPower* devices, do not apply more than 5.5 V to the gray wire. The FlexPower radios will operate equally well when powered from the brown or gray wire. It is not necessary to supply both. The power for the sensors can be supplied by the radio's SPx terminals or from the 10 V DC to 30 V DC used to power the radio.

	Pin	Wire Color	Models powered by 10 to 30 V dc with RS-485	FlexPower models with RS-485	FlexPower models with RS-232
	1	brown	10 V DC to 30 V DC	10 V DC to 30 V DC	10 V DC to 30 V DC
	2	white	RS-485 / D1 / B / +	RS-485 / D1 / B / +	RS-232 Tx
	3	blue	dc common (GND)	dc common (GND)	dc common (GND)
	4	black	RS-485 / D0 / A / -	RS-485 / D0 / A / -	RS-232 Rx
	5	gray	-	3.6 V DC to 5.5 V DC	3.6 V DC to 5.5 V DC

3.2 Set the MultiHop Radio (Slave) ID

The slave ID is an identifying number used for devices within a Modbus system. When using more than one Modbus slave, assign each slave a unique ID number.

For MultiHop radios with rotary dials, use the rotary dials to set the device's MultiHop Radio ID. The left dial sets the left digit and the right dial sets the right digit.

- Modbus Slave IDs 01 through 10—Reserved for slaves directly connected to the host (local I/O). Polling messages addressed to these devices are not relayed over the wireless link.

- Modbus Slave IDs 11 through 60—Use for MultiHop master, repeater, and slave radios. Up to 50 devices (local slaves and remote slaves) may be used in this system.

If your MultiHop radio does not have rotary dials, you must use the master radio to set the Slave ID during the binding process.

3.3 Bind a MultiHop Radio (with Rotary Dials)

To create your MultiHop network, bind the repeater and slave radios to the designated master radio.

Before binding your radio, verify you have used the radio's rotary dials to assign a unique slave ID to the radio.

1. Apply power to all MultiHop radios and place the MultiHop radios configured as slaves or repeaters at least two meters away from the master radio.
2. Put the MultiHop master radio into binding mode.
 - For two button master radios, triple-click button 2.
 - For one button master radios, triple-click the button.

For the two LED/button models, both LEDs flash red and the LCD shows *BINDNG and *MASTER. For single LED/button models, the LED flashes alternatively red and green.

3. Put the MultiHop repeater or slave radio into binding mode.
 - For two button radios, triple-click button 2.
 - For one button radios, triple-click the button.

The child radio enters binding mode and searches for any Master radio in binding mode. While searching for the Master radio, the two red LEDs flash alternately. When the child radio finds the Master radio and is bound, both red LEDs are solid for four seconds, then both red LEDs flash simultaneously four times. For M-GAGE Nodes, both colors of the single LED are solid (looks orange), then flash. After the slave/repeater receives the binding code transmitted by the master, the slave and repeater radios automatically exit binding mode.

4. Repeat step 3 for as many slave or repeater radios as are needed for your network.
5. When all MultiHop radios are bound, exit binding mode on the master.
 - For two button master radios, double-click button 2.
 - For one button master radios, double-click the button.

All radio devices begin to form the network after the master data radio exits binding mode.

Child Radios Synchronize to the Parent Radios

The synchronization process enables a Sure Cross® radio to join a wireless network formed by a master radio. After power-up, synchronization may take a few minutes to complete. First, all radios within range of the master data radio wirelessly synchronize to the master radio. These radios may be slave radios or repeater radios.

After repeater radios are synchronized to the master radio, any radios that are not in sync with the master but can "hear" the repeater radio will synchronize to the repeater radios. Each repeater "family" that forms a wireless network path creates another layer of synchronization process. The table below details the process of synchronization with a parent. When testing the devices before installation, verify the radio devices are at least two meters apart or the communications may fail.

3.3.1 Slave and Repeater LED Behavior

All bound radios set to slave or repeater modes follow this LED behavior after powering up.

Process Steps	Response	Two Button/LED Models		Single Button/LED Models
		LED 1	LED 2	LED
1	Power is supplied to the radio.	-	Solid amber (briefly)	Solid amber
2	The slave/repeater searches for a parent device.	Flashes red	-	Flashes red (1 per 3 sec)
3	A parent device is detected. The slave/repeater searches for other parent radios within range.	Solid red	-	Solid red
4	The slave/repeater selects a suitable parent.	-	Solid amber	Solid amber
5	The slave/repeater attempts to synchronize to the selected parent.	-	Solid red	Solid red
6	The slave/repeater is synchronized to the parent.	Flashes green	-	Flashes green

Process Steps	Response	Two Button/LED Models		Single Button/LED Models
		LED 1	LED 2	LED
7	The slave/repeater enters RUN mode.	Solid green, then flashes green		Solid green, then flashes green
	Serial data packets begin transmitting between the slave/repeater and its parent radio.	-	Flashes amber	Flashes amber

3.3.2 Master LED Behavior

All bound radios set to operate as masters follow this LED behavior after powering up.

Process Steps	Response	Two Button/LED Models		Single Button/LED Models
		LED 1	LED 2	LED
1	Power is supplied to the master radio	-	Solid amber	Solid amber
2	The master radio enters RUN mode.	Flashes green	-	Flashes green
	Serial data packets begin transmitting between the master and its children radios.	-	Flashes amber	Flashes amber

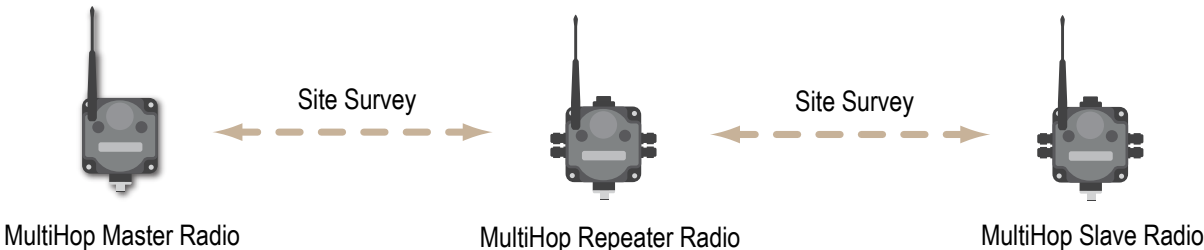
3.4 Conduct a Site Survey

A site survey analyzes the radio signal between a MultiHop child radio and its parent and reports the number of data packets missed or received at relative signal strengths.

3.4.1 Conduct a MultiHop Site Survey (from the LCD Menu System)

Perform the site survey before permanently installing your network to pre-screen a site for its radio communication potential, compare link quality in different locations in a factory, or assist with final antenna placement and aiming.

Site surveys can be conducted from either the master, repeater, or slave radios. A master radio is always a parent and the slave radios are always children radios within the radio communication relationship. A repeater radio, however, may be both a child radio to the master or another repeater and a parent radio to other repeater or slave radios. For a more detailed description of the parent-child relationships, refer to the device data sheets.



Other radios bound within the same network remain synchronized to the network, but are blocked from sending data while the site survey is running. 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.

Single-click button 2 to pause or resume autoscrolling the site survey results. While paused, button 1 single-step advances through the four signal strength categories: green, yellow, red, and missed. Double-click button 2 to exit the results display. (Refer to the data sheet for the menu structure.)

1. On a MultiHop radio, press button 1 until the display reads *SITE. When the site survey runs, serial and I/O data radio communication between that parent and its children stops.
2. Single-click button 2 to enter the Site Survey menu. Master radio: The display reads CHLDRN. Repeater radio: The display reads PARENT. Slave radio: The display reads PARENT.

3. Select the MultiHop radio to analyze.

MultiHop Model **Select the radio to analyze:**

From the master radio Single-click button 2 to display the child radio's device address. (A radio's device address is displayed under its *RUN menu). Single click button 1 to scroll between all the master radio's children. When you reach the child radio you want to run the site survey with, single-click button 2.

From the repeater radio Single-click button 1 to cycle between PARENT and CHLDRN. Single-click button 2 to select PARENT or CHLDRN. If conducting the site survey with one of the repeater's children, single-click button 1 to scroll among a repeater's children radios. (Each data radio's device address is displayed under its *RUN menu.) Single-click button 2 at the device address screen to select the child or parent and begin the site survey.

From the slave radio Single-click button 2 to display PARENT. Single-click button 2 to begin the site survey.

The site survey begins. LED 2 on both the parent and child radios flash for every received RF packet. To indicate the parent is in site survey mode, LED 1 is a solid green. The data radio analyzes the quality of the signal between the parent and child by counting the number of data packets received and measuring the signal strength (green, yellow, and red).

4. Examine reception readings (G, Y, R, M) of the devices at various locations. M displays the percent of missed packets while G, Y, and R display the percent of received packets at those signal strengths. These values are continuously updated as long as the site survey is running.
GRN = GREEN excellent signal strength; YEL = YELLOW good signal strength; RED = RED marginal signal strength; MIS = Percentage of missed packets. When possible, install all devices to optimize the percentage of YELLOW and GREEN data packets received.
5. While the site survey is in process, single-click button 2 to pause or resume autoscrolling the site survey results. While paused, button 1 single-step advances through the four signal strength categories: green, yellow, red, and missed. Double-click button 2 to exit the results display.
6. Double-click button 2 on either the child or the parent device.
Site survey ends and the devices automatically resume operation.

3.4.2 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.

3.4.3 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.

4 Installing Your Sure Cross® Radios

Follow these recommendations to install your wireless network components.

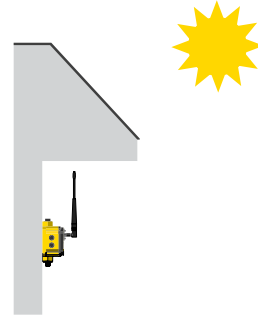
4.1 Mounting Sure Cross Devices Outdoors

Use a Secondary Enclosure. For most outdoor applications, we recommend installing your Sure Cross devices inside a secondary enclosure. For a list of available enclosures, refer to the Accessories List (p/n [b_3147091](#)).

Point Away From Direct Sunlight. When you are not using a secondary enclosure, minimize the damaging effects of ultra-violet radiation by mounting the devices to avoid facing intense direct sunlight.

- Mount under an overhang or other source of shade,
- Install indoors, or
- Face the devices north when installing outside.

For harsh outdoor applications, consider installing your radio inside a secondary enclosure. For a list of available enclosures, refer to the Accessories List (p/n [b_3147091](#)).



Mount Vertically to Avoid Collecting Rain. When possible, mount the devices where rain or snow will drain away from the device.

- Mount vertically so that precipitation, dust, and dirt do not accumulate on permeable surfaces.
- Avoid mounting the devices on flat or concave surfaces, especially if the display will be pointing up.

Remove Moisture and Condensation. If condensation is present in any device, add a small desiccant packet to the inside of the radio. To help vent the radios, Banner also sells a vented plug (model number **BWA-HW-031**) for the 1/2-inch NPT port of the Sure Cross radios.



4.1.1 Watertight Glands and NPT Ports

To make glands and plugs watertight, use PTFE tape and follow these steps.

1. Wrap four to eight passes of polytetrafluoroethylene (PTFE) tape around the threads as close as possible to the hexagonal body of the gland.
2. Manually thread the gland into the housing hole. Never apply more than 5 in-lbf of torque to the gland or its cable clamp nut. ¹



Seal any unused access holes with one of the supplied plastic plugs. To install a watertight plug:

1. Wrap four to eight passes of PTFE tape around the plug's threads, as close as possible to the flanged surface.
2. Carefully thread the plastic plug into the vacant hole in the housing and tighten using a slotting screwdriver. Never apply more than 10 in-lbf torque to the plastic plug.

If your device has an unused NPT port, install a watertight NPT plug:

1. Wrap 12 to 16 passes of PTFE tape evenly across the length of the threads.
2. Manually thread the plug into the housing port until reaching some resistance.
3. Using a crescent wrench, turn the plug until all the plug's threads are engaged by the housing port or until the resistance doubles. Do not over-tighten as this will damage the device. These threads are tapered and will create a waterproof seal without over-tightening.

¹ This is equivalent to the torque generated without using tools. If a wrench is used, apply only very light pressure. Torquing these fittings excessively damages the device.

4.2 Other Installation Requirements

Reduce Chemical Exposure—Before installing any devices in a chemically harsh environment, contact the manufacturer for more information regarding the life-expectancy. Solvents, oxidizing agents, and other chemicals will damage the devices.

Minimize Mechanical Stress—Although these radio devices are very durable, they are sophisticated electronic devices that are sensitive to shock and excessive loading.

- Avoid mounting the devices to an object that may be shifting or vibrating excessively. High levels of static force or acceleration may damage the housing or electronic components.
- Do not subject the devices to external loads. Do not step on them or use them as handgrips.
- Do not allow long lengths of cable to hang from the glands on the Gateway or Node. Cabling heavier than 100 grams should be supported instead of allowed to hang from the housing.
- Do not crack the housing by over-tightening the top screws. Do not exceed the maximum torque of 4 in-lbf.

It is the user's responsibility to install these devices so they will not be subject to over-voltage transients. Always ground the devices in accordance with local, state, or national regulations.

When Installing 1-Watt Radios—Notice: This equipment must be professionally installed. The output power must be limited, through the use of firmware or a hardware attenuator, when using high-gain antennas such that the +36 dBm EIRP limit is not exceeded.

4.3 Installation Quick Tips

The following are some quick tips for improving the installation of wireless network components.

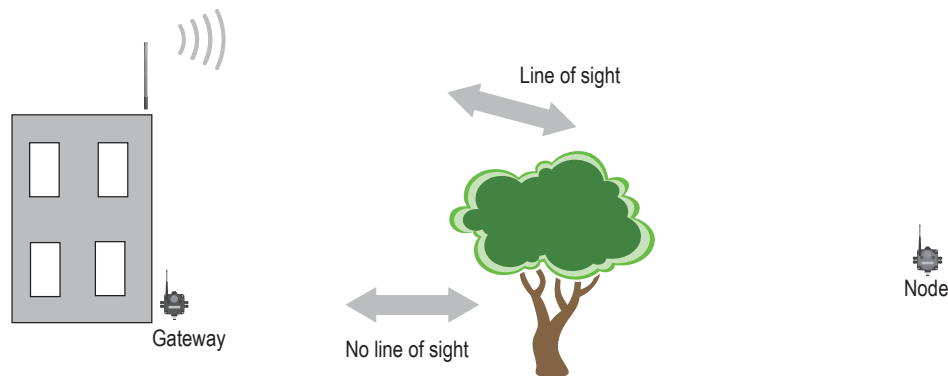
4.3.1 Create a Clear Communication Path

Wireless communication is hindered by radio interference and obstructions in the path between the transmitter and receiver. To achieve the best radio performance, carefully consider the installation locations for the Gateways and Nodes and select locations without obstructions in the path.

For more information about antennas, please refer to the *Antenna Basics* reference guide, Banner document p/n 132113.

4.3.2 Increase the Height of the Antennas

Position the external antenna vertically for optimal RF communication. If necessary, consider changing the height of the Sure Cross radio, or its antenna, to improve reception. For outdoor applications, mounting the antenna on top of a building or pole may help achieve a line-of-sight radio link with the other radios in the network.



4.3.3 Collocated Radios

When the radio network's master device is located too close to another radio device, communications between all devices is interrupted. For this reason, always assign a unique Network ID to your wireless networks.

The Network ID (NID) is a unique identifier you assign to each wireless network to minimize the chances of two collocated networks interfering with each other. Assigning different NIDs to different networks improves collocation performance in dense installations.

Do not install antennas within the minimum separation distance.

Antenna Minimum Separation Distance

- 900 MHz, 150 mW and 250 mW: 2 m (6 ft)
- 900 MHz, 1 Watt: 4.57 m (15 ft)
- 2.4 GHz, 65 mW: 0.3 m (1 ft)

4.3.4 Be Aware of Seasonal Changes

When conducting the initial Site Survey, the fewest possible missed packets for a given link is better. However, seasonal changes may affect the signal strength and the total signal quality. Radios installed outside with 50% missed packets in the winter months may have 80% or more missed packets in the summer when leaves and trees interfere with radio reception.

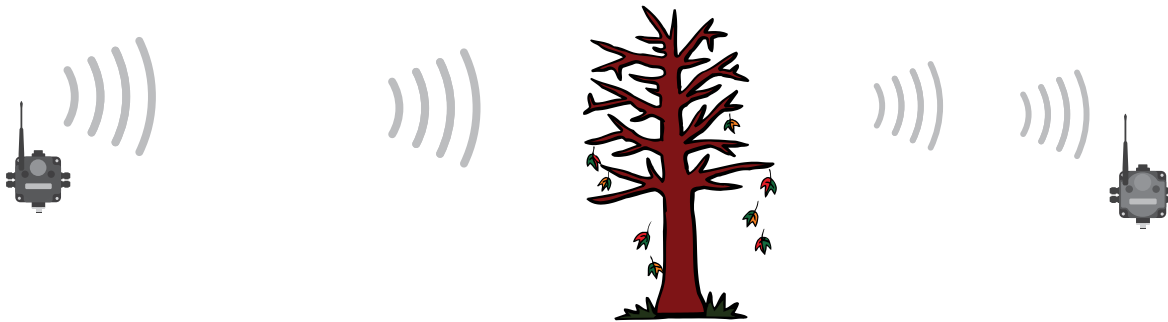


Figure 4. A good signal in winter doesn't always mean you will get the same signal strength the rest of the year.

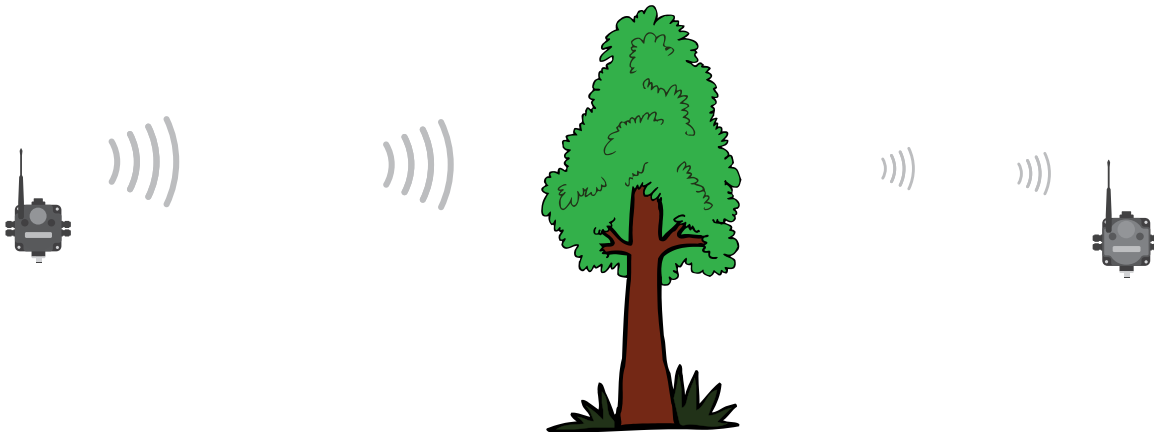


Figure 5. During spring and summer, leaves may block more of the radio signal.

4.4 Installing a Basic Remote Antenna

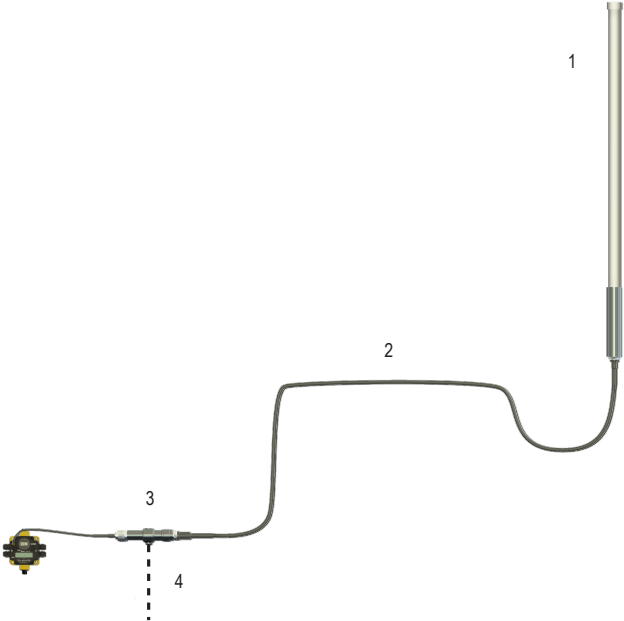
A remote antenna system is any antenna system where the antenna is not connected directly to the radio; coaxial cable connects the antenna to the radio.

When installing a remote antenna system, always include a lightning arrestor or coaxial surge suppressor in the system. Remote antenna systems installed without surge protection invalidate the warranty of the radio devices.

Surge suppressors should be properly grounded and mounted at ground level near where the cabling enters a building. Install the surge suppressor indoors or inside a weatherproof enclosure to minimize corrosion or component deterioration. For best results, mount the surge suppressor as close to the ground as possible to minimize the length of the ground connection and use a single-point ground system to avoid creating ground loops.

For more detailed information about how antennas work and how to install them, refer to Antenna Basics (p/n [132113](#)).

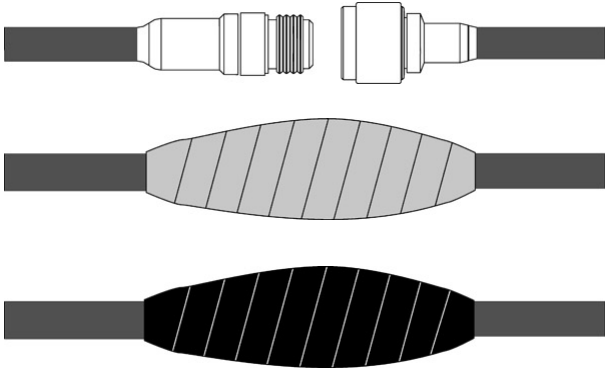
- 1. Antenna mounted remotely from the radio device.
- 2. Coaxial cable
- 3. Surge suppressor
- 4. Ground wire to a single-point ground system



I/O Isolation. When connecting analog and discrete I/O to external equipment such as VFDs (Variable Frequency Drives), it may be appropriate to install interposing relays and/or loop isolation devices to protect the DX80 unit from transients, noise, and ground plane interference originating from devices or the environment. Contact Banner Engineering Corp. for more information.

4.4.1 Weatherproof Remote Antenna Installations

Seal the connections with rubber splicing tape and electrical tape to prevent water damage to the cable and connections.



Step 1: Verify both connections are clean and dry before connecting the antenna cable to the antenna or other cable. Hand-tighten the cable connections.

Step 2: Tightly wrap the entire connection with rubber splicing tape. Begin wrapping the rubber splicing tape one inch away from the connection and continue wrapping until you are one inch past the other end of the connection. Each new round of tape should overlap about half the previous round.

Step 3: Protect the rubber splicing tape from UV damage by tightly wrapping electrical tape on top of the rubber splicing tape. The electrical tape should completely cover the rubber splicing tape and overlap the rubber tape by one inch on each side of the connection.

4.4.2 Installing Remote Antennas

Install and properly ground a qualified surge suppressor when installing a remote antenna system. Remote antenna configurations installed without surge suppressors invalidate the manufacturer's warranty. Keep the ground wire as short as possible and make all ground connections to a single-point ground system to ensure no ground loops are created. No surge suppressor can absorb all lightning strikes; do not touch the Sure Cross® device or any equipment connected to the Sure Cross device during a thunderstorm.

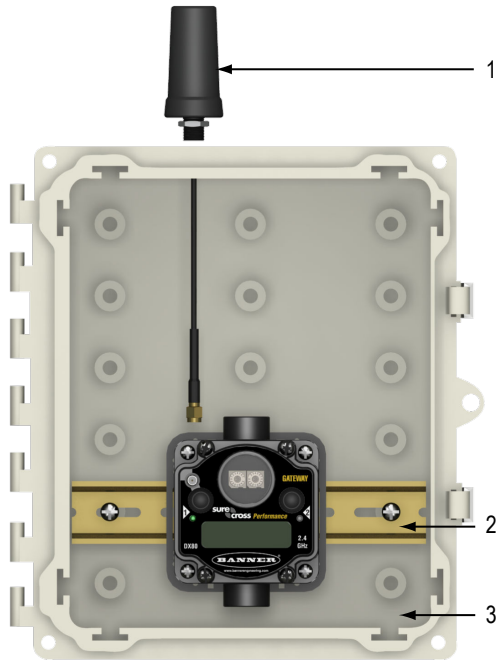
4.4.3 Mount a Dome Antenna to the Enclosure

Use a -D dome antenna when mounting an antenna directly to the outside of the enclosure.

1. Dome antenna
2. DIN rail and DIN rail bracket
3. Enclosure

The -D dome antennas come with an 18-inch RP-SMA extension cable connected to the antenna. Use this extension cable to connect the antenna directly to the radio.

To mount, drill a hole in the enclosure and insert the antenna.

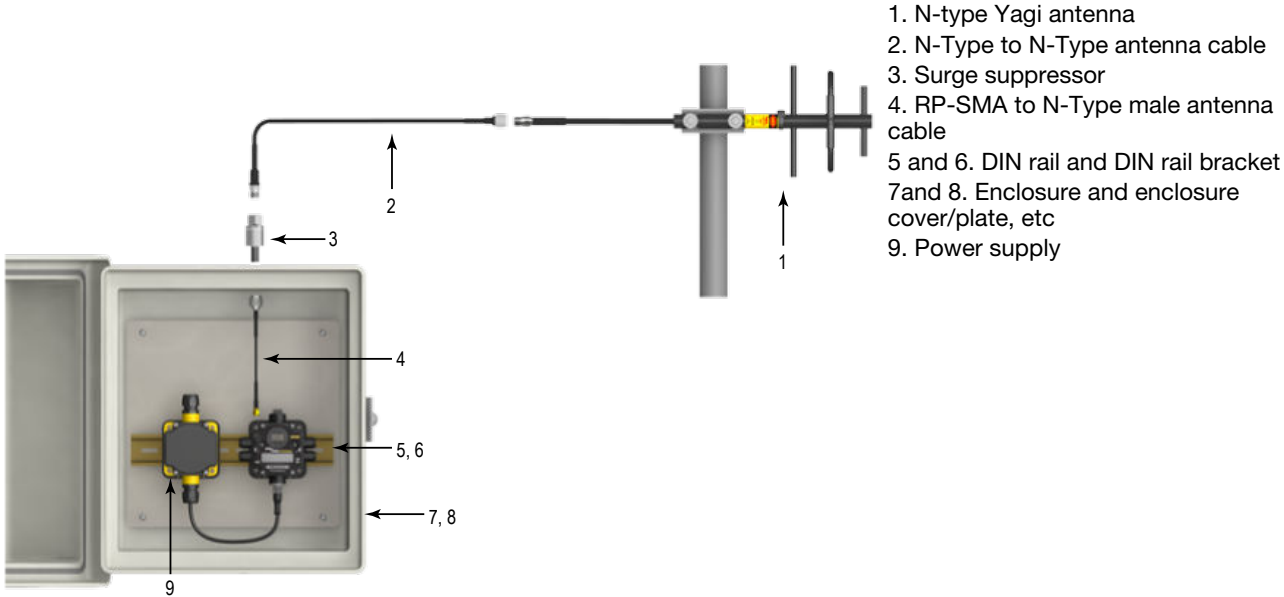


Models	Description	List Price
BWA-902-D	Antenna, Omni, 900 MHz, 2 dBd, Dome, RP-SMA MALE Box mount, 18-inch antenna cable	\$95
BWA-202-D	Antenna, Omni, 2.4 GHz, 2 dBd, Dome, RP-SMA MALE Box mount, 18-inch antenna cable	\$95

4.4.4 Use an N-Type, Pole-Mounted Antenna

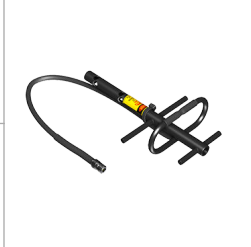
This antenna mounts remotely from the box, with the SureCross device mounted inside the box.

Ground the surge suppressor and antenna. Keep the ground wire as short as possible and make all ground connections to a single-point ground system to ensure no ground loops are created.



Directional (Yagi) Antennas with an N-Type Female Connection

- BWA-9Y6-A**
- 6.5 dBd, 6.8 x 13 inches Outdoor, 900 MHz
 - Datasheet: [b_3145127](#)
- BWA-9Y10-A**
- 10 dBd, 6.8 x 24 inches Outdoor, 900 MHz
 - Datasheet: [b_3145130](#)






Omni-Directional Fiberglass Antennas with N-Type Female Connections

- BWA-906-A**
- 6 dBd, Fiberglass, Full wave, 71.5 inches, 900 MHz
 - Datasheet: [b_314512](#)
- BWA-208-A**
- 8.5 dBi, Fiberglass, 24 inches, 2.4 GHz
 - Datasheet: [b_3145131](#)
- BWA-206-A**
- 6 dBi, Fiberglass, 16 inches (shown), 2.4 GHz
 - Datasheet: [b_3145117](#)
- BWA-906-AS**
- 6 dBi, Fiberglass, 1/4 Wave, 23.6 inches (1.3 inch dia.), 900 MHz
 - Datasheet: [b_3145125](#)
- BWA-908-AS**
- 8 dBi, Fiberglass, 3/4 Wave, 63 inches (1.5 inch dia.), 900 MHz
 - Datasheet: [b_3145126](#)




Use the LMR400 cables to connect the surge suppressor to the antenna.

N-Type to N-Type Cables—LMR400 Type			
Model	Length (m)	Description	
BWC-4MNFN3	3	LMR400 N-Type Male to N-Type Female	
BWC-4MNFN6	6		
BWC-4MNFN15	15		
BWC-4MNFN30	30		

Surge Suppressors			
<p>BWC-LMRSFRPB</p> <ul style="list-style-type: none"> Surge Suppressor, Bulkhead, RP-SMA Type RP-SMA to RP-SMA 		<p>BWC-LFNBMN-DC</p> <ul style="list-style-type: none"> Surge Suppressor, bulkhead, N-Type, DC Blocking N-Type Female, N-Type Male 	

Use the RP-SMA to N-Type male cables to connect the radio to the surge suppressor.

RP-SMA to N-Type Cables—LMR200 Type			
Model	Length (m)	Description	
BWC-1MRSMN05	0.5	LMR200 RP-SMA to N-Type Male	
BWC-1MRSMN2	2		

5 Modbus Register Configuration

Change the factory default settings for the inputs, outputs, and device operations using the device Modbus registers. To change parameters, set the data radio network to Modbus mode and assign the data radio a valid Modbus slave ID.

Generic input or output parameters are grouped together based on the device input or output number: input 1, input 2, output 1 etc. Operation type specific parameters (discrete, counter, analog 4 to 20 mA) are grouped together based on the I/O type number: analog 1, analog 2, counter 1, etc. Not all inputs or outputs may be available for all models. To determine which specific I/O is available on your model, refer to the Modbus Input/Output Register Maps listed in the device's datasheet. For more information about registers, refer to the MultiHop Product Instruction Manual (p/n [151317](#)).

5.1 00000s Standard Physical Inputs

Registers 1 through 16 are the results registers for inputs 1 through 16.

For a list of the active results registers for your MultiHop radio, refer to your product's datasheet.

5.1.1 00400s Extra Inputs

Registers 401 through 500 are the results registers for extra inputs 1 through 100.

For a list of the active results registers for your MultiHop radio, refer to your product's datasheet.

5.2 00500s Standard Physical Outputs

Registers 501 through 516 are the results registers for outputs 1 through 16.

For a list of the active results registers for your MultiHop radio, refer to your product's datasheet.

5.2.1 00900s Extra Outputs

Registers 901 through 1000 are the results registers for extra outputs 1 through 100.

For a list of the active results registers for your MultiHop radio, refer to your product's datasheet.

5.3 01000s Input Parameters

Data radio inputs have the following generic parameters. These are not global parameters but are associated only with a particular input.

There are currently 16 separate inputs possible; the factory default settings are defined in the I/O specifications. Parameters for Input 1 are at 1001 through 1008. Parameters for input 2 are at 1051 through 1058. Each following input is offset from the previous one by 50 registers.

Parameter Registers for Inputs (4xxx)									
1	2	3	4	5	6	7	8	9	Parameters
1001	1051	1101	1151	1201	1251	1301	1351	1401	Enable
1002	1052	1102	1152	1202	1252	1302	1352	1402	Sample Interval (high word)
1003	1053	1103	1153	1203	1253	1303	1353	1403	Sample Interval (low word)
1008	1058	1108	1158	1208	1258	1308	1358	1408	Out-of-Sync Enable

Enable

A 1 enables the input and a 0 to disable the particular input.

Out-of-Sync Enable

Set to one (1) to enable the input to continue operating when the device is out of sync with the master radio. Set to zero (0) to disable the input when the device is not synchronized to the master radio. The default value is one (1).

Sample Interval (High Word)

The sample interval (rate) is a 32-bit value (requires two Modbus registers) that represents how often the data radio samples the input. The register value is the number of time units. For example, a Modbus register value of 125 (for a 900 MHz device) represents a sample interval of 5 seconds (125 x .040 seconds = 5 seconds). A unit of time for a 900 MHz data radio is 40 milliseconds. A unit of time for a 2.4 GHz data radio is 20 milliseconds.

Sample Interval (Low Word)

See Sample Interval (High Word).

1xx4 through 1xx7

See *Switch Power Input Parameters*.

5.3.1 Switch Power Input Parameters

The switch power input parameters are not global parameters but are associated only with a particular input.

There are currently 16 separate inputs possible; the factory default settings are defined in the I/O specifications. Switch power parameters for Input 1 are at 1004 through 1007. Switch power parameters for input 2 are at 1054 through 1057. Each following input is offset from the previous one by 50 registers.

Parameter Registers for Inputs (4xxxx)									
1	2	3	4	5	6	7	8	9	Parameters
1004	1054	1104	1154	1204	1254	1304	1354	1404	Switch Power Enable
1005	1055	1105	1155	1205	1255	1305	1355	1405	Switch Power Warm-up
1006	1056	1106	1156	1206	1256	1306	1356	1406	Switch Power Voltage
1007	1057	1107	1157	1207	1257	1307	1357	1407	Extended Input Read

Extended Input Read

The Extended Input Read is a bit field parameter that allows multiple inputs to be sampled with the same switch power parameters. If the bit field is set to 0x000F, the first four inputs are sampled after the switch power parameters are satisfied. If this parameter is set in the input 1 configuration registers, set inputs 2 through 4 to zero.

Switch Power Enable

The bit mask can select any number of switch power outputs 1 through 4. Switch power enable works with the warm-up and voltage parameters to define the switch power output. Some devices have only two switch power outputs. Refer to your model's datasheet to confirm which switch power outputs are active for your MultiHop radio.

- 0x0 - No switch power enabled
- 0x1 - Enable SP1
- 0x2 - Enable SP2
- 0x3 - Enable SP1 and SP2
- 0x4 - Enable SP3
- 0x8 - Enable SP4
- 0xC - Enable SP3 and SP4

Switch Power Voltage

The Switch Power Voltage parameter defines the output voltage of the switch power output. This parameter applies only to inputs using switched power. If switch power is not used with an input, use the Continuous Voltage parameter to control the voltage.

Output Voltage	Parameter Value	Output Voltage	Parameter Value
0 V	255	15 V	32
5 V	204	20 V	12
7 V	125	24 V	03
10 V	69		

Switch Power Warm-up

When the data radio supplies power to external sensors, the Switch Power Warm-up parameter defines how long power is applied to the external sensor before the input point is examined for changes. The register value is the number of time units.

A unit of time for a 900 MHz data radio is 40 milliseconds. A unit of time for a 2.4 GHz data radio is 20 milliseconds.

5.4 02000s Output Parameters

The following characteristics are configurable for each output.

Parameters for Output 1 start at 2001 through 2004. Parameters for output 2 start at 2051 through 2054. Each following output is offset from the previous one by 50 registers.

Parameter Registers for Outputs (4xxx)									
1	2	3	4	5	6	7	8	9	Parameters
2001	2051	2101	2151	2201	2251	2301	2351	2401	Enable
2002	2052	2102	2152	2202	2252	2302	2352	2402	Flash Output Enable
2003	2053	2103	2153	2203	2253	2303	2353	2403	Flash Index
2004	2054	2104	2154	2204	2254	2304	2354	2404	Out of Sync Enable

Enable

Set to 1 to enable the output; set to 0 to disable the output.

Flash Index

The Flash Index can have values 1, 2, 3, or 4. For a particular output, the Flash Index 1 through 4 select a certain output pattern as defined in registers 4401, 4411, 4421, or 4431.

Flash Output Enable

The Flash Output Enable, Flash Index, and Output Flash Pattern registers are all used to set up flashing patterns for indicator lights connected to the data radio. Set the Flash Output Enable register to 1 to enable the ability to select an output flash pattern; set to 0 to disable this feature. Select the output pattern using the Flash Index and Output Flash Pattern registers.

Out of Sync Enable

Set to one (1) to enable the output to continue operating when the device is out of sync with the master radio. Set to zero (0) to disable the output when the device is not synchronized to the master radio. The default value is one (1).

5.5 02950s Default Output Parameters

Several device conditions may be used to send outputs to their default state. Use these properties to define the device's default output conditions.

2951 Enable Default Out Of Sync

When a radio is "out of sync," it is not communicating with its parent radio.

Set this value to 1 to enable the default condition when the device is not communicating with its parent radio. Set to 0 to disable.

2952 Enable Default Communication Timeout

A "communication timeout" refers to the communication between the host system and this radio. Set this register to 1 to enable the default condition when the host has not communicated with this radio for the period of time defined by the Communication Default IO Timeout.

2953 Communication Default I/O Timeout (100 ms/Count)

This parameter defines the host timeout period in 100 millisecond increments. If a host does not communicate within this timeout period, the device outputs are set to the default values.

2954 Enable Default on Power Up

Setting this parameter to 1 sends the device outputs to their default condition when the radio is powered up. Set to 0 to disable this feature.

5.6 03000s Discrete Input Parameters

The Discrete Input Configuration parameters configure certain aspects of the data radio's discrete inputs.

Parameters for Discrete Input 1 start at 3001, and parameters for Discrete Input 2 start at 3021. Each following input is offset from the previous one by 20 registers.

Parameter Registers for Discrete Inputs (4xxx)				
IN 1	IN 2	IN 3	IN 4	Parameters
3001	3021	3041	3061	PNP/NPN
3002	3022	3042	3062	Sample High
3003	3023	3043	3063	Sample Low
3004	3024	3044	3064	Enable Latch on Change of State
3007	3027	3047	3067	Enable Discrete Input Time Active Counter
3008	3028	3048	3068	Discrete Input Time Active Count
3009	3029	3049	3069	Discrete Input Time Active Count
3013	3033	3053	3073	Enable Rising Edge
3014	3034	3054	3074	Enable Falling Edge
3015-3016	3035-3036	3055-3056	3075-3076	Digital Counter Value

Digital Counter Value

The 32-bit counter results are placed in registers 3015 and 3016 for input #1. To clear or preset the counter value, write a zero value or the preset value into registers 3015 and 3016. Cycling the power sets the counter values back to zero. The host system is responsible for saving the counter values in case of a power failure or power reset condition. A discrete input will not count when the device is not in sync with a parent MultiHop device. To allow for counting when out of sync, set configuration register 1008 to 1 for input #1.

Out of Sync Actions				
IN 1	IN 2	IN 3	IN 4	Description
1008	1058	1108	1158	Enable out-of-sync action. Set to 1 to enable, set to 0 to disable.

Discrete Input Time Active Count

These two registers contain the counter value. Register 3xx8 contains the high portion of the active counter and 3xx9 contains the low portion of the active counter. The counter stores a time value in 100 ms increments. This value is reset to zero when the power cycles off.

Enable Discrete Input Time Active Counter

The time active counter counts the time a discrete input is in the active state. Set to one (1) to enable the time counter; set to zero (0) to disable the counter. By default, this counter is enabled.

Enable Latch on Change of State

Writing a 1 to this register causes a data "push" (data transmitted to the master radio) on Change of State.

Enable Falling Edge

Enables the sync counter falling edge. Set to 1 to enable, set to 0 to disable.

Enable Rising Edge

Enables the sync counter rising edge. Set to 1 to enable, set to 0 to disable. To count on both rising and falling edges, set both the configuration registers to 1 to enable.

PNP or NPN

Set to 1 to define the input as a PNP (sourcing) input. Set to 0 to define the input as an NPN (sinking) input.

Sample High

The default value is 0, which disables this feature. The value range is 1 through 255. The Sample High parameter refers to the number of samples (1 through 255) a discrete input must be detected high (1) before it is considered to be a change of state.

Sample Low

The default value of 0 disables this feature. The value range is 1 through 255. The Sample Low parameter refers to the number of samples (1 through 255) a discrete input must be detected low (0) before it is considered to be a change of state.

5.7 03300s Analog Input Parameters

The following characteristics are configurable for each of the analog inputs.

Analog input parameters for input 1 start at 3301. Analog input parameters for input 2 start at 3321. Each following input is offset from the previous one by 20 registers.

Registers for Analog Parameters (4xxx)				Parameters
IN 1 (3301-3320)	IN 2 (3321-3340)	IN 3 (3341-3360)	IN 4 (3361-3380)	
3301	3321	3341	3361	Maximum Analog Value
3302	3322	3342	3362	Minimum Analog Value
3303	3323	3343	3363	Enable Register Full Scale
3304	3324	3344	3364	Temperature Degrees C/F
3305	3325	3345	3365	Temperature Scaling
3306	3326	3346	3366	Thermocouple Type
3307	3327	3347	3367	Temperature Resolution
3308	3328	3348	3368	Threshold
3309	3329	3349	3369	Hysteresis
3310	3330	3350	3370	Delta
3311	3331	3351	3371	
3312	3332	3352	3372	
3313	3333	3353	3373	
3314	3334	3354	3374	
3315	3335	3355	3375	
3316	3336	3356	3376	Sample High
3317	3337	3357	3377	Sample Low
3318	3338	3358	3379	Change of State Push Enable
3319	3339	3359	3379	Median Filter Enable
3320	3340	3360	3380	Tau Filter

Change of State Push Enable

Set to one (1) to enable push registers for this input. When the analog input changes state, the register value will be pushed to the master radio if this register is configured to be a push register.

Delta

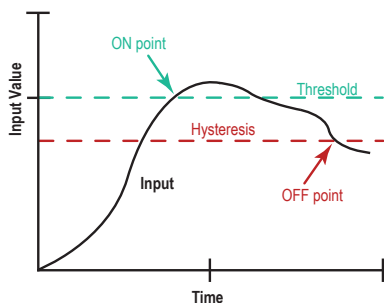
The delta parameter defines the change required between sample points of an analog input before the analog input reports a new value. To turn off this option, set the Delta value to 0.

Enable Register Full Scale

Set to 1 to enable a linear range from 0 to 65535 for specified input range. For a 4 to 20 mA input, a value of 0 represents 4 mA and 65535 represents 20 mA. Set this parameter to 0 to store input readings in unit-specific data. For example, the register data representing a 15.53 mA reading is 15530. For units of current (0 to 20 mA inputs), values are stored as μ A (micro Amps) and voltage values are stored as mV (millivolts).

Hysteresis and Threshold

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.

Maximum Analog Value

The Maximum Value register stores the maximum allowed analog value. The specific units of measure apply to the register value. For example, the register may contain 20000, for 20 mA, or for a voltage input the register may contain 8000, for 8 volts.

Median Filter Enable

Set to zero (0) to turn off the median filter. Set to one (1) to turn on the median filter.

Minimum Analog Value

The Minimum Value register stores the minimum allowed analog value. The specific units of measure apply to the register value. For example, the register may contain 4000, for 4 mA, or for a voltage input the register may contain 2000, for 2 volts.

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.)

5.7 Temperature Parameters

The following parameters are used to configure analog inputs involving temperature and are typically used to configure thermocouple or RTD inputs.

Registers for Analog Parameters (4xxx)				Parameters
IN 1 (3301-3320)	IN 2 (3321-3340)	IN 3 (3341-3360)	IN 4 (3361-3380)	
3304	3324	3344	3364	Temperature Degrees C/F
3305	3325	3345	3365	Temperature Scaling
3306	3326	3346	3366	Thermocouple Type
3307	3327	3347	3367	Temperature Resolution

Temperature Degrees C/F

Set to 1 to represent temperature units in degrees Fahrenheit, and set to 0 (default) to represent temperature units in degrees Celsius.

Temperature Resolution

Thermocouples and RTDs may record temperatures in either high resolution (tenths of a degree) or low resolution (whole degree).

Write a 0 to select high resolution (default) or a 1 to select low resolution. Choosing high or low resolution changes the range of temperatures that can be written to the register.

Temperature Scaling

Set to 1 to store temperatures the same way as the DX80 devices (measured temp × 20) represent temperature.

Set to 0 (default) to store temperature values in tenths of a degree (measured temp × 10).

For example, if the measured temperature is 20.5 degrees, using temperature scaling set to 1 would store the temperature value as 410; using temperature scaling set to 0 would store the temperature as 205.

Thermocouple Type

Write the listed value to this register to select a thermocouple type. The default configuration is set to a Type B thermocouple (0).

Value	Thermocouple Type	Value	Thermocouple Type	Value	Thermocouple Type
0	B	5	J	10	P
1	C	6	K	11	R
2	D	7	L	12	S
3	E	8	M	13	T
4	G	9	N	14	U

5.8 03500s Counter Input Parameters

The following parameters are configurable for the counter input.

Counter Input parameters for Counter Input 1 start at 3501 through 3505. Counter Input parameters for Counter Input 2 start at 3521 through 3525. Each following counter input is offset from the previous one by 20 registers.

Parameter Registers for Counter Inputs (4xxx)	
IN 1	Parameters
3501	Enable Frequency/Event Counter
3502	Enable Read Counter State
3503	Set Preset Value
3504	Counter Preset Value
3505	Counter Preset Value

Counter Preset Value

Registers 3504 (high word) and 3505 (low word) contain the 32-bit value for presetting the counter. Write the 'Counter Preset Value' registers first, then use the 'Set Preset Value' register to execute the counter preset.

Enable Frequency/Event Counter

A counter input can be defined to calculate the frequency of the input in hertz or as a counter that increments with every input change (event counter) from 0 to 1 (for PNP inputs).

Set this parameter to 1 to configure the input to calculate frequency. Set to 0 to configure the counter to count input changes, for example, an event counter or totalizer. Because the counter is reset to zero when power is cycled to the device, it is up to the host system to save count data.

Enable Read Counter State

Manufacturing/test register only

Set Preset Value

Writing this value to 1 signals the data radio to preset the counter with the value stored in Modbus registers 3504 and 3505. When the task is complete, the value is written to 0.

5.9 03600s H-Bridge Output Parameters

The following parameters are configurable for the H-bridge outputs.

Parameters for H-bridge 1 start at 3604 through 3609. Parameters for H-bridge 2 start at 3624 through 3629. Each following H-bridge parameter set is offset from the previous one by 20 registers.

Parameter Registers for H-Bridge Outputs (4xxx)	
H-Bridge 1	Parameters
3604	Enable H-Bridge
3605	H-Bridge Warmup Cap Time
3606	H-Bridge Active Current Time
3607	H-Bridge Switches
3608	H-Bridge Switches
3609	H-Bridge Booster Enabled When Active

Enable H-Bridge

Enable (1) or disable (0) the h-bridge inputs as needed. Disable the h-bridge inputs when using SDI-12 devices.

H-Bridge Active Current Time

Set how long, in 40 millisecond increments, the capacitor is switched into and supplying power to the solenoid circuit.

H-Bridge Switches

Use these two parameters as a bit mask to set the ON and OFF conditions of the h-bridge switch.

	DO4	DO3	DO2	DO1	SP4	SP3	SP2	SP1
3607 Rising Switch (ON)	0	0	1	0	0	0	0	1
3608 Falling Switch (OFF)	0	0	0	1	0	0	1	0

H-Bridge Warm Up Cap Time

Similar to the switch power warm up time, the h-bridge capacitor warm up time is the time allotted, in 40 millisecond increments, to charge the capacitor used to activate the h-bridge and latching solenoid.

H-Bridge Booster Enabled When Active

To use this parameter, contact the applications engineers at Banner Engineering Corp. This parameter leaves the boost voltage on while the capacitor discharges into the solenoid. While this can supply more power to the solenoid circuit, it may also brown-out the radio device.

5.9.1 03600s Switch Power Output Parameters

The Power Output Configuration parameters provide the basic operation for each power output. These parameters are not associated to specific inputs.

Efficient power management technology enables some FlexPower devices to include an internal power supply, called switch power (SP), that briefly steps up to power sensors that require more than 3.6 V dc power, such as 4 to 20 mA loop-powered sensors. When the switch power output cycles on, the voltage is stepped up to power the sensor for a specific time. 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 switch power shuts off to prolong battery life. The switch power voltage, warm-up time, and sample interval are configurable parameters.

Parameters for SP 1 start at 3601 through 3603. Parameters for SP 2 start at 3621 through 3623. Each following switch power is offset from the previous one by 20 registers.

Parameter Registers for Switch Power Outputs (4xxx)				
SP1	SP2	SP3	SP4	Parameters
3601	3621	3641	3661	Continuous Voltage Setting

Parameter Registers for Switch Power Outputs (4xxx)				
SP1	SP2	SP3	SP4	Parameters
3602	3622	3642	3662	Default Output State
3603	3623	3643	3663	Hold Last State Enable

Continuous Voltage Setting

Use this voltage parameter to set the output voltage when supplying continuous power through the SP# terminals (not associated with inputs). The Continuous Voltage parameter cannot be used if any input uses switch power. To set a continuous voltage on the SP output, also turn on the default output condition “default on power up.” This will turn on this continuous voltage output when the radio powers up.

Output Voltage	Parameter Value	Output Voltage	Parameter Value
0 V	255	15 V	32
5 V	204	20 V	12
7 V	125	24 V	03
10 V	69		

Default Output State

The Default Output State parameter represents the default condition of the switch power output. When communication is lost to the host or the wireless link is lost for the I/O data radio, the data radio can set the outputs and switch power outputs in this default state.

When set to 0, the switch power is turned off. When set to 1, the switch power is set to the voltage established by the Continuous Voltage Setting.

Hold Last State Enable

Set Hold Last State Enable to 1 to set the switch power output to its last known value when communications are lost.

Set this parameter to 0 to disable the Host Last State Enable and use the Default Output State settings.

5.10 03700s Discrete Output Parameters

The following characteristics are configurable for each of the discrete outputs.

Parameters for Output 1 start at 3701 through 3703. Parameters for Output 2 start at 3721 through 3723. Each following input is offset from the previous one by 20 registers.

Parameter Registers for Discrete Outputs (4xxx)				
OUT 1	OUT 2	OUT 3	OUT 4	Parameters
3701	3721	3741	3761	Default Output State
3702	3722	3742	3762	Hold Last State Enable
3703	3723	3743	3763	Enable Switch Power Logic

Default Output State

The Default Output State parameter represents the default condition of the discrete output. When an error condition exists, the outputs are set to this user-defined output state, either a 0 or a 1.

Enable Switch Power Logic

Hold Last State Enable

Set the Hold Last State to 1 to set the output to its last known value before the error occurred. Set this parameter to 0 to disable the Hold Last State and use the Default Output State setting during an error condition.

5.11 04000s Analog Output Parameters

The following characteristics are configurable for each of the analog outputs.

Parameters for Analog Output 1 start at 4001 through 4005. Parameters for Analog Output 2 start at 4021 through 4025. Each following input is offset from the previous one by 20 registers.

Parameter Registers for Analog Outputs (4xxx)				
OUT 1	OUT 2	OUT 3	OUT 4	Parameters
4001	4021	4041	4061	Maximum Analog Value
4002	4022	4042	4062	Minimum Analog Value
4003	4023	4043	4063	Enable Register Full Scale
4004	4024	4044	4064	Hold Last State Enable
4005	4025	4045	4065	Default Output State

Default Output State

The Default Output State parameter represents the default condition of the analog output. When an error condition exists, the outputs are set to this 16-bit user-defined output state.

Enable Register Full Scale

Set to 1 to enable a linear range from 0 to 65535 for specified input range. For a 4 to 20 mA output, a value of 0 represents 4 mA and 65535 represents 20 mA. Set this parameter to 0 to store readings in unit-specific data. For example, the register data representing a 15.53 mA reading is 15530. For units of current (0 to 20 mA outputs), values are stored as μA (micro Amps) and voltage values are stored as mV (millivolts).

Hold Last State Enable

Set the Hold Last State to 1 to set the output to its last known value before the error occurred. Set this parameter to 0 to disable the Hold Last State and use the Default Output State setting during an error condition.

Maximum Analog Value

The Maximum Analog Value register stores the maximum allowed analog value. The specific units of measure apply to the register value. For example, the register may contain 20000, for 20 mA, or for a voltage output the register may contain 8000, for 8 volts.

Minimum Analog Value

The Minimum Analog Value register stores the minimum allowed analog value. The specific units of measure apply to register value. For example, the register may contain 4000, for 4 mA, or for a voltage output the register may contain 2000, for 2 volts.

5.12 04150s Initialization Controls

4151 Reset Device

Write a 1 to this register to trigger a device reset of the parameters selected by the next three registers.

4152 Default I/O Configuration

Returns all I/O configuration parameters to their factory default settings.

4153 Default System Parameters

Returns all system-level parameters to their factory default settings.

4154 Initialize Variables from the Serial Number

Returns all variables that are normally calculated (or seeded) from the serial number to values seeded from the serial number.

5.13 04400s Output Flash Pattern Parameters

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

Flash patterns are established by selecting specific 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. Each slot represents one frame size, which may vary from radio to radio. The default frame is 40 milliseconds. Users may configure up to four different flash patterns.

4401-4408 Flash Pattern Index 1.

4411-4418 Flash Pattern Index 2.

4421-4428 Flash Pattern Index 3.

4431-4438 Flash Pattern Index 4.

5.14 04500s M-GAGE Parameters

The following characteristics are configurable for the M-GAGE devices.

4501 Set Baseline

Write a 1 to this register to set the baseline. The baseline function of the M-GAGE stores the ambient magnetic field values of the X, Y, and Z axes as a baseline value. Once this baseline is established, any deviation in the magnetic field represents the presence of a ferrous object and will be reflected in the M-GAGE register. The more disruption in the magnetic field, the larger the M-GAGE register value.

4502 Disable Axes

A bit-wise register (0000). Write a one to disable the selected axis where bit 0 is the x axis, bit 1 is the y axis, and bit 2 is the z axis.

4503 Disable Compensation Median Filter

Write a 1 to this register to disable the compensation median filter.

4504 Disable Sensing Median Filter

Write a 1 to this register to disable the sensing median filter.

4505 Low Pass Filter

The filters T0 through T6 are parameter settings that define the degree of input digital signal filtering for analog inputs. T0 is the least amount of filtering. T6 is the highest filter setting and has the least amount of fluctuation between readings. Write the following values to select a low pass (tau) filter.

Low Pass (Tau) Filter	Register Value	Low Pass (Tau) Filter	Register Value
T0	0	T4	4
T1	1	T5	5
T2	2	T6	6
T3	3		

4506 Sample High

The sample high counter parameter defines the number of consecutive samples the input signal must be above the threshold before a signal is considered active. The default value is 0, which disables this feature. The value range is 1 through 255. The Sample High parameter refers to the number of samples (1 through 255) a discrete input must be detected high (1) before it is considered to be a change of state.

4507 Sample Low

The default value of 0 disables this feature. The value range is 1 through 255. The Sample Low parameter refers to the number of samples (1 through 255) a discrete input must be detected low (0) before it is considered to be a change of state.

4509 Delta

Rate of change filter.

4510 Threshold and 4511 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 the M-GAGE™ input. The hysteresis value establishes how much 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.

The M-GAGE's threshold and hysteresis ranges are 0 to 65,535.

The factory default threshold setting is 150 and default hysteresis is 30 (the sensor detects an OFF condition at threshold minus hysteresis, or $150 - 30 = 120$). With the default settings, once the magnetic field reading is above 150, an ON or "1" is stored in the lowest significant bit (LSB) in the Modbus register. When the M-GAGE reading drops below the OFF point (threshold minus hysteresis), the LSB of the Modbus register is set to "0."

To determine your threshold, take M-GAGE readings of the test objects at the distance they are likely to be from the sensor. For example, if a car reads 150, a bicycle 15, and a truck reads 250, setting the threshold to 200 will detect only trucks of a specific size. Magnetic field fluctuations vary based on the amount of ferrous metal present and the distance from the sensor.

4512 Baseline (Drift) Filter Time

Baseline filter time. When the Baseline Filter is on and the magnetic field readings are below the baseline filter threshold setting, an algorithm is used to slowly match the device's baseline to the current ambient magnetic field. This helps to account for the natural fluctuations in the magnetic field.

4513 Baseline (Drift) Filter Threshold

Baseline filter threshold is used with the baseline filter time to account for the natural fluctuations on the magnetic field.

4514 Baseline (Drift) Filter Tau

Baseline filter's low pass filter.

4521 Baseline Difference Signal Value Total

A combination of the x-, y-, and z-axis baseline different signal values.

4522–4524 Baseline Difference Signal Value [x-axis]

4522 [x-axis]—The difference between the ambient magnetic field and the current magnetic field reading for the x axis.

4523 [y-axis]—The difference between the ambient magnetic field and the current magnetic field reading for the y axis.

4524 [z-axis]—The difference between the ambient magnetic field and the current magnetic field reading for the z axis.

4525–4527 Baseline Value

4525 [x-axis]—Ambient magnetic field reading for the x axis.

4526 [y-axis]—Ambient magnetic field reading for the y axis.

4527 [z-axis]—Ambient magnetic field reading for the z axis.

4528–4530 Raw Signal Value

4528 [x-axis]—The actual magnetic field reading for the x axis.

4529 [y-axis]—The actual magnetic field reading for the y axis.

4530 [z-axis]—The actual magnetic field reading for the z axis.

5.15 04800s Ultrasonic Input Parameters

The following characteristics are configurable for the Ultrasonic input devices.

0001 Temperature Measured

Temperature is measured in 0.1 °C increments.

0002 Distance Measured

Distance is measured in mm.

The least significant bit indicates threshold status

Value 65535 or 65534: Alarm, No Reflection Detected

Value 65533 or 65532: Alarm, Reflection Mismatch

Value 65531 or 65530: Alarm, Thermistor Error

1051 Enable

Write a 1 to enable the ultrasonic sensor. Write a 0 to disable.

1053 Sample Interval

The sample interval (rate) defines how often the data radio samples the input. The register value is the number of time units. For example, a Modbus register value of 125 (for a 900 MHz device) represents a sample interval of 5 seconds (125×0.040 seconds = 5 seconds).

A unit of time for a 900 MHz data radio is 40 milliseconds. A unit of time for a 2.4 GHz data radio is 20 milliseconds.

4801 Drive Pulses

Defines the number of cycles the transducer is pulsed.

4808 Receive Pulses

Defines the number of cycles that must be seen to recognize a reflection.

4810 Max Scale Value

The Maximum Value register stores the maximum allowed analog value. The specific units of measure apply to the register value. For example, the register may contain 20000, for 20 mA, or for a voltage input the register may contain 8000, for 8 volts.

4811 Min Scale Value

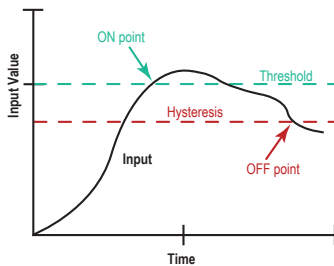
The Minimum Value register stores the minimum allowed analog value. The specific units of measure apply to the register value. For example, the register may contain 4000, for 4 mA, or for a voltage input the register may contain 2000, for 2 volts.

4812 Enable Register Full Scale

Set to 1 to enable a linear range from 0 to 65535 for specified input range. For a 4 to 20 mA input, a value of 0 represents 4 mA and 65535 represents 20 mA. Set this parameter to 0 to store input readings in unit-specific data. For example, the register data representing a 15.53 mA reading is 15530. For units of current (0 to 20 mA inputs), values are stored as μ A (micro Amps) and voltage values are stored as mV (millivolts).

4813 Threshold and 4814 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.

4815 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.

4816 Sample High and 4817 Sample Low

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.

4818 Change of State Push Enable

Set to one (1) to enable push registers for this input. When the analog input changes state, the register value will be pushed to the master radio if this register is configured to be a push register.

4819 Median Filter Enable

Set to zero (0) to turn off the median filter. Set to one (1) to turn on the median filter.

4820 Low Pass (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.) Write the following values to select a low pass (tau) filter.

Low Pass (Tau) Filter	Register Value	Low Pass (Tau) Filter	Register Value
T0	0	T4	4
T1	1	T5	5
T2	2	T6	6
T3	3		

4823 Window Range

Measured in mm.

When ultrasonic teach is active, the threshold is set to the distance measured minus the window range.

4825 Ultrasonic Teach

Write a 1 to initiate a threshold teach.

When ultrasonic teach is active, the threshold is set to the distance measured minus the window range.

4826 Invert Digital Logic

If the set distance measures below the threshold, the transition has an LSB of 1.

If the clear distance measures below the threshold, the transition has an LSB of 0.

4827 Boost Enable

Controls the ultrasonic transducer power level.

Set to 0 for low power level, a longer battery life, less noise, and a shorter range.

Set to 1 for higher power levels, a shorter battery life, more noise, and a longer range.

4828 Ultrasonic Sensitivity Control

Adjusts ultrasonic reflection sensitivity.

Write a 0 to disables the control feature

Start control at 0x8000 to match default

Control below 0x8000 is more sensitive

Control above 0x8000 is less sensitive

4831 Set Alarm as Logic 0

If set, an alarm is treated is if it is below the threshold.

If cleared, an alarm is treated is if it is above the threshold.

7909-7912 Push Registers

7909 Push Register 1 — Pushes the value of register 0002 (Distance Measured).

7910 Push Register 2 — Pushes the value of register 0001 (Temperature in 0.1 °C increments).

7911 Push Register 3 — Pushes the value of register 4813 (Current threshold setting).

7912 Push Register 4 — Pushes the value of register 4823 (Current teach window range).

5.16 06050s Battery Monitoring Parameters

Use the battery monitor parameters to monitor and set a threshold based on the incoming device voltage (on some models).

The incoming voltage is approximately 3.6 V dc from a battery input or 4.2 V dc from the 10 to 30 V dc input. These parameters allow users to determine which power source is powering the MultiHop device.

6051 Enable Battery Read

Set to zero to disable the battery read function. Set to 1 to enable the battery read function.

6052 Battery Read Sample Interval

Use this parameter to set the time interval at which the incoming voltage is read. Sample Interval (in seconds) = 0.040 seconds × 2^{RegValue}. Default register value: 9 (20 seconds).

6053 Battery Voltage Threshold

Use this parameter to define the incoming voltage threshold at which register 44061 will be set to a zero or one. Set this value in number of 100 mA increments. The default value is 38 (or 3.8 V).

6054 Hardware Reference Select

Use this parameter to allow for the correct calibration reference for different hardware platforms. Set to zero for 3.0 V PCB Vcc. Set to one for 3.3 V PCB Vcc. Default value is zero.

6061 Battery Threshold Reading

When zero (0), the incoming voltage is below the threshold defined by parameter 6053 (powered by battery). When one (1), the incoming voltage reading is above the defined threshold (powered by a solar panel or 10 to 30 V dc).

6062 Battery Voltage Reading

Actual incoming voltage reading in units of 100 mV.

5.17 Configuring the SDI-12 Inputs

The SDI-12 interface on the MultiHop radio can support up to five devices with (12) 32-bit register values each. The radio's SDI-12 interface can be configured to increase the number of registers per device address for devices with large register sets. The factory default enables one SDI-12 device using device address 1 with up to nine registers with a SDI-12 command of "M!".

Configure the MultiHop device by writing to non-volatile Modbus registers with configuration parameters. Read or write the device configuration parameters using standard Modbus commands.

5.17.1 Basic SDI-12 Interface Parameters

Up to five devices/commands can be accessed using the SDI-12 interface. There are three parameters for each device/command: Enable, Device Address, Device Command. For more information, refer to the SDI-12 Technical Notes.

Enable. Instructs the MultiHop Radio device to activate or deactivate the SDI-12 device. Write a 1 to enable, and write a 0 to disable. The factory default for device 1 is enabled; devices 2 through 5 are disabled.

Device Address. Each SDI-12 device must have a unique device address. This parameter is the ASCII code for the device address. Valid device addresses are 0-9 and a-z that map to ASCII codes 48-57 and 97-122, respectively. The factory default addresses are:

- SDI-12 Device 0 uses ASCII code 48
- SDI-12 Device 1 uses ASCII code 49
- SDI-12 Device 2 uses ASCII code 50
- SDI-12 Device 3 uses ASCII code 51
- SDI-12 Device 4 uses ASCII code 52

Device Command The SDI-12 interface supports "M!" or "C!" commands. Use the Device Command parameter to define which command to use for this device. The factory default is "M!" commands for all devices (value of 10 in the Modbus register).

Supported M! Commands		Supported C! Commands	
SDI-12 Command	Register Value	SDI-12 Command	Register Value
xM!	0 or 10	xC!	1 or 20
xM1!	11	xC1!	21
xM2!	12	xC2!	22
xM3!	13	xC3!	23
xM4!	14	xC4!	24
xM5!	15	xC5!	25
xM6!	16	xC6!	26
xM7!	17	xC7!	27
xM8!	18	xC8!	28
xM9!	19	xC9!	29

The Modbus configuration registers are listed. All registers are defined as Modbus holding registers. The factory default values are shown in parentheses. All values are in decimal, unless noted otherwise.

Device/CMD Configuration	Registers (Default Value)		
	Enable	Device Address	Device Command
SDI-12 Device/CMD 1	1751 (1)	11001 (48) ²	11002 (10)
SDI-12 Device/CMD 2	1701 (0)	11201 (49)	11202 (10)
SDI-12 Device/CMD 3	1651 (0)	11401 (50)	11402 (10)
SDI-12 Device/CMD 4	1601 (0)	11601 (51)	11602 (10)
SDI-12 Device/CMD 5	1551 (0)	11801 (52)	11802 (10)

5.17.2 Result Registers Configuration Parameters

There are 12 result registers allocated for each device, and each register can be individually configured to change its formatting. Use these parameters to customize the formatting for each data value coming from a SDI-12 device.

The default configuration of a floating point format works for most SDI-12 values. For each register the following parameters apply:

- **Enable.** Enable or disable for each device. To enable, set to 1. To disable, set to 0.
- **Decimal point Move:** Moves the decimal point 0 to 7 places.
- **Decimal point Direction:** To move the decimal point to the right, set to 0. To move the decimal point to the left, set to 1.
- **Register Sign:** For an unsigned value, set to 0. For a signed value, set to 1.
- **Register Size:** For a 16-bit word, set to 0. For a 32-bit word, set to 1. Select 32-bit when using floating point.
- **Floating Point Enable:** For an integer, set to 0. For a floating point number, set to 1.

The following tables define the Modbus configuration registers for the result registers. All registers are defined to be Modbus holding registers. The default values are shown in parentheses, factory defaults enable the first nine registers as floating point registers. The "M!" command only supports a maximum of nine registers.

SDI-12 Device 1 / CMD 1	Register 1	Register 2	Register 3	Register 4	Register 5	Register 6
Result Register Enable	11011 (1)	11021 (1)	11031 (1)	11041 (1)	11051 (1)	11061 (1)
Decimal Point Move	11012 (0)	11022 (0)	11032 (0)	11042 (0)	11052 (0)	11062 (0)
Decimal Point Direction	11013 (0)	11023 (0)	11033 (0)	11043 (0)	11053 (0)	11063 (0)
Register Sign	11014 (0)	11024 (0)	11034 (0)	11044 (0)	11054 (0)	11064 (0)
Register Size	11015 (1)	11025 (1)	11035 (1)	11045 (1)	11055 (1)	11065 (1)
Floating Point Enable	11016 (1)	11026 (1)	11036 (1)	11046 (1)	11056 (1)	11066 (1)
	Register 7	Register 8	Register 9	Register 10	Register 11	Register 12
Result Register Enable	11071 (1)	11081 (1)	11091 (1)	11141 (0)	11151 (0)	11161 (0)
Decimal Point Move	11072 (0)	11082 (0)	11092 (0)	11142 (0)	11152 (0)	11162 (0)
Decimal Point Direction	11073 (0)	11083 (0)	11093 (0)	11143 (0)	11153 (0)	11163 (0)
Register Sign	11074 (0)	11084 (0)	11094 (0)	11144 (0)	11154 (0)	11164 (0)
Register Size	11075 (1)	11085 (1)	11095 (1)	11145 (1)	11155 (1)	11165 (1)

² The default device addresses 48 through 52 are in ASCII.

SDI-12 Device 1 / CMD 1	Register 1	Register 2	Register 3	Register 4	Register 5	Register 6
Floating Point Enable	11076 (1)	11086 (1)	11096 (1)	11146 (1)	11156 (1)	11166 (1)

SDI-12 Device 2 / CMD 2	Register 1	Register 2	Register 3	Register 4	Register 5	Register 6
Result Register Enable	11211 (1)	11221 (1)	11231 (1)	11241 (1)	11251 (1)	11261 (1)
Decimal Point Move	11212 (0)	11222 (0)	11232 (0)	11242 (0)	11252 (0)	11262 (0)
Decimal Point Direction	11213 (0)	11223 (0)	11233 (0)	11243 (0)	11253 (0)	11263 (0)
Register Sign	11214 (0)	11224 (0)	11234 (0)	11244 (0)	11254 (0)	11264 (0)
Register Size	11215 (1)	11225 (1)	11235 (1)	11245 (1)	11255 (1)	11265 (1)
Floating Point Enable	11216 (1)	11226 (1)	11236 (1)	11246 (1)	11256 (1)	11266 (1)
	Register 7	Register 8	Register 9	Register 10	Register 11	Register 12
Result Register Enable	11271 (1)	11281 (1)	11291 (1)	11341 (0)	11351 (0)	11361 (0)
Decimal Point Move	11272 (0)	11282 (0)	11292 (0)	11342 (0)	11352 (0)	11362 (0)
Decimal Point Direction	11273 (0)	11283 (0)	11293 (0)	11343 (0)	11353 (0)	11363 (0)
Register Sign	11274 (0)	11284 (0)	11294 (0)	11344 (0)	11354 (0)	11364 (0)
Register Size	11275 (1)	11285 (1)	11295 (1)	11345 (1)	11355 (1)	11365 (1)
Floating Point Enable	11276 (1)	11286 (1)	11296 (1)	11346 (1)	11356 (1)	11366 (1)

SDI-12 Device 3 / CMD 3	Register 1	Register 2	Register 3	Register 4	Register 5	Register 6
Result Register Enable	11411 (1)	11421 (1)	11431 (1)	11441 (1)	11451 (1)	11461 (1)
Decimal Point Move	11412 (0)	11422 (0)	11432 (0)	11442 (0)	11452 (0)	11462 (0)
Decimal Point Direction	11413 (0)	11423 (0)	11433 (0)	11443 (0)	11453 (0)	11463 (0)
Register Sign	11414 (0)	11424 (0)	11434 (0)	11444 (0)	11454 (0)	11464 (0)
Register Size	11415 (1)	11425 (1)	11435 (1)	11445 (1)	11455 (1)	11465 (1)
Floating Point Enable	11416 (1)	11426 (1)	11436 (1)	11446 (1)	11456 (1)	11466 (1)
	Register 7	Register 8	Register 9	Register 10	Register 11	Register 12
Result Register Enable	11471 (1)	11481 (1)	11491 (1)	11541 (0)	11551 (0)	11561 (0)
Decimal Point Move	11472 (0)	11482 (0)	11492 (0)	11542 (0)	11552 (0)	11562 (0)

SDI-12 Device 3 / CMD 3	Register 1	Register 2	Register 3	Register 4	Register 5	Register 6
Decimal Point Direction	11473 (0)	11483 (0)	11493 (0)	11543 (0)	11553 (0)	11563 (0)
Register Sign	11474 (0)	11484 (0)	11494 (0)	11544 (0)	11554 (0)	11564 (0)
Register Size	11475 (1)	11485 (1)	11495 (1)	11545 (1)	11555 (1)	11565 (1)
Floating Point Enable	11476 (1)	11486 (1)	11496 (1)	11546 (1)	11556 (1)	11566 (1)

SDI-12 Device 4 / CMD 4	Register 1	Register 2	Register 3	Register 4	Register 5	Register 6
Result Register Enable	11611 (1)	11621 (1)	11631 (1)	11641 (1)	11651 (1)	11661 (1)
Decimal Point Move	11612 (0)	11622 (0)	11632 (0)	11642 (0)	11652 (0)	11662 (0)
Decimal Point Direction	11613 (0)	11623 (0)	11633 (0)	11643 (0)	11653 (0)	11663 (0)
Register Sign	11614 (0)	11624 (0)	11634 (0)	11644 (0)	11654 (0)	11664 (0)
Register Size	11615 (1)	11625 (1)	11635 (1)	11645 (1)	11655 (1)	11665 (1)
Floating Point Enable	11616 (1)	11626 (1)	11636 (1)	11646 (1)	11656 (1)	11666 (1)
	Register 7	Register 8	Register 9	Register 10	Register 11	Register 12
Result Register Enable	11671 (1)	11681 (1)	11691 (1)	11741 (0)	11751 (0)	11761 (0)
Decimal Point Move	11672 (0)	11682 (0)	11692 (0)	11742 (0)	11752 (0)	11762 (0)
Decimal Point Direction	11673 (0)	11683 (0)	11693 (0)	11743 (0)	11753 (0)	11763 (0)
Register Sign	11674 (0)	11684 (0)	11694 (0)	11744 (0)	11754 (0)	11764 (0)
Register Size	11675 (1)	11685 (1)	11695 (1)	11745 (1)	11755 (1)	11765 (1)
Floating Point Enable	11676 (1)	11686 (1)	11696 (1)	11746 (1)	11756 (1)	11766 (1)

SDI-12 Device 5 / CMD 5	Register 1	Register 2	Register 3	Register 4	Register 5	Register 6
Result Register Enable	11811 (1)	11821 (1)	11831 (1)	11841 (1)	11851 (1)	11861 (1)
Decimal Point Move	11812 (0)	11822 (0)	11832 (0)	11842 (0)	11852 (0)	11862 (0)
Decimal Point Direction	11813 (0)	11823 (0)	11833 (0)	11843 (0)	11853 (0)	11863 (0)
Register Sign	11814 (0)	11824 (0)	11834 (0)	11844 (0)	11854 (0)	11864 (0)
Register Size	11815 (1)	11825 (1)	11835 (1)	11845 (1)	11855 (1)	11865 (1)
Floating Point Enable	11816 (1)	11826 (1)	11836 (1)	11846 (1)	11856 (1)	11866 (1)
	Register 7	Register 8	Register 9	Register 10	Register 11	Register 12

SDI-12 Device 5 / CMD 5	Register 1	Register 2	Register 3	Register 4	Register 5	Register 6
Result Register Enable	11871 (1)	11881 (1)	11891 (1)	11941 (0)	11951 (0)	11961 (0)
Decimal Point Move	11872 (0)	11882 (0)	11892 (0)	11942 (0)	11952 (0)	11962 (0)
Decimal Point Direction	11873 (0)	11883 (0)	11893 (0)	11943 (0)	11953 (0)	11963 (0)
Register Sign	11874 (0)	11884 (0)	11894 (0)	11944 (0)	11954 (0)	11964 (0)
Register Size	11875 (1)	11885 (1)	11895 (1)	11945 (1)	11955 (1)	11965 (1)
Floating Point Enable	11876 (1)	11886 (1)	11896 (1)	11946 (1)	11956 (1)	11966 (1)

5.17.3 SDI-12 Device Result Registers

The result registers store all information received from the SDI-12 devices.

The registers are 16-bit registers and require two registers to store a 32-bit value. The factory default configuration defines the result registers as 32-bit registers, floating point format, and the first nine result registers are enabled for use. A host system reads the SDI-12 device data from these registers.

Result Registers	Register 1	Register 2	Register 3	Register 4	Register 5	Register 6
SDI-12 Device/CMD 1 Result Upper	11101	11103	11105	11107	11109	11111
SDI-12 Device/CMD 1 Result Lower	11102	11104	11106	11108	11110	11112
SDI-12 Device/CMD 2 Result Upper	11301	11303	11305	11307	11309	11311
SDI-12 Device/CMD 2 Result Lower	11302	11304	11306	11308	11310	11312
SDI-12 Device/CMD 3 Result Upper	11501	11503	11505	11507	11509	11511
SDI-12 Device/CMD 3 Result Lower	11502	11504	11506	11508	11510	11512
SDI-12 Device/CMD 4 Result Upper	11701	11703	11705	11707	11709	11711
SDI-12 Device/CMD 4 Result Lower	11702	11704	11706	11708	11710	11712
SDI-12 Device/CMD 5 Result Upper	11901	11903	11905	11907	11909	11911
SDI-12 Device/CMD 5 Result Lower	11902	11904	11906	11908	11910	11912

Result Registers	Register 7	Register 8	Register 9	Register 10	Register 11	Register 12
SDI-12 Device/CMD 1 Result Upper	11113	11115	11117	11119	11121	11123
SDI-12 Device/CMD 1 Result Lower	11114	11116	11118	11120	11122	11124
SDI-12 Device/CMD 2 Result Upper	11313	11315	11317	11319	11321	11323
SDI-12 Device/CMD 2 Result Lower	11314	11316	11318	11320	11322	11324
SDI-12 Device/CMD 3 Result Upper	11513	11515	11517	11519	11521	11523
SDI-12 Device/CMD 3 Result Lower	11514	11516	11518	11520	11522	11524
SDI-12 Device/CMD 4 Result Upper	11713	11715	11717	11719	11721	11723
SDI-12 Device/CMD 4 Result Lower	11714	11716	11718	11720	11722	11724
SDI-12 Device/CMD 5 Result Upper	11913	11915	11917	11919	11921	11923
SDI-12 Device/CMD 5 Result Lower	11914	11916	11918	11920	11922	11924

5.17.4 SDI-12 Device Settings

The following are generic sampling, power and warmup parameters that should work for all SDI-12 devices. See the tested device table below. In most cases, parameters will not need to be adjusted but if needed there are three common SDI-12 device parameters that control the communications and power of the SDI-12 device. Contact Banner Engineering Corp support for more guidance.

- **Sample Rate.** Formed using two 16-bit parameters, a HI word and a LOW word. The sample rate is how often the SDI-12 device is powered up, then interrogated for data. The value in the registers is the number of 0.040 second counts. For example, the default value is 22,500, which calculates to a sample rate of 22500×0.040 seconds. Adjusting this value affects the battery life.
- **Warmup time.** Amount of time to wait, in 0.040 second increments, from powering on the device to the time to send communications to the device. The default value is 50, or 50×0.040 seconds. Adjusting this value affects the battery life.
- **Voltage.** The default voltage setting is 6 volts or a register value of 168. Adjusting this value affects the battery life.

Device / Cmd Configuration	Registers (Default Value)							
	Enable	Device Address	Switch Power Enable	Device Command	Sample HI	Sample Low	Warmup Time	Voltage
SDI-12 Device/CMD 1	1751 (1)	11001 (48) ³	1754 (1)	11002 (10)	1752 (0)	1753 (22500)	1755 (50)	1756 (148)
SDI-12 Device/CMD 2	1701 (0)	11201 (49)	1704 (0)	11202 (10)	1702 (0)	1703 (22500)	1705 (50)	1706 (148)
SDI-12 Device/CMD 3	1651 (0)	11401 (50)	1654 (0)	11402 (10)	1652 (0)	1653 (22500)	1655 (50)	1656 (148)
SDI-12 Device/CMD 4	1601 (0)	11601 (51)	1604 (0)	11602 (10)	1602 (0)	1603 (22500)	1605 (50)	1606 (148)
SDI-12 Device/CMD 5	1551 (0)	11801 (52)	1554 (0)	11802 (10)	1552 (0)	1553 (22500)	1555 (50)	1556 (148)

These SDI-12 probes have been tested and are functional with the factory default settings.

MFG	Models	Technical Note
Acclima	SEN-SDI (TDT SDI-12 Soil Moisture Sensor)	SDI-12 and the Acclima TDT SDI-12 Soil Moisture Probe
Adcon Telemetry	HydraProbell	
AquaCheck	Sub-surface Probe	SDI-12 and the AquaCheck Sub-Surface Soil Moisture Probe
Decagon	MPS-2, MPS-6, 5TE, TS1, T8	SDI-12 and the Decagon 5TE Soil Moisture Probe SDI-12 and the Decagon GS3 Soil Moisture Probe SDI-12 and the Decagon MPS-2 Soil Moisture Probe
HSTI	HydraScout	SDI-12 and the HydraScout HSTI Probe
Sentek	EnviroSCAN	SDI-12 and the Sentek EnviroScan Soil Moisture Probe

5.17.5 Configuring for Acclima SDI-12 Sensors

Table 1: Acclima SDI-12 Parameter Registers

SDI-12 Device Register (Acclima)	Register Enable (1)	Decimal Point Move (0-7)	Move Right (0) or Left (1)	Signed (1) or Unsigned (0)	16 bit (0) or 32 bit (1)
1 Volumetric water content	ON	2	Left	Unsigned	32 bit
2 Temperature	ON	1	Left	Signed	32 bit
3 Soil Permittivity	ON	2	Left	Unsigned	32 bit
4 Soil Conductivity	ON	2	Left	Unsigned	32 bit

³ The default device addresses 48 through 52 are in ASCII.

Table 2: Acclima SDI-12 Results Registers

Acclima Register No.		Results Registers (high:low)	Integer Conversion Multiplier	Sample Reading	Actual Value
1	Volumetric water content	11101:11102	×100	0:124	1.24%
2	Temperature	11103:11104	×10	0:238	23.8 °C
3	Soil Permittivity	11105:11106	×100	0:402	4.02
4	Soil Conductivity	11107:11108	×100	0:123	1.23 dS/m

5.17.6 Configuring for Decagon 5T3 SDI-12 Sensors

Table 3: Decagon SDI-12 Parameter Registers

SDI-12 Device Register (Decagon 5T3)	Register Enable (1)	Decimal Point Move (0-7)	Move Right (0) or Left (1)	Signed (1) or Unsigned (0)	16 bit (0) or 32 bit (1)	
1	Volumetric water content	ON	2	Left	Unsigned	32 bit
2	Soil Conductivity	ON	2	Left	Unsigned	32 bit
3	Temperature	ON	1	Left	Signed	32 bit

Table 4: Decagon SDI-12 Results Registers

Decagon Register No.		Results Registers (high:low)	Integer Conversion Multiplier	Sample Reading	Actual Value
1	Volumetric water content	11101:11102	×100	0:124	1.24%
2	Soil Conductivity	11103:11104	×100	0:123	1.23 dS/m
3	Temperature	11105:11106	×10	0:238	23.8 °C

5.18 Manufacturer Parameter Registers

The following are the device-specific and manufacturer parameters for the MultiHop radio devices. These registers are all within the 4xxxx range.

5.18 04100s Manufacturing Information

Address (4xxxx)	Name	Format
4101-4104	Serial number, digits 1-8	ASCII, read only
4111-4113	Model number, digits 1-6	ASCII, read only
4121-4123	Production date, digits 1-6	ASCII, read only

5.18 04200s Device Name

Address (4xxxx)	Name	Format
4201-4209	Name characters 1-18	ASCII

5.18 04300s Software Information

Address (4xxxx)	Name	Format
4301–4303	RF firmware p/n	ASCII, read only
4304–4305	RF firmware version	ASCII, read only
4306–4308	RF EEPROM part number, digits 1–6	ASCII, read only
4309–4310	RF EEPROM version number, characters 1–3	ASCII, read only
4311–4313	LCD firmware p/n	ASCII, read only
4314–4315	LCD firmware version	ASCII, read only
4316–4318	LCD EEPROM part number, digits 1–6	ASCII, read only
4319–4320	LCD EEPROM version number, characters 1–3	ASCII, read only

5.18 06400s Message Parameters

Strings stored in ASCII format are read as two characters per Modbus register. The lower numbered Modbus register contains the right-most characters in the string. Within a given Modbus register, the upper byte contains the ASCII character that goes to the right of the character in the lower byte.

Address (4xxxx)	Name	Format
6401	Device address	Hex
6402	Parent address	Hex, read only

Storing a Model Number

For example, the model number 148691 is stored as shown below.

Address (4xxxx)	Name	Modbus Register Value (in hex)	Character Representation
4111	Model number digits 6-5	0x3139	1 9
4112	Model number digits 4-3	0x3638	6 8
4113	Model number digits 2-1	0x3431	4 1

Parameters Stored as Numbers

Parameters stored as number values (not ASCII) read out directly as 16-bit values. Examples of parameters of this type include the Parent Address or Device Address.

Address (4xxxx)	Name	Value (in hex)	Value (decimal)
6401	Device address	0x002A	42
6402	Parent address	0x0023	35

5.19 Device and System Parameters

5.19.1 08200s Sample On Demand

To Sample on Demand is to trigger inputs to immediately sample. A host system triggers this sampling by writing a specific value to the Sample on Demand registers.

After the selected inputs are sampled, the MultiHop device resets the Sample on Demand register(s) back to zero. It is up to the host system to retrieve the value of the sampled input. There are two ways to trigger a Sample on Demand.

1. Write a value to register 8201, or
2. Write a one (1) to any of the individual input's registers 8221 (input 1) through 8236 (input 16).

Do not write to both register 8201 and the registers 8221 through 8236.

8201 Input 1-16 Sample on Demand Latch (bit field)

Use this bit field register to trigger a sample on demand to more than one input using a single register. For example, to trigger a sample on demand for inputs 1 and 5, write 0000 0000 0001 0001 (0x0011) to this register.

8221 Input 1 Sample on Demand Latch

Write a one (1) to this register to sample input 1.

8222 Input 2 Sample on Demand Latch

Write a one (1) to this register to sample input 2.

8236 Input 16 Sample on Demand Latch

Write a one (1) to this register to sample input 16.

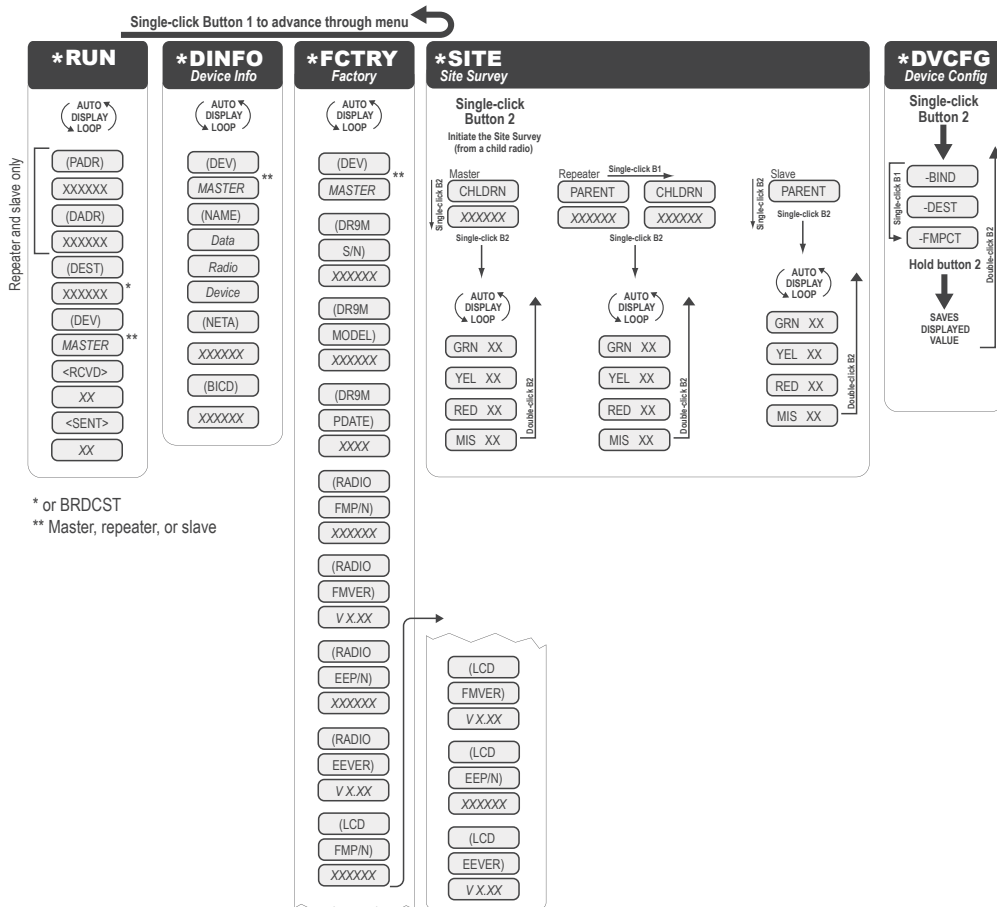
6 Additional Information

6.1 MultiHop Radio Menu System



When power is applied, the MultiHop radio begins running. The display screen autoscrolls through the **RUN** menu and communication between the devices is enabled. Autoscrolling through the **RUN** menu is the normal operating mode for all devices on the wireless network.

Access the menu system using the push buttons and the LCD.



From the **RUN** menu (or any menu), single-click button 1 to advance through the top-level menus. Top-level menus are displayed on the LCD with an asterisk (*) in front of the menu name.

Double-click button 2 to pause or resume the auto display loop. Use button 1 to advance through the items in that menu. (Enter "auto scrolled" menus by double clicking button 2. Enter the other menus by single clicking button 2.)

Run

The **RUN** menu displays the network ID, parent address, device address, current destination address, operational mode (master, repeater, slave), and the number of received and sent data packets.

PADR—Parent's device address, a unique number based on the parent device's serial number and assigned by the factory. The **PADR** is the 6-digit serial number minus 65535.

DADR—Device address, a unique number based on the serial number and assigned by the factory. The **DADR** is the 6-digit serial number minus 65535.

DEST—The current destination address to route messages. When this displays **BRDCST**, the device is either in transparent mode and is broadcasting the messages to all devices, or the device is in the early stages of Modbus mode and is broadcasting messages to determine the paths to specific device addresses.

RCVD—The number of serial messages received.

SENT—The number of serial messages sent.

DINFO (Device Info)

The **DINFO** menu displays the device information.

(NAME)—An 18-character name users may assign to the device.

(NETA)—Network Address (display only).

(BICD)—Binding Code (display only).

FCTRY (Factory)

The **FCTRY** menu displays the factory information about the device, including the model, dates of manufacture, and version numbers.

S/N—The device's serial number.

Model #—The DX80DR9M family model number.

PDate—Production date.

Radio FMP/N—Firmware part number.

SITE (Site Survey)

Single-click button 2 to pause/resume the auto display loop. While paused, use button 1 to advance through the GRN, YEL, RED, and MIS displays.

DVCFG (Device Configuration)

Single-click button 2 to enter this menu. Use button 1 to move through the options in this menu.

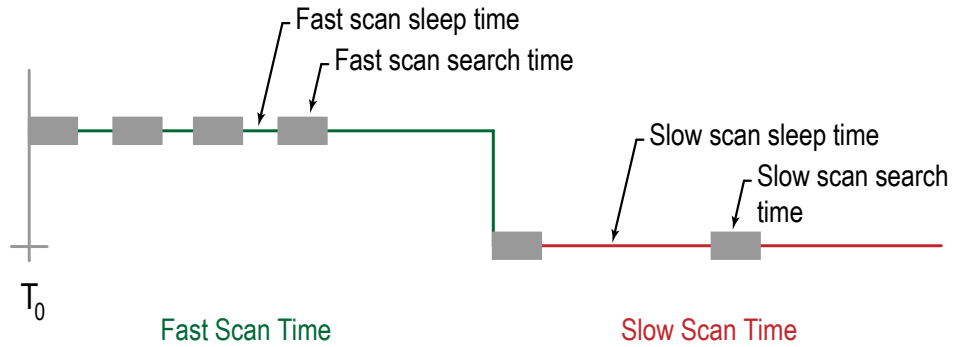
-BIND—Binding Code. Single click button 2 to manually set the binding code. Once in the binding code command, use button 2 to select the digits; use button 1 to increment the selected digit. Press and hold button 2 to save the new binding code. The device asks if you want to save the new setting (button 2) or discard the new setting and reselect (button 1).

-DEST—Destination Address. To force message routing when operating in transparent mode, set a specific destination address.

-FMPCT—Formation percentage, default value of 50%. This device will not form a parent/child relationship with a parent radio that misses more than 50% of the timing beacons (approximately a 25% site survey link value). If the only option for a child is a parent with a less than a 25% site survey link value, change this value.

6.2 Sleep Mode in MultiHop Radios

Sleep mode was created to extend the battery life of a battery-powered radio after it loses its radio connection to its parent radio. Instead of continuously searching for the parent, and using up battery life, MultiHop radios search for the "lost" parent briefly, then go to sleep for a specific period of time before searching again.



Five parameters are used to define sleep mode.

6345 Fast Scan Time

The Fast Scan Time defines the initial "search" time for a device. During this time, the device searches for its parent. After the Fast Scan Time has ended, the device enters Slow Scan Time. Set in 100 milliseconds intervals. Default: 15 minutes, which is nine thousand 100 ms intervals. Set to 0 to disable.

6346 Fast Scan Search Time

The Fast Scan Search Time is the length of time within the Fast Scan Time that the radio is actively searching for a parent radio. Set in 100 milliseconds intervals. Default: 15 minutes, which is nine thousand 100 ms intervals. Set to 0 to disable.

6347 Fast Scan Sleep Time

The Fast Scan Sleep Time is the length of time the radio "sleeps" between searches. Set in 100 milliseconds intervals. Default: 0 seconds. Set to 0 to disable.

Using these values for the Fast Scan Time settings results in a radio that for the first 15 minutes it is turned on, continuously "searches" for its parent radio. If your radio is powered by 10 to 30V dc, you may set 6345 through 6349 to zero to disable. Fast and Slow Scan Time settings are used to prolong battery life for battery-powered devices.

6348 Slow Scan Search Time

After the Fast Scan Time has ended, the device enters Slow Scan Time. The Slow Scan Search Time is the length of time within the Slow Scan Time that the radio is actively searching for a parent radio. Set in 100 milliseconds intervals. Default: 15 seconds, which is one hundred fifty 100 ms intervals. Set to 0 to disable.

6349 Slow Scan Sleep Time

The Slow Scan Sleep Time is the length of time the radio "sleeps" between searches. Set in 100 milliseconds intervals. Default: 15 minutes, which is nine thousand 100 ms intervals. Set to 0 to disable.

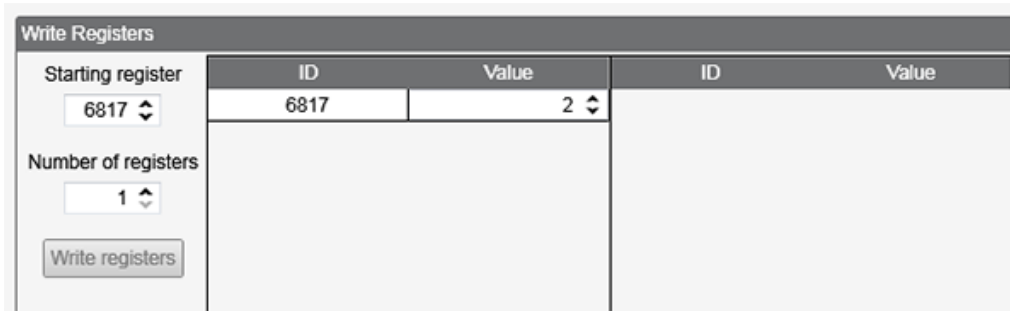
Using these values for the Slow Scan Time settings results in a radio that, after the first 15 minutes of being turned on, spends 15 seconds every 15 minutes searching for its parent radio. If your radio is powered by 10 to 30V dc, you may set 6345 through 6349 to zero to disable. Fast and Slow Scan Time settings are used to prolong battery life for battery-powered devices.

If your MultiHop radio is powered by 10–30 V dc, there is no need to conserve power by using Sleep Mode. To disable Sleep Mode, write a zero (0) to the Sleep Mode parameters listed.

6.2.1 Enabling Deep Sleep Mode

Battery-powered radios can be stored in Deep Sleep mode to conserve battery power. During Deep Sleep, the radio does not communicate with or attempt to locate its parent radio and all I/O and switched power are inactive.

To enable Deep Sleep mode on a MultiHop radio, follow these steps.



1. Launch the MultiHop Configuration Software.
2. Go to the **Register View** screen.
3. Select the MultiHop device ID from the drop-down list.
4. In the **Write Register** section, enter 6817 as the **Starting register**.
5. Enter 1 as the **Number of registers**.
6. In the **Value** field, enter 2.
7. Click **Write registers**.

After enabling the ability to use Deep Sleep mode, enter Deep Sleep mode by holding down button 2 for 5 seconds. To wake the MultiHop radio from Deep Sleep mode, hold down button 2 for 5 seconds.

6.3 Reset the Radio or Restore the Factory Defaults

To remotely reset radios or restore factory defaults, use the Modbus registers defined below or use the MultiHop Configuration Software.

You may also use a Modbus multiple write command to write to all registers at once.

To reset the binding code back to the serial number, use the MultiHop radio’s LCD menu system and set the binding code to 0.

1. Write to one of these three registers, depending on the desired function.
 - To restore the factory defaults for I/O parameters, write a 1 to register 44152. (Default value: 0)
 - To restore the system parameters, write a 1 to register 44153. After restoring system parameters, the radio must be re-bound to its master. (Default value: 0)
 - To re-initialize all system parameters created from the serial number, write a 0 to register 44154. This does not reset the binding code. After resetting system parameters, the radio must be re-bound to its master. (Default value: 1)

After performing a system parameter restore or re-initialize using registers 44153 or 44154, the MultiHop radio stops communicating with the wireless network.

2. Trigger the reset/restore by writing a delay time to register 44151. This is the delay time before the selected function begins.

The delay time is in 100 millisecond units. For example, writing a 1 triggers the selected action to occur in 100 milliseconds; writing a 20 causes the action to occur in 20 × 100 milliseconds, or two seconds. Default value: 0

After the selected functions are completed, the system writes a zero to this register.

3. If you have performed a system parameter restore or re-initialized using registers 44153 or 44154, run the binding procedure to add the radio back into the network.

Examples

This example restores the I/O parameters to the factory defaults after one second has passed. After the I/O parameters return to their factory default values, the radio writes a 0 into register 44151.

Function	44152	44153	44154	44151
Restore I/O parameters to default settings	1	0	1	10

This example restores all system parameters to the factory defaults after 100 milliseconds. After the restore is complete, the radio writes a 0 into register 44151. After the system defaults are reset, rebind the radio to the network.

Function	44152	44153	44154	44151
Restore system parameters to default settings	0	1	1	1

This example cycles the power to the radio after 1 second. After the cycle is complete, the radio writes a 0 into register 44151. This command also forces the radio to re-synchronize to its parent radio.

Function	44151
Cycle power to the radio	10

6.4 Configuring Low-Power Radios

Changing some default settings optimizes MultiHop radios for low power applications. To extend the battery life or reduce the radio traffic of your MultiHop radio, consider changing the following parameters.

There are several DIP switch positions that can be modified to reduce power consumption.

- **Reduce the number of receive slots**—The number of receive slots indicates the number of times out of 128 slots/frames that a child radio can receive data from its parent radio. Setting a child radio's receive slots to four reduces the total power consumption by establishing that the child can only receive data from its parent four times per 128 slots, or every 1.28 seconds. To control the receive slots using DIP switches 1 through 4, the serial connection must be disabled by setting DIP switches 3 and 4 to the ON position. To change the number of receive slots without disabling the serial connection, contact the factory.
- **Disable the serial communication**—Reduces the power consumption.
- **Reduce the radio transmit power**—For 900 MHz radios, the transmit power can be reduced from 1 watt to 250 mW. The transmit power will be a significant portion of the total power consumption if data is transmitted more than once per minute. For slower transmit rates, such as once every ten minutes, reducing the transmit power to 250 mW does not significantly reduce the total power consumption.

Using the MultiHop Configuration Software, increase the sample interval for inputs. The greater the interval, the slower the input samples. For example, a default sample interval is once every 0.04 seconds (or 40 milliseconds). To reduce the energy consumption of this MultiHop radio, increase the interval between samples to once every 0.5 seconds or once every 1 second. Set the sample interval based on the desired energy consumption and the speed necessary for your application.

6.5 Connecting Multiple Modbus Sensors to a MultiHop Radio

The MultiHop Radio networks may have up to 50 remote Modbus devices within their network. This allows the user to hard wire multiple Modbus sensors in the same general location without the need for additional slave radios. When the network uses the DXM100-B1R2 Wireless Controller, the network may have up to 99 remote Modbus devices (includes both radios and Modbus sensors).

The following Modbus sensors may be configured similarly:

- QM42VT2 Vibration and Temperature Sensors
- M12FTH3Q Temperature and Humidity Sensor
- K50UX2RA Ultrasonic Sensor

6.5.1 Set the Slave ID on a Modbus Sensor

Required tools include: a PC with the Sensor Configuration Software installed and the BWA-HW-006 or BWA-UCT-900 USB to RS-485 converter cable.

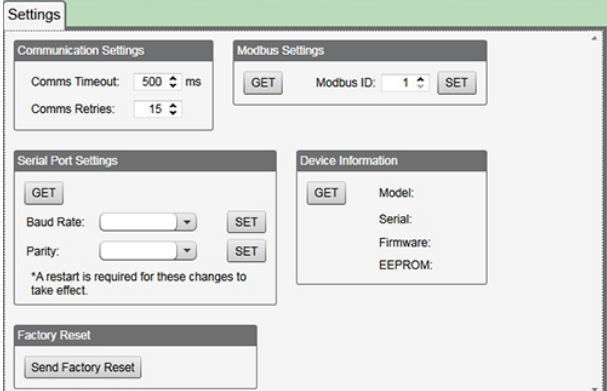
The default Modbus slave ID of the QM42VT2 sensor is 01 and must be changed for each sensor using the software. Modbus Slave IDs 01 through 10 are reserved for slaves directly connected to the host. Use Modbus slave IDs 11 through 60 for the Multihop master, repeater, slave radios, and for the QM42VT2 Modbus slave sensors.

For example, assign the Master radio to be slave ID 11, the slave radio to be slave ID 12, and five QM42VT2s to be slave IDs 13 through 17.

1. Connect the QM42VT2 to the computer running the Sensor Configuration Software using a BWA-HW-006 converter cable.
2. Launch the software.
3. Choose the correct COM port and click **Connect**.
4. From the drop-down list, select the Modbus sensor you are configuring and click **Ok**. For this example, select Vibration.

The software screens specific to the Vibration sensor display.

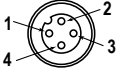
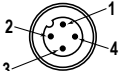
5. From the **Settings** screen under **Modbus Settings**, select the **Modbus Slave ID** and click **Set**.



- 6. To verify the Modbus Slave ID has been changed, go to the **Vibration** screen. Under **Read Settings**, click **Read**. The sensor's Modbus Slave ID displays.
- 7. Disconnect the sensor from the adapter cable and connect the next sensor. Repeat steps 3 through 6 for each sensors you need to assign a slave ID to.

6.5.2 Wiring Multiple Modbus Sensors to a MultiHop Slave Radio

Use either a splitter cable or a junction box to wire multiple Modbus slave sensors to a MultiHop slave radio. To connect two Modbus sensors to a MultiHop radio, you may use the following splitter cable.

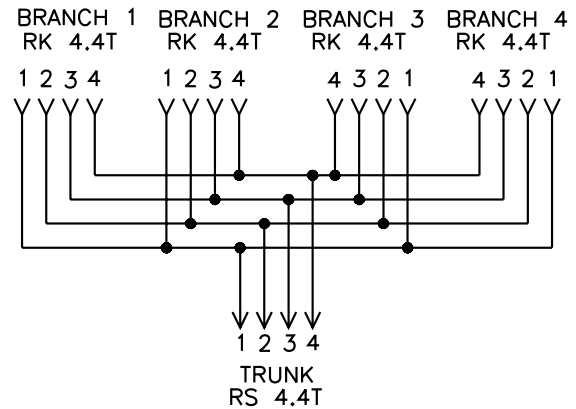
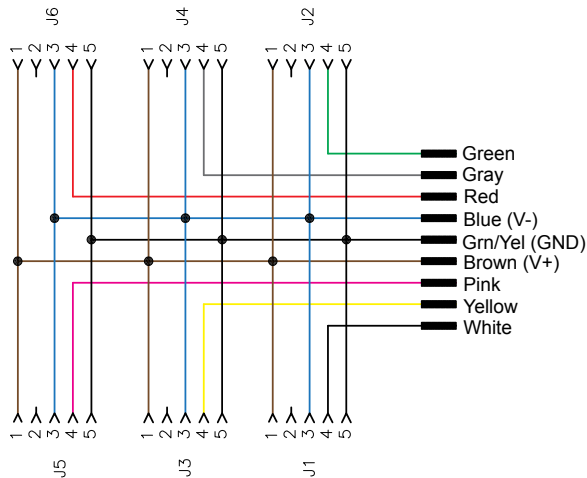
4-Pin Threaded M12/Euro-Style Splitter Cordsets—Rounded Junction			
Model	Branches (Female)	Trunk (Male)	Pinout
CSRB-M1240M1241	0.305 m (1 ft)	No Trunk	<p>Female</p>  <p>Male</p>  <p>1 = Brown 2 = White 3 = Blue 4 = Black</p>
CSRB-M1240M1242	0.61 m (2 ft)		
CSRB-M1240M1243	0.914 m (3 ft)		
CSRB-M1240M1244	1.22 m (4 ft)		

The technical drawing shows a cylindrical junction box with an M12 x 1 threaded cap on the left and two M12 x 1 threaded ports on the right. It has four wires extending from the top. Dimensions include a 16.7 mm diameter for the cap, a 20.0 mm length for the cap section, a 5.0 mm length for the wire section, and a 44 mm typical length for the trunk section. Two 5.5 mm diameter wires are shown branching from the trunk.

Wiring to connect more than two Modbus sensors to a MultiHop radio

Wiring for a junction box

Wiring for a four-trunk splitter cable



6.6 Network Formation

6.6.1 Binding Mode: What Does MultiHop Binding Do?

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.

6.6.2 Why Would I Manually Set the Binding Code?

To quickly replace radios or create ready-to-go spares in an existing network, use the manual binding feature to preset the binding code.

The binding code ties all radios of a wireless network together and is required for radios to communicate with each other. By presetting the binding code in spare radios, replacing radios is quick and easy, minimizing the down time of the network.

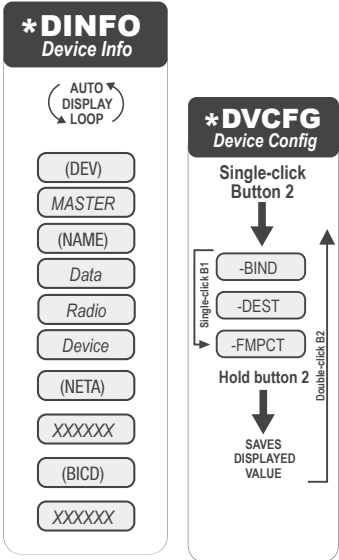
Binding involves locking a MultiHop radio to a specific MultiHop radio configured as the wireless master. After a radio is bound, it only communicates with other radios using the same binding code. All radios within a single wireless network must use the same binding code.

When adding new devices to a network or replacing a damaged device, it may be useful to load the new or replacement device with the binding code without having to take down the network to put the master into binding mode.

Set the Binding Code Using the Menu System

Normally, all radios are bound together before they are physically installed. In a replacement situation, the radio master may not always be accessible. Using the manual binding process eliminates the need to put the radio master into binding mode and allows the wireless network to remain operational.

Obtain the existing binding code from the master radio by going to the ***DINFO** screen. The binding code is displayed under the **BICD** entry at the end of the parameter list. To manually enter a binding code, follow these steps.

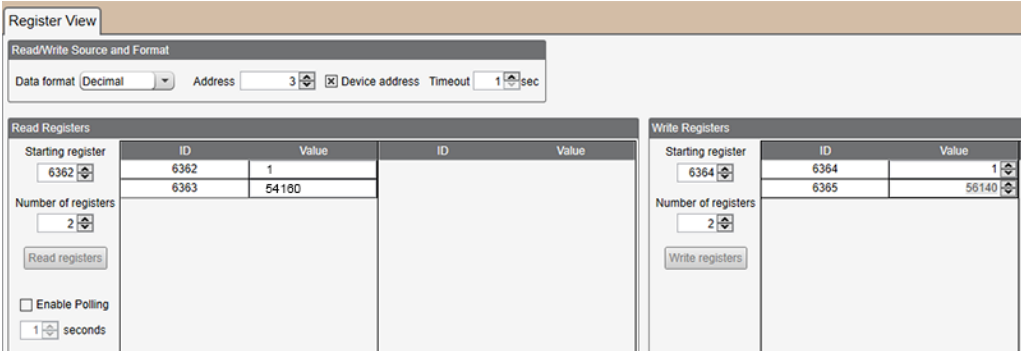


1. Single click button 1 to advance to the *DVCFG menu.
2. Single click button 2 to enter the DVCFG menu.
-BIND displays on the screen as the first option under DVCFG.
3. Single click button 2 to display the binding code. Record this number if this is the binding code you are copying.
4. To change this binding code, use button 1 to increment the blinking digit. Use button 2 to advance, from left to right, to the next digit.
5. When you are finished making changes, press and hold down button 2 to save your changes. When the screen reads SAVE, release button 2.
6. The radio confirms your request to save.
 - Press button 1 to reject your changes.
 - Press button 2 to save your changes.
7. Double-click button 2 to exit the DVCFG menu.

Set the MultiHop Binding Code Using Modbus Registers

On a MultiHop master radio, the binding code is held in Modbus registers 6362–6363; maximum value of 999999. The binding code is automatically generated at the factory using the serial number of the master device, but can also be set using these Modbus registers or by using the LCD menu system on the master device.

Read the Master Radio's binding code or calculate the binding code.



To read the master radio's binding code: Connect the master device to the MultiHop Configuration Software, then read the master's binding code stored in Modbus registers 6362 and 6363. This example shows that register 6362 = 1, 6363 = 56140.

To calculate the master radio's binding code: The factory binding code is a 32-bit value stored in two 16-bit registers within the master radio and can be calculated using the device's serial number. In this example, the master radio's serial number is 121676. (The serial number is printed on the device label, displayed within the menu system on the LCD, or is stored in Modbus registers 4104–4101 as ASCII values.)

For this example, the binding code is:

The value in Modbus register 6362 = Serial # ÷ 65536 = 121676 ÷ 65536 = 1

The value in Modbus register 6363 = Serial # - (Value of 6263)65536 = 121676 - (1)65536 = 56140

Other devices (repeaters and slaves) in the MultiHop network store their binding code in Modbus registers 6364–6365. Typically, in the binding process the master radio sends its binding code to the repeater or slave; the repeater or slave stores this binding code in Modbus registers 6364–6365. The example reads a master radio's binding code, then writes the binding code to a slave radio.

Write the binding code to the slave radio.

- a) Temporarily configure the slave radio to be a master radio by altering the DIP switches on the device.
- b) Connect to the MultiHop Configuration Software.
- c) Write the Modbus register values read from the master device's Modbus registers 6362 and 6363 into the attached device's registers 6364 and 6365.
- d) When complete, change the DIP switches back to configure your slave radio into a slave radio.

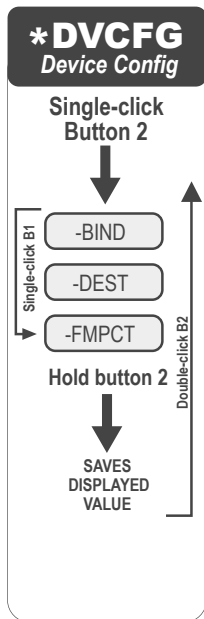
All MultiHop radios store two binding codes. Which code they use is dependent upon the DIP switches that establish if they are master, repeater, or slave radios.

- All radios are programmed from the factory with a binding code (stored in registers 6362 and 6363) calculated from their individual serial number as if they will be used as master radios.
- Repeater and slave radios use Modbus registers 6364 and 6365 to store the binding code they receive from a master radio during the binding process.

A single wireless network uses one binding code — the one that is transmitted from the master device during binding. Although a binding code calculated using the serial number is stored in registers 6362 and 6363 of slave and repeater radios, they use the binding code they receive during the binding process, stored in registers 6364 and 6365.

6.6.3 Bind a MultiHop Radio using Menu Navigation

To quickly replace radios or create ready-to-go spares in an existing network, use the manual binding feature to preset the binding code.



Normally, all devices are bound together before they are physically installed. In a replacement situation, the master device may not always be accessible. Using the manual binding process eliminates the need to put the master device into binding mode and allows the wireless network to remain operational.

To manually enter a binding code:

1. Single click button 1 to advance to the *DVCFG menu.
2. Single click button 2 to enter the DVCFG menu. -BIND displays on the screen as the first option under DVCFG.
3. Single click button 2 to display the binding code. Record this number if this is the binding code you are copying.
4. To change this binding code, use button 1 to increment the blinking digit. Use button 2 to advance, from left to right, to the next digit.
5. When you are finished making changes, press and hold down button 2 to save your changes. When the screen reads **SAVE**, release button 2.
6. The device confirms your request to save. Press button 1 to reject your changes. Press button 2 to save your changes.
7. Double-click button 2 to exit the DVCFG menu.

6.6.4 Bind a MultiHop Radio (without Rotary Dials)

To create your MultiHop network, bind the MultiHop slave radios to the designated master radio and assign a device ID using the master's rotary dials.

1. Apply power to the master radio.
2. Put the MultiHop master radio into binding mode.
 - For master radios with two buttons: triple-click button 2
 - For master radios with one button: trick-click the button

For the two LED/button models, both LEDs flash red and the LCD shows *BINDNG and *MASTER. For single LED/button models, the LED flashes alternatively red and green.

3. Using the master radio's rotary dials, select the Device ID to assign to the MultiHop slave radio. Use the left rotary dial for the left digit and the right rotary dial for the right digit. For example, to assign your slave radio to Device ID 10, set the left dial to 1 and the right dial to 0.
4. Put the MultiHop slave radio into binding mode.
 - For two button radios, triple-click button 2.
 - For one button radios, triple-click the button.

The slave radio enters binding mode and searches for any Master radio in binding mode. While searching for the Master radio, the two red LEDs flash alternately. When the slave radio finds the Master radio and is bound, both red LEDs are solid for four seconds, then both red LEDs flash simultaneously four times. After the slave receives the binding code transmitted by the master, the slave radio automatically exits binding mode.

5. Repeat this sequence (steps 3 and 4) for as many MultiHop slave radios as you need to bind. If two MultiHop slave radios are accidentally assigned the same Device ID, rerun the binding procedure on one of the radios to reassign the ID. The binding sequence may be run as many times as necessary.
6. To exit binding mode on the MultiHop master radio, double-click button 2 on the MultiHop master radio. The master radio restarts and enters RUN mode.

Child Radios Synchronize to the Parent Radios

The synchronization process enables a Sure Cross® radio to join a wireless network formed by a master radio. After power-up, synchronization may take a few minutes to complete. First, all radios within range of the master data radio wirelessly synchronize to the master radio. These radios may be slave radios or repeater radios.

After repeater radios are synchronized to the master radio, any radios that are not in sync with the master but can "hear" the repeater radio will synchronize to the repeater radios. Each repeater "family" that forms a wireless network path creates another layer of synchronization process. The table below details the process of synchronization with a parent. When testing the devices before installation, verify the radio devices are at least two meters apart or the communications may fail.

6.6.5 Bind a MultiHop Radio without Rotary Dials Using Modbus Commands

Use Modbus commands to bind slave MultiHop radios to a master radio when the slave radio does not have rotary dials.

To use a Modbus host controller to trigger binding mode on a MultiHop radio, the following conditions are required:

- The MultiHop radio is configured as a master radio
- The firmware version of the master MultiHop radio is v2.9C or higher

Apply power to the radios. From the Modbus host controller:

1. Write 0x01*NN* (hex) to the MultiHop master's register 6371; where *NN* is the slave ID number in hex.

Value to write to register 6371		Action
Decimal	Hex	
256	0x0100	The master radio enters binding mode and does not assign a slave ID (used with slaves that get their ID from the rotary dials).
256	0x0101	The master radio enters binding mode and assigns the slave that enters binding mode to ID 1
261	0x0105	The master radio enters binding mode and assigns the slave that enters binding mode to ID 5
291	0x0123	The master radio enters binding mode and assigns the slave that enters binding mode to ID 35

The LEDs flash alternately when the master radio is in binding mode.

2. Enter binding mode on the slave radio.
 - If you have a two-button slave, triple-click button 2.
 - If you have a one-button slave, triple-click the button.
 - If you have a slave with no buttons, remove the top cover and set both the left and right rotary dials to F to enter binding mode.

The slave enters binding mode and locates the master radio in binding mode. Verify the two LEDs on the data radio are flashing red alternatively during the binding mode. For the board level data radio, the LED should be flashing green and red alternatively during the binding mode.

After the slave/repeater receives the binding code transmitted by the master, the slave and repeater radios automatically exit binding mode.

3. Repeat steps 1 and 2 for all slaves that will communicate to this master radio.
4. Write 0x0000 (hex) to the MultiHop master radio's register 6371 to stop the binding procedure.

For more information about using Modbus commands, refer to Host Controller Systems instruction manual (p/n [132114](#)).

6.6.6 Bind a MultiHop Radio Using the Configuration Software

The MultiHop Configuration Software can be used to simulate the procedure with the computer acting as the Modbus host controller.

To use the software to enter binding mode:

1. Go to the **Register View** tab.
2. Under **Write Registers**, enter 6371 for the starting register.
3. In the **Value** drop-down box, enter 256.

The screenshot shows the Banner Sure Cross MultiHop Configuration Software interface. The 'Register View' tab is selected. The 'Data Type' is set to 'Decimal'. The 'Modbus Slave ID' is set to '1'. Under 'Read Registers', the 'Starting Register' is 6371 and 'Number of Registers' is 1. Under 'Write Registers', the 'Starting Register' is 6371 and 'Value (DEC)' is 256. A green 'Write' button is visible.

4. Click **Write** to send the value to the MultiHop master radio. The data radio enters binding mode.
5. Verify the LEDs on the data radio are flashing red alternatively during the binding mode. For the MultiHop board modules, the LED flashes green and red alternatively while in binding mode.

To disable the binding mode, write a 0 to register 6371.

6.6.7 Conduct a Site Survey using Modbus Commands

When triggering a site survey from a Modbus master/host system, only the child radio is used to start the site survey. While the site survey is running, you will not be able to communicate with the radio slave. To trigger a site survey using a Modbus master/host-controlled system, follow these steps:

1. Write zeros (0) to the child radio's Site Survey Results registers: 46452 through 46455.
2. Write a one (1) to the child radio's External Site Survey Control register: 46451
The site survey between the child radio and its parent radio begins. Unlike other site survey processes, this method of triggering a site survey results in only 100 packets sent between the parent and child.
3. Wait about 10 seconds for the site survey to complete.
After the 100 packets are sent, the site survey shuts down automatically.
4. Read the child radio's results registers.
Register 46452 contains the green signal strength results. Register 46453 contains the yellow signal strength results. Register 46454 contains the red signal strength results. Register 46455 contains the number of missed packets.

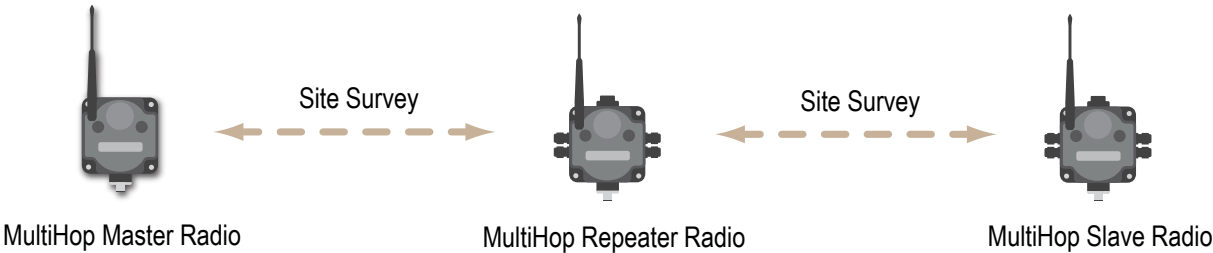
6.6.8 MultiHop Network Formation

At the root of the wireless network is the MultiHop radio master. The radio master contains the initial network routing data and the translation data for the Modbus Address IDs. If the MultiHop radios are running in transparent mode (non-Modbus protocol), network routing information is not used and transactions are broadcast to the entire network.

As the MultiHop radios power up, all MultiHop radio repeaters or slaves within range of the MultiHop radio master connect as children of the radio master, which serves as their parent. After radio repeaters synchronize to the radio master, additional radios within range of the repeater can join the network. The radios that synchronize to the repeater form the

same parent/child relationship the repeater has with the radio master: the repeater is the parent and the new radios are children of the repeater.

The network formation continues to build the hierarchical structure until all MultiHop radios connect to a parent radio. A MultiHop radio can only have one designated parent radio.



After MultiHop radios are communicating to their parents, the network formation information is transmitted back to the radio master, creating a path that is stored in each parent radio's routing tables. Each parent radio stores only one link or step along a path to an end radio. The routing information for non-MultiHop Modbus slave devices is stored as the devices are accessed by the host system.

Only the MultiHop radio master understands Modbus Address IDs. The conversion from Modbus Address ID to a MultiHop device address is done in the radio master as a Modbus message is received. After the Modbus Address ID to MultiHop device address conversion is determined, all network routing uses the device address, not the Modbus Address ID. A device address is similar to an Ethernet MAC address (sometimes the MultiHop device address is referred to as the MAC address).

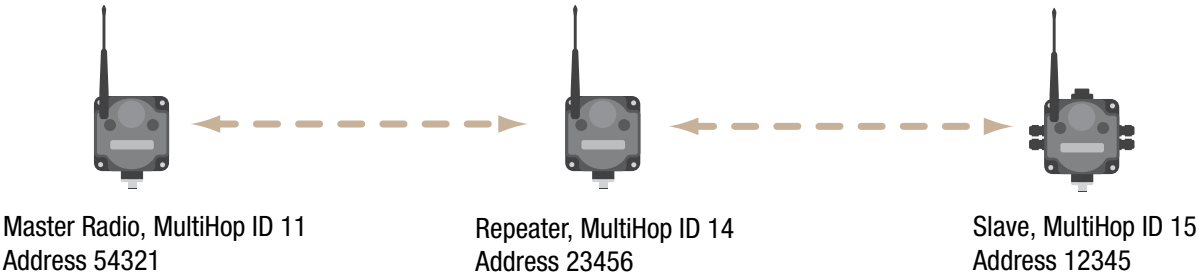
Building MultiHop Formation Tables

As the network is formed, new device addresses are placed in the Network Formation Table in the MultiHop radio master (starting at register 47002). The new radios are stored in the order in which they synchronized to parent radios.

Register 47001 stores the number of radios in the Network Formation Table. Associated by position to the device address in the Network Formation Table is the routing data (starting at register 47302). The actual routing data is the next device address in the path to get to the end radio. The example below shows a Network Formation Table on the radio master for three radios in the network.

Register	Data	Description	Register	Data	Description
47001	03	Defines the number of radios in the network			
47002	54321	First device address in the network formation table	47302	54321	The same device address indicates that the target device is connected to this radio.
47003	12345	Second device address in the network formation table	47303	23456	A different device address indicates the first step in the route is going to device 23456.
47004	23456	Final device address in the network	47304	23456	Link indicates the device is connected to this parent radio.

Register 47302 is associated to register 47002 by its position in the table. Therefore, the link for the device address stored at register 47002 is stored in register 47302.



Correlating Device Address to Modbus Address IDs

The Modbus Address ID table defines the association from a Modbus Address ID to the MultiHop device address. (The Modbus Address ID for a MultiHop radio is usually defined by the rotary switches whereas the device address is a 5-digit number assigned by the factory.)

Register 46502 defines the Modbus Address ID offset for wireless Modbus Slaves. An '11' in this register would mean that wireless Modbus Slave devices start at Address ID 11. Any messages referring to Modbus Slaves 1 through 10 will be ignored by the wireless devices.

Registers 46504 through 46604 store the MultiHop device addresses in order, starting with the Modbus Address ID defined by the offset register (46502). In the example below Modbus Slaves 11, 14, and 15 are in the table. Register 46503 defines the maximum number of Modbus slaves for this system.

Register	MultiHop ID	Data	Description
46502		11	Wireless Modbus Slave IDs start at 11
46503		50	The number of Modbus Slaves defined for the system
46504	11	54321	MultiHop device address 54321 is Modbus Slave ID 11
46505	12	65535	Modbus slave ID 12 is not used
46506	13	65535	Modbus slave ID 13 is not used
46507	14	23456	Device address 23456 is Modbus Slave ID 14
46508	15	12345	Device address 12345 is Modbus Slave ID 15

6.6.9 Formation Percentage on MultiHop Radios

The formation percentage parameter determines what minimum site survey link quality is acceptable to join to a parent radio. The factory default for the formation percentage is a value of 70.

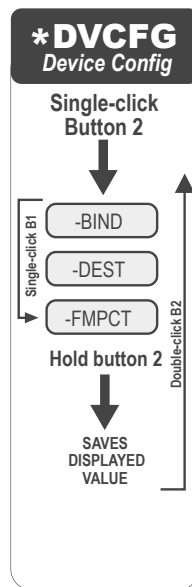
After powering up, MultiHop radios automatically begin forming a wireless network. Radio repeaters and radio slaves listen to all potential parent radios and use the site survey results to select the most efficient and reliable radio as their parent radios.

The formation percentage parameter determines what minimum percentage of RF link is acceptable to join to a parent radio. To calculate the link percentage, divide the register value by 100, then square it. For example, $(70 \div 100)^2$ results in an approximately 49% site survey radio link, as shown on the MultiHop Configuration Software **Network > Network and Device Overview** screen.

For most applications, the factory default value is a good setting because signal strength varies from season to season. Under some long-range conditions, users may want to decrease this value and allow radios with a weaker signal to join a network. To build a robust wireless network that forces radio slaves to use radio repeaters instead of linking directly to the radio master, increase the formation percentage.

Change the Formation Percentage

Use the MultiHop radio's LCD to manually set the formation percentage. The formation percentage parameter can also be set using Modbus Register 46351.



1. Single click button 1 to advance to the DVCFG menu.
2. Single click button 2 to enter the DVCFG menu. BIND displays on the screen as the first option under DVCFG.
3. Single click button 1 to move through the DVCFG menu until you reach FMPCT (Formation Percentage).
4. Single click button 2 to display the current formation percentage. The formation percentage displays using the full six-digit screen. Factory default will display as 000070 though only the last two digits are used for this parameter.
5. Click button 2 to advance from left to right. When the second digit from the right is blinking, use button 1 to increment the digit.
6. After you are finished making changes, press and hold down button 2 to save your changes. When the screen reads SAVE, release button 2.
7. The radio confirms your request to save. Press button 1 to reject your changes. Press button 2 to save your changes.
8. Double-click button 2 to exit the DVCFG menu.

Setting the Formation Percentage

An application only requires data once per day, but because of the distance and obstacles between radios, the site survey link quality is about 20%. The register value should then be: $100 \times (0.20)^{1/2} = 100 \times 0.447 = 45$

Write to Modbus register 46351, or, using the menu system and LCD on the radio, set the value to 000045.

Formation parameter (register value) = $100 \times (\text{site survey link quality percent} \div 100)^{1/2}$

6.6.10 Forced Routing with MultiHop Radios

The MultiHop forced routing feature allows users to define routing tree structures.

Users can define the parent radio device for some or all the slave or repeater devices. As an added benefit, the sync time for the radios with forced routing decreases because the device doesn't spend time looking for multiple parent devices. Force the routing using the radio's LCD or the MultiHop Configuration Software.

RF firmware V3.1 or higher is required to enable this feature. Contact Banner Engineering to obtain the latest firmware revisions.



Important: The user must still bind all radios that communicate within the same wireless network. Forced routing only defines a parent device for a child radio (slave or repeater).

Determine the Firmware Version

Use the MultiHop radio's LCD menu system to verify the radio's firmware version.

1. Press button 1 until you reach the **FCTRY** menu.
2. Press button 2 to enter the **FCTRY** menu. The LCD automatically displays all device information.

3. The firmware version is displayed as the **FMVER**.

Configure a Forced Routing from the Child Radio's LCD

Follow these steps to use the LCD menu system to configure force routing.

1. Press button 1 until you reach the **DVCFG** menu (device configure menu).
2. Press button 2 to enter the **DVCFG** menu.
3. Press button 1 until the display shows **-PARNT**.
4. Press button 2.
5. Use button 1 to increment the digits and button 2 to move between digits. The first digit is always ZERO, the largest entered value will be 65535.
6. Enter the parent device address (1 through 65535). Find the parent device address by viewing the LCD menu (**RUN > DADR**).
7. Press and hold down button 2 to enter the save option.
8. Select 'yes' or 'no' by using button 2 or button 1 to save the parent address.

Configure a Forced Routing using the Software

Follow these steps to use the MultiHop Configuration Software to configure force routing.

1. Use adapter cable **BWA-UCT-900** to connect a 1 Watt MultiHop radio to your computer.
2. Launch the MultiHop Configuration Software and connect to your master radio.
3. On the **Network** screen, enter the MultiHop Radio ID of the master radio and click **Read**. The network of repeater and slave radios displays, along with the serial number, model number, and all versions. Verify the child radio you want to force a routing from has RF firmware v3.1 or higher.
4. On the **Register View > Write Registers** screen, enter the Modbus Slave ID (child) of the device to be force routed.
5. Enter **6368** in the **Starting Register** and enter the Parent Device Address in the **Value Register**. Click **Write registers**.
6. To verify the contents of the Read Register, enter **6368** and click **Read registers**. The route of the child should now be forced.

Remove a Forced Routing

To remove a forced routing using the child radio's LCD, follow the same procedure used to configure the forced route, but enter all zeros (0) for the **-PARNT** address.

To remove a forced routing using the MultiHop Configuration Software, follow the same procedure used to configure the forced route, but enter 00000 into Starting Register 6368. After the forced route is removed from the child radio, the network is still bound and the child radio automatically detects a path back to the master radio.

If you want to unbind the radio from the wireless network, follow these steps from the child radio:

1. Triple-click button 2 to put the device into binding mode.
2. When in binding mode, press and hold button 2 for 10 seconds. The radio automatically exits binding mode. The radio is now unbound from the network and must be re-bound to the Master.

6.7 Power

6.7.1 Using 10–30 V DC to Power Two Radios

When using 10 V DC to 30 V DC (Outside the USA: 12 V DC to 24 V DC, $\pm 10\%$) to power both the MultiHop data radio and a Gateway, use the 4-pin Euro-style splitter cable to avoid damaging either radio.



- 1 CSB-M1240M1241. Splitter cable, 4-pin Euro-style QD, No trunk male, two female branches, yellow. Use to connect the data radio to the Gateway.
- 2 DX80DR9M-Hx. MultiHop Data Radio powered by 10 V DC to 30 V DC (Outside the USA: 12 V DC to 24 V DC, $\pm 10\%$)
- 3 DX80 Gateway, powered by 10 V DC to 30 V DC (Outside the USA: 12 V DC to 24 V DC, $\pm 10\%$)

6.7.2 Using Solar to Power Two Radios

When using a solar panel to power two radios, use the 5-pin M12/Euro-style splitter cable.



- 1 CSRB-M1250M125.47M125.73. Splitter cable, 5-pin M12/Euro-style QD, No trunk male, two female branches, black. Most commonly used with solar and other FlexPower devices.
- 2 DX80DR9M-H.x. MultiHop Data Radio
- 3 DX80 FlexPower Gateway

6.8 Communication

6.8.1 Set the MultiHop Baud Rate to 1200

The standard baud rate settings for the serial interface are 9600, 19200, and 38400. These are typically selected using the DIP switch settings on the MultiHop radio. A 1200 baud rate was implemented in firmware 1.3H and later.

To select a 1200 baud rate using the MultiHop Configuration Software, select the baud rate from the drop-down list. All other parameters are automatically changed to their appropriate value.

To select a 1200 baud rate by writing to Modbus registers, follow these steps:

1. Verify you have MultiHop firmware version 1.3H or later.
2. Set the DIP switches to select the custom baud rate.
For most MultiHop radio models, the custom baud rate is selected using DIP switches 1 and 2.
3. Write Modbus register 46101 with 0x04 to select the baud rate timing for 1200 baud.
4. Write Modbus register 46105 with 0xFF (255) to select the maximum End-of-Message time value.
5. Write Modbus register 46109 with 1 to adjust the End-of-Message timeout when running this slow baud rate.
6. Cycle power on the device.

6.8.2 Set the MultiHop Baud Rate to 2400

The standard baud rate settings for the serial interface are 9600, 19200, and 38400. These are typically selected using the DIP switch settings on the MultiHop radio. A 2400 baud rate was implemented in firmware 1.3H and later.

To select a 2400 baud rate using the MultiHop Configuration Software, select the baud rate from the drop-down list. All other parameters are automatically changed to their appropriate value.

To select a 2400 baud rate by writing to Modbus registers, follow these steps:

1. Verify you have MultiHop firmware version 1.3H or later.
2. Set the DIP switches to select the custom baud rate.
For most MultiHop radio models, the custom baud rate is selected using DIP switches 1 and 2.
3. Write Modbus register 46101 with 0x0B to select the baud rate timing for 2400 baud.
4. Write Modbus register 46109 with 1 to adjust the End-of-Message timeout when running this slow baud rate.
5. Cycle power on the device.

7 Product Support and Maintenance

7.1 Sure Cross® MultiHop Data Radio Documentation

For additional information, including installation and setup, weatherproofing, device menu maps, troubleshooting, and a list of accessories, refer to one of the following product manuals.

- MultiHop Data Radio Quick Start Guide: [152653](#)
- MultiHop Data Radio Instruction Manual: [151317](#)
- Sure Cross® Accessories List [b_3147091](#)
- Sure Cross® Installation Guide: [151514](#)
- Conducting a Site Survey: [133602](#)
- Power Solutions: FlexPower and Battery Life: [140386](#)
- Power Solutions: Solar: [201843](#)
- Antenna Basics: [132113](#)
- Sensor Connections: [136214](#)
- System Layouts: [133601](#)
- [Glossary](#) of Wireless Terminology
- MultiHop Register Guide: [155289](#)

The following manuals are for the configuration software:

- MultiHop Configuration Software Instruction Manual: [150473](#)
- Sensor Configuration Software Instruction Manual: [170002](#)

7.2 Verifying the Firmware Version of the MultiHop Radio

To verify the data radio's firmware version, you can use the MultiHop Configuration Software or the LCD menu system.

1. To use the MultiHop Configuration Software:
 - a) Go to the **Device Config** tab.
 - b) Under **Read Firmware Version**, click **From Device**.
2. To use the LCD menu system:
 - a) Single-click button 1 to advance through the top level menu until you reach ***FCTRY**.
 - b) Within the ***FCTRY** menu, the values automatically display in a loop. Note the **RADIO FMVER** value that displays; this is your radio firmware version.

7.3 Maintenance

Follow these instructions to perform basic maintenance tasks.

7.3.1 Replacing the Main Body Gasket

Check the main body gasket every time a SureCross device is opened.



Replace the gasket when it is damaged, discolored, or showing signs of wear. The gasket must be:

- Fully seated within its channel along the full length of the perimeter, and
- Positioned straight within the channel with no twisting, stress, or stretching.

7.3.2 Replacing the Rotary Dial Access Cover

Check the rotary dial access cover o-ring every time the access cover is removed.



Replace the o-ring when it is damaged, discolored, or showing signs of wear. The o-ring should be:

- Seated firmly against the threads without stretching to fit or without bulging loosely, and
- Pushed against the flanged cover.

When removing or closing the rotary dial access cover, manually twist the cover into position. Do not allow cross-threading between the cover and the device's face. After the cover is in place and manually tightened, use a small screwdriver (no longer than five inches total length) as a lever to apply enough torque to bring the rotary dial access cover even with the cover surface.

7.3.3 Install or Replace the Battery for a DX81 Model

To replace the lithium "D" cell battery in the FlexPower Supply Module, follow these steps.

1. Unplug the **DX81-LITH** or **DX81H** FlexPower Supply Module from the Sure Cross® device it powers.
2. Remove the four screws mounting the battery module face plate to the body and remove the face plate.
3. Remove the discharged battery by pressing the battery towards the negative terminal to compress the spring. Pry up on the battery's positive end to remove from the battery holder.
4. Install the new battery or batteries.
5. Verify the battery's positive and negative terminals align to the positive and negative terminals of the battery holder mounted within the case. Caution: There is a risk of explosion if the battery is replaced incorrectly.
6. After replacing the battery, allow up to 60 seconds for the device to power up.
7. Properly dispose of your used battery according to local regulations by taking it to a hazardous waste collection site, an e-waste disposal center, or any other facility qualified to accept lithium batteries.



For outside or high humidity environments, dielectric grease may be applied to the battery terminals to prevent moisture and corrosion buildup.

As with all batteries, these are a fire, explosion, and severe burn hazard. Do not burn or expose them to high temperatures. Do not recharge, crush, disassemble, or expose the contents to water.

The battery may be replaced in explosive gas atmospheres.

For non-hazardous locations, the replacement battery is model **BWA-BATT-011**. For non-hazardous or hazardous locations, the replacement battery is Xeno model XL-205F, Banner model **BWA-BATT-001**. For pricing and availability, contact Banner Engineering.



WARNING:

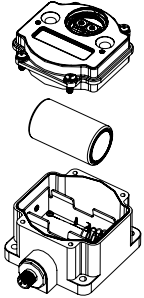
- Potential electrostatic charging hazard — only clean with a damp cloth.
- The replacement battery **MUST** be a Banner approved battery, model number **BWA-BATT-001**. Use of a different battery will **VOID** the intrinsic safety rating of this device and may result in an explosion!
- When replacing the battery, the negative end of the battery holder is the side with the spring terminal. This side is marked with a minus (-) sign.
- Do not attempt to recharge the battery. These batteries are not rechargeable. Recharging may cause serious injury to personnel or damage the equipment. Replace only with factory recommended batteries.

7.3.4 Install or Replace the Battery for a DX80 Integrated Battery Model

To install or replace the 3.6 V lithium "D" cell battery in any model with a battery integrated into the housing, follow these steps.

1. Remove the four screws mounting the face plate to the housing and remove the face plate.

2. Remove the discharged battery.
3. Install the new battery, verifying the battery's positive and negative terminals align to the positive and negative terminals of the battery holder mounted within the case.
4. After installing the battery, allow up to 60 seconds for the device to power up.
5. Properly dispose of used batteries according to local regulations by taking it to a hazardous waste collection site, an e-waste disposal center, or other facility qualified to accept lithium batteries.



CAUTION: There is a risk of explosion if the battery is replaced incorrectly.

As with all batteries, these are a fire, explosion, and severe burn hazard. Do not burn or expose them to high temperatures. Do not recharge, crush, disassemble, or expose the contents to water.

For non-hazardous locations, the replacement battery is model **BWA-BATT-011**. For non-hazardous or hazardous locations, the replacement battery is Xeno model XL-205F, Banner model **BWA-BATT-001**. For pricing and availability, contact Banner Engineering.

7.3.5 Install or Replace the Battery (DX99...D Models)



WARNING:

- Do not replace battery when an explosive dust atmosphere may be present.
- The replacement battery **MUST** be a Banner approved battery, model number **BWA-BATT-001**. Use of a different battery will VOID the intrinsic safety rating of this device and may result in an explosion!
- When replacing the battery, the negative end of the battery holder is the side by the large capacitors. This side is marked with a minus (-) sign.
- Do not attempt to recharge the battery. These batteries are not rechargeable. Recharging may cause serious injury to personnel or damage the equipment. Replace only with factory recommended batteries.

To install or replace the lithium "D" cell battery in the metal housings, follow these steps.

1. Unscrew the lid of the metal enclosure.
2. Lift the radio out of the metal enclosure and pull the spacer frame off the back side of the radio.
3. Disconnect the radio by unplugging the ribbon cable from the radio board and set aside the radio and spacer frame.
4. If you are replacing an existing battery, remove the discharged battery.
5. Insert a new battery. Only use a 3.6 V lithium battery from Xeno, model number XL-205F.
6. Verify the battery's positive and negative terminals align to the positive and negative terminals of the battery holder mounted within the case. Caution: There is a risk of explosion if the battery is replaced incorrectly.
7. Wait two minutes.
8. Insert the ribbon cable through the center of the spacer frame, then plug the ribbon cable back into the radio board.
9. Insert the radio back onto the spacer frame pins. Push the radio and spacer frame assembly back into the enclosure until it is seated.
10. Screw on the lid and tighten.
11. After replacing the battery, allow up to 60 seconds for the device to power up.
12. Properly dispose of your used battery according to local regulations by taking it to a hazardous waste collection site, an e-waste disposal center, or other facility qualified to accept lithium batteries.



As with all batteries, these are a fire, explosion, and severe burn hazard. Do not burn or expose them to high temperatures. Do not recharge, crush, disassemble, or expose the contents to water.

The battery may be replaced in explosive gas atmospheres. Replacement battery model number: BWA-BATT-001. For pricing and availability, contact Banner Engineering.

7.4 Sure Cross® Radio Certifications

Banner's Sure Cross product line is certified by the FCC, European Union, and many other countries for operation within specific radio frequencies.

7.4.1 FCC and ISED Certification, 900 MHz, 1 Watt Radios

This equipment contains transmitter module RM1809.

FCC ID: UE3RM1809
IC: 7044A-RM1809
HVIN: RM1809

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

This device contains licence-exempt transmitter(s)/receiver(s) that comply with Innovation, Science and Economic Development Canada's licence-exempt RSS(s). Operation is subject to the following two conditions: (1) This device may not cause interference, and (2) This device must accept any interference, including interference that may cause undesired operation of the device.

Cet appareil contient des émetteurs/récepteurs exemptés de licence conformes à la norme Innovation, Sciences, et Développement économique Canada. L'exploitation est autorisée aux deux conditions suivantes: (1) L'appareil ne doit pas produire de brouillage, and (2) L'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

7.4.1 FCC Notices

IMPORTANT: The transmitter modules RM1809 have been certified by the FCC / ISED for use with other products without any further certification (as per FCC section 2.1091). Changes or modifications not expressly approved by the manufacturer could void the user's authority to operate the equipment.

IMPORTANT: The transmitter modules RM1809 have been certified for fixed base station and mobile applications. If modules will be used for portable applications, the device must undergo SAR testing.

IMPORTANT: If integrated into another product, the FCC ID label must be visible through a window on the final device or it must be visible when an access panel, door, or cover is easily removed. If not, a second label must be placed on the outside of the final device that contains the following text:

Contains Transmitter Module RM1809
FCC ID: UE3RM1809
IC: 7044A-RM1809
HVIN: RM1809

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

7.4.1 Note

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or

television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna,
- Increase the separation between the equipment and receiving module,
- Connect the equipment into an outlet on a circuit different from that to which the receiving module is connected, and/or
- Consult the dealer or an experienced radio/TV technician for help.

Antenna WARNING: This device has been tested with Reverse Polarity SMA connectors with the antennas listed in [Table 5](#) on p. 64. When integrated into OEM products, fixed antennas require installation preventing end-users from replacing them with non-approved antennas. Antennas not listed in the tables must be tested to comply with FCC Section 15.203 (unique antenna connectors), FCC Section 15.247 (emissions), and ISED RSS-Gen Section 6.8.

7.4.1 FCC and ISED Approved Antennas

WARNING: This equipment is approved only for mobile and base station transmitting devices. Antenna(s) used for this transmitter must be installed to provide a separation distance of at least 20 cm from all persons and must not be collocated or operating in conjunction with any other antenna or transmitter.

This radio transmitter module RM1809 have been approved by FCC and ISED Canada to operate with the antenna types listed below, with the maximum permissible gain indicated. Antenna types not included in this list that have a gain greater than the maximum gain indicated for any type listed are strictly prohibited for use with this device.

Table 5: Certified Antennas for 900 MHz 1 Watt

Model Number	Antenna Type	Maximum Gain	Impedance	Minimum Required Cable/ Connector Loss
-	Integral Antenna	Unity gain		0
BWA-901-x	Omni, 1/4 wave dipole	≤2 dBi	50 Ω	0
BWA-902-C	Omni, 1/2 wave dipole, Swivel	≤2 dBi	50 Ω	0
BWA-906-A	Omni Wideband, Fiberglass Radome	≤8.2 dBi	50 Ω	2.2 dB
BWA-905-B	Omni Base Whip	≤7.2 dBi	50 Ω	1.2 dB
BWA-9Y10-A	Yagi	≤10 dBi	50 Ω	4 dB

7.4.2 FCC and ISED Certification, 2.4GHz

This equipment contains transmitter module DX80-2400 or SX243.

FCC ID:
 UE300DX80-2400
 IC: 7044A-DX8024
 FCC ID: UE3SX243
 IC: 7044A-SX243
 HVIN: DX80G2 /
 DX80N2 / SX243

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

This device contains licence-exempt transmitters(s)/receiver(s) that comply with Innovation, Science and Economic Development Canada’s licence-exempt RSS(s). Operation is subject to the following two conditions: (1) This device may not cause interference, and (2) This device must accept any interference, including interference that may cause undesired operation of the device.

Cet appareil contient des émetteurs/récepteurs exemptés de licence conformes à la norme Innovation, Sciences, et Développement économique Canada. L’exploitation est autorisée aux deux conditions suivantes: (1) L’appareil ne doit pas produire de brouillage, and (2) L’utilisateur de l’appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d’en compromettre le fonctionnement.

7.4.2 FCC Notices

IMPORTANT: The transmitter modules DX80-2400 and SX243 have been certified by the FCC / ISED for use with other products without any further certification (as per FCC section 2.1091). Changes or modifications not expressly approved by the manufacturer could void the user’s authority to operate the equipment.

IMPORTANT: The transmitter modules DX80-2400 and SX243 have been certified for fixed base station and mobile applications. If modules will be used for portable applications, the device must undergo SAR testing.

IMPORTANT: If integrated into another product, the FCC ID/IC label must be visible through a window on the final device or it must be visible when an access panel, door, or cover is easily removed. If not, a second label must be placed on the outside of the final device that contains the following text:

Contains Transmitter Module [DX80-2400 or SX243]

FCC ID: [UE300DX80-2400 or UE3SX243]

IC: [7044A-DX8024 or 7044A-SX243]

HVIN: [DX80G2, DX80N2 or SX243]

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

7.4.2 Note

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna,
- Increase the separation between the equipment and receiving module,
- Connect the equipment into an outlet on a circuit different from that to which the receiving module is connected, and/or
- Consult the dealer or an experienced radio/TV technician for help.

Antenna Warning: This device has been tested with Reverse Polarity SMA connectors with the antennas listed in [Table 6](#) on p. 65. When integrated into OEM products, fixed antennas require installation preventing end-users from replacing them with non-approved antennas. Antennas not listed in the tables must be tested to comply with FCC Section 15.203 (unique antenna connectors), FCC Section 15.247 (emissions), and ISED RSS-Gen Section 6.8.

7.4.2 FCC and ISED Approved Antennas

WARNING: This equipment is approved only for mobile and base station transmitting devices. Antenna(s) used for this transmitter must be installed to provide a separation distance of at least 20 cm from all persons and must not be collocated or operating in conjunction with any other antenna or transmitter.

The radio transmitter modules DX80-2400 and SX243 have been approved by FCC and ISED Canada to operate with the antenna types listed below, with the maximum permissible gain indicated. Antenna types not included in this list that have a gain greater than the maximum gain indicated for any type listed are strictly prohibited for use with this device.

Table 6: Certified Antennas for 2.4 GHz

Model	Antenna Type	2.4 GHz Radio Module	Maximum Gain	Impedance
	Integral antenna	DX80-2400	Unity gain	
BWA-202-C	Omni, 1/2 wave dipole, Swivel	DX80-2400 or SX243	≤ 2 dBi	50 Ω
BWA-202-D	Omni, Dome, Box Mount	DX80-2400	≤ 2 dBi	50 Ω
BWA-202-E	Omni, 1/4 wave dipole, Swivel	DX80-2400	≤ 2 dBi	50 Ω
BWA-205-C	Omni, Collinear, Swivel	DX80-2400	≤ 5 dBi	50 Ω
BWA-205-MA	Omni, full-wave dipole, NMO	DX80-2400	≤ 4.5 dBi	50 Ω
BWA-206-A	Omni, Dome, Box Mount	DX80-2400	≤ 6 dBi	50 Ω
BWA-207-C	Omni, Coaxial Sleeve, Swivel	DX80-2400	≤ 7 dBi	50 Ω

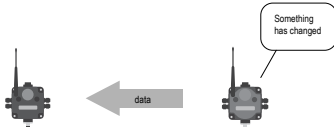
7.4.3 Exporting Sure Cross® Radios

Exporting Sure Cross® Radios. It is our intent to fully comply with all national and regional regulations regarding radio frequency emissions. **Customers who want to re-export this product to a country other than that to which it was sold must ensure the device is approved in the destination country.** The Sure Cross wireless products were certified for use in these countries using the antenna that ships with the product. When using other antennas, verify you are not exceeding the transmit power levels allowed by local governing agencies. This device has been designed to operate with the antennas listed on Banner Engineering's website and having a maximum gain of 9 dBm. Antennas not included in this list or having a gain greater than 9 dBm are strictly prohibited for use with this device. The required antenna impedance is 50 ohms. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen such that the equivalent isotropically radiated power (EIRP) is not more than that permitted for successful communication. Consult with Banner Engineering Corp. if the destination country is not on this list.

7.5 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)	<p>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.</p> <p>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.</p>
binding (MultiHop networks)	<p>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.</p> <p>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.</p>
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.

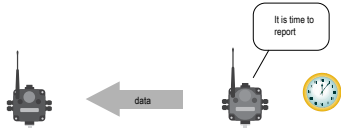
collocated networks To prevent interference between collocated wireless networks, assign each wireless network a different Network ID. The Network ID is a unique identifier assigned to each wireless network using the rotary dials on the Gateway.

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.



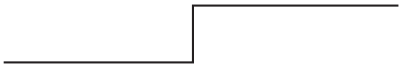
debounce When a signal changes state using a mechanical switch or relay, the signal can oscillate briefly before stabilizing to the new state. The debounce filter examines the signal's transitions to determine the signal's state.



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, $\text{dBm} = \text{dBi} = \text{dBd} + 2.15$ 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.

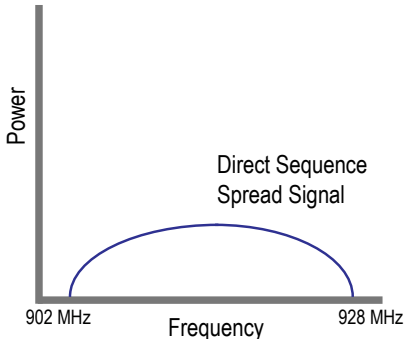
directional antenna

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.

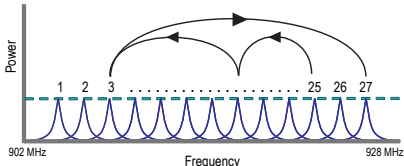
flash pattern Flash patterns are established by selecting timeslots to turn the output on or off. While originally the flash pattern was designed to turn on and off an indicator light, the flash pattern can be set for any discrete output or switch power output.

FlexPower Banner’s FlexPower® 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 FlexPower Node and an optimized sensing device for up to 5 years on a single lithium D cell.

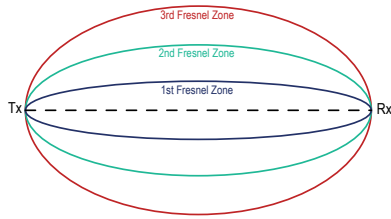
free space loss (FSL) The radio signal loss occurring as the signal radiates through free space. Free Space Loss = 20 Log (4(3.1416)d/λ) where d is in meters. Remembering that λf = c = 300 x 10⁶ m/s, the equations reduce down to:

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.)

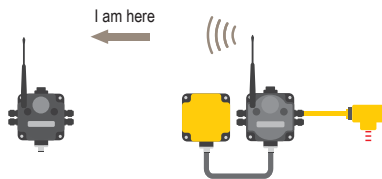
Frequency Hopping Spread Spectrum (FHSS) Frequency Hopping Spread Spectrum (FHSS) is a method for generating spread spectrum transmissions where the signal is switched between different frequency channels in a pseudo-random sequence known by both the transmitter and the receiver. FHSS is useful for sending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



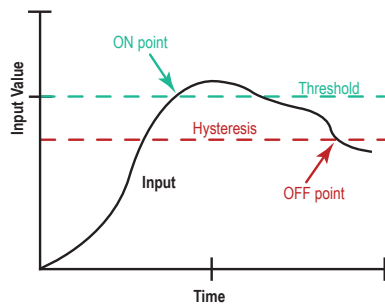
Fresnel zone Fresnel zones are the three-dimensional elliptical zones of radio signals between the transmitter and receiver. Because the signal strength is strongest in the first zone and decreases in each successive zone, obstacles within the first Fresnel zone cause the greatest amount of destructive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

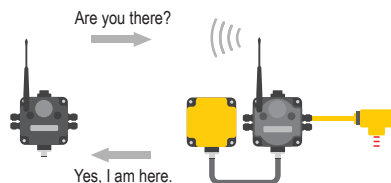
maximum misses

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.

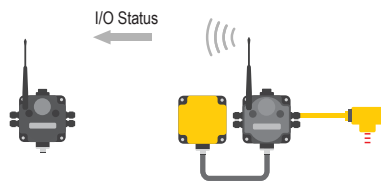
- Modbus** Modbus is a master-slave communications protocol typically used for industrial applications.
- Modbus/TCP** Modbus/TCP is an open standard protocol very similar to Modbus RTU except that it uses standard Internet communication protocols.
- MultiHop** MultiHop networks are made up of one master 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 minimize 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 *FlexPower*® 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*.

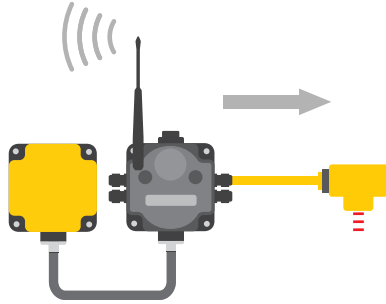
- resistance
temperature
detector (RTD)** An RTD is a temperature measurement device that measures the electrical resistance across a pure metal. The most commonly used metal is platinum because of its temperature range, accuracy, and stability.

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.

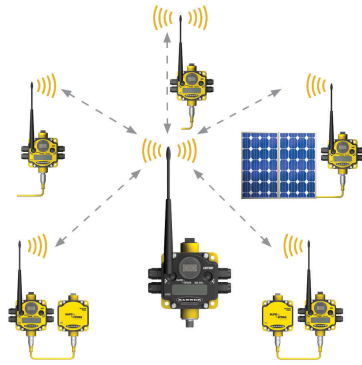


- sample on demand** Sample on demand allows a host system to send a Modbus command to any register and require the inputs to immediately sample the sensor and report readings back to the host system. Sampling on demand can be used between the normal periodic reporting.
To use the Sample on Demand feature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

$$\text{SNR} = 20 \times \log (V_s/V_n)$$
 where V_s is the signal voltage and V_n is the noise voltage;

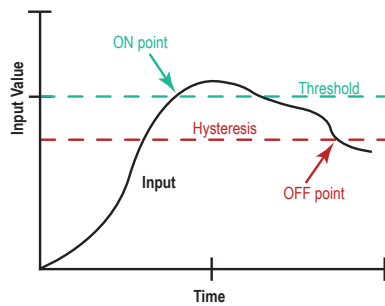
$$\text{SNR} = 20 \times \log (A_s/A_n)$$
 where A_s is the signal amplitude and A_n is the noise amplitude; or

$$\text{SNR} = 10 \times \log (P_s/P_n)$$
 where P_s is the signal power and P_n 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. When using more than one Modbus slave, assign each slave a unique ID number.
By default, Gateways are set to Modbus Slave ID 1.
- 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 MultiHop Radio enters a deeper sleep mode to conserve battery power N/A after the MultiHop Radio loses its communication link with its parent or master radio. The MultiHop Radio wakes up every N/A to search for its parent radio. If a parent or master radio is not found, the MultiHop Radio goes back to sleep for another N/A. If the parent or master radio is detected, the MultiHop Radio exits slow scan mode. To manually exit slow scan mode, press the MultiHop Radio's binding button.
- 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 *FlexPower* 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.



7.6 Contact Us

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7.7 Warnings

Install and properly ground a qualified surge suppressor when installing a remote antenna system. Remote antenna configurations installed without surge suppressors invalidate the manufacturer's warranty. Keep the ground wire as short as possible and make all ground connections to a single-point ground system to ensure no ground loops are created. No surge suppressor can absorb all lightning strikes; do not touch the Sure Cross® device or any equipment connected to the Sure Cross device during a thunderstorm.

Exporting Sure Cross® Radios. It is our intent to fully comply with all national and regional regulations regarding radio frequency emissions. **Customers who want to re-export this product to a country other than that to which it was sold must ensure the device is approved in the destination country.** The Sure Cross wireless products were certified for use in these countries using the antenna that ships with the product. When using other antennas, verify you are not exceeding the transmit power levels allowed by local governing agencies. This device has been designed to operate with the antennas listed on Banner Engineering's website and having a maximum gain of 9 dBm. Antennas not included in this list or having a gain greater than 9 dBm are strictly prohibited for use with this device. The required antenna impedance is 50 ohms. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen such that the equivalent isotropically radiated power (EIRP) is not more than that permitted for successful communication. Consult with Banner Engineering Corp. if the destination country is not on this list.

7.8 Banner Engineering Corp. Limited Warranty

Banner Engineering Corp. warrants its products to be free from defects in material and workmanship for one year following the date of shipment. Banner Engineering Corp. will repair or replace, free of charge, any product of its manufacture which, at the time it is returned to the factory, is found to have been defective during the warranty period. This warranty does not cover damage or liability for misuse, abuse, or the improper application or installation of the Banner product.

THIS LIMITED WARRANTY IS EXCLUSIVE AND IN LIEU OF ALL OTHER WARRANTIES WHETHER EXPRESS OR IMPLIED (INCLUDING, WITHOUT LIMITATION, ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE), AND WHETHER ARISING UNDER COURSE OF PERFORMANCE, COURSE OF DEALING OR TRADE USAGE.

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For patent information, see www.bannerengineering.com/patents.

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