MultiHop Radio Product Manual

BANNER®

Contents

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. The MultiHop Radio architecture creates a hierarchical network of devices to solve the most challenging wireless applications. A MultiHop Radio is either a master radio, a repeater radio, or a slave radio.

- The single master device controls the overall wireless network.
- The repeater mode allows for range extension 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:
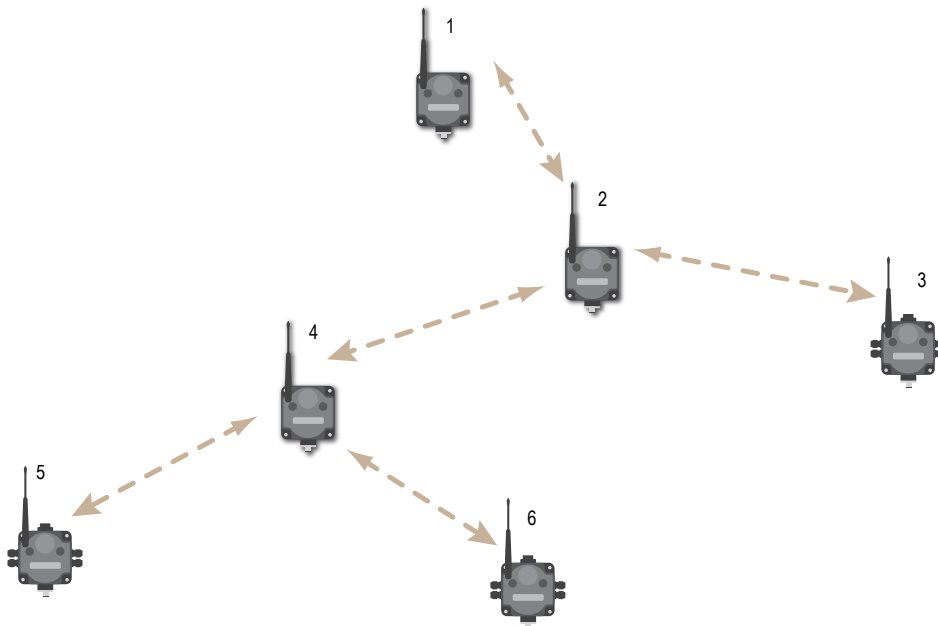
- Radio 1 is the master radio and is parent to radio 2 (repeater).
- Radio 2 (repeater) is child to radio 1 (master), but is parent to radios 3 (slave) and 4 (repeater).
- Radio 4 (repeater) is child to radio 2 (repeater), but is parent to radios 5 and 6 (both slaves).

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.

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.

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 61 for remote Modbus slaves — devices serially connected to a data radio — allowing a maximum of 50 attached devices.

The figure below illustrates 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.
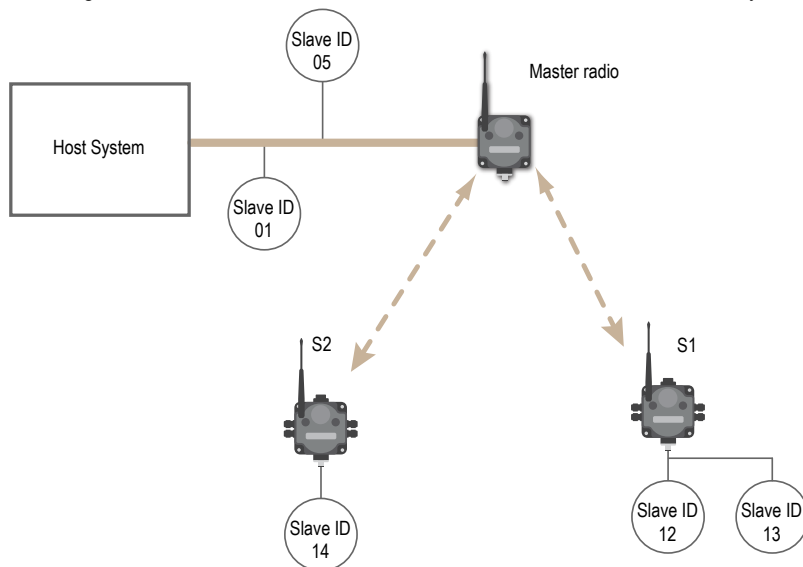
MultiHop Radio Registers and Radio IDs

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.

SureCross Radio Rotary Dials
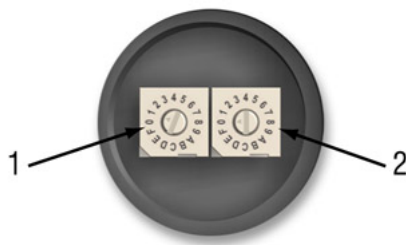
1   Left dial - Represents the tens unit of the slave or device ID.

2   Right dial - Represents the ones unit of the slave or device ID.

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 61; 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 61).

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

- **Rotary dial positions 11 through 61**. 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 61 are sent out the wireless network.
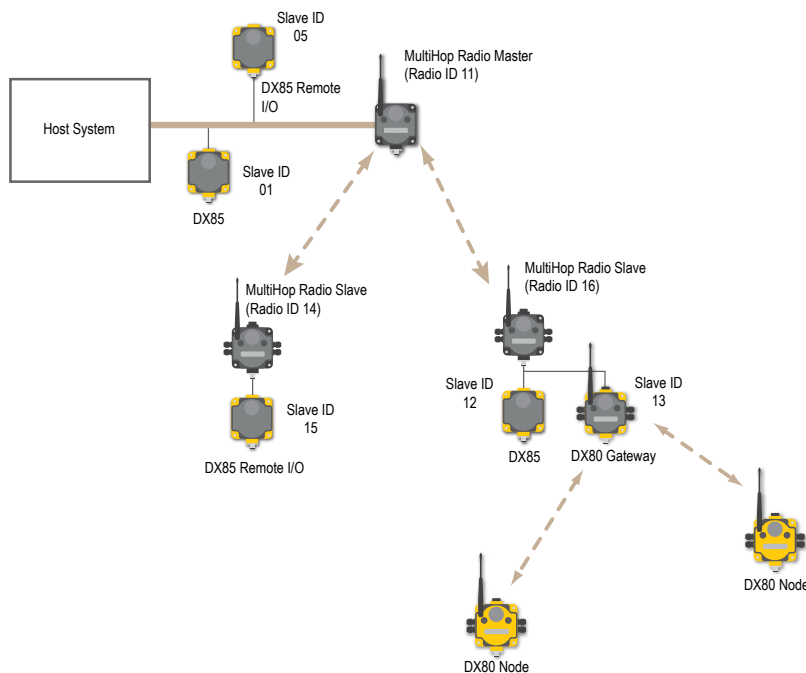
Transparent Mode

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. 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.

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.)

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.
6. Observe the LED behavior to verify the devices are communicating with each other.
7. Conduct a site survey between the MultiHop Radios.
8. Install your wireless sensor network components.

Configure the MultiHop Radios

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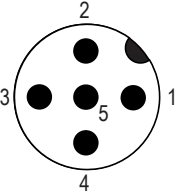
MultiHop Radios use the master device identification number to form groups of radios that communicate with each other. Follow the procedure outlined below for binding radios to a particular master radio.

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.

Wiring for MultiHop Radios

Connecting dc power to the communication pins will cause permanent damage. For FlexPower devices, do not apply more than 5.5V to the gray wire.

The FlexPower Multihop 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 to 30V dc used to power the radio.

	Wire No.	Wire Color	10 to 30V dc (RS-485)	FlexPower (RS-485)	FlexPower (RS-232)
	1	Brown	10 to 30V dc	10 to 30V dc	10 to 30V 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 to 5.5V dc	3.6 to 5.5V dc

Set the MultiHop Radio (Slave) ID

On a MultiHop radio, use the rotary dials to set the device's MultiHop Radio ID.

Modbus Slave IDs 01 through 10 are reserved for slaves directly connected to the host (local I/O). Polling messages addressed to these devices are not relayed over the wireless link. Use Modbus Slave IDs 11 through 61 for MultiHop master, repeater, and slave radios. Up to 50 devices (local slaves and remote slaves) may be used in this system.
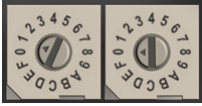
With the left dial acting as the left digit and the right dial acting as the right digit, the MultiHop Radio ID can be set from 01 through 61.

Bind the MultiHop Radios to Form Networks

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

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 menu, -BIND submenu on the LCD. Knowing the binding code prevents having to re-bind all radios if the master is ever replaced.

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.

MultiHop Master Model	To enter binding mode:
Two button master radios	Triple click button 2
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.

MultiHop Repeater/Slave Model	To enter binding mode:
Two button radios	Triple click button 2
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.

MultiHop Master Model	To exit binding mode:
Two button master radios	Double click button 2
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 SureCross 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.

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	Apply power to the radio	-	Solid yellow (briefly)	Red and green
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 yellow	Solid red and green (looks yellow/orange)
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
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 yellow	Flashes red and green (looks yellow/orange)

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	Apply power to the master radio	-	Solid yellow	Red and green
2	The master radio enters RUN mode.	Flashes green	-	Flashes green
	Serial data packets begin transmitting between the master and its children radios.	-	Flashes yellow	Flashes red and green (looks yellow/orange)

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.

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.

| MultiHop Master Radio | MultiHop Repeater Radio | MultiHop Slave Radio |
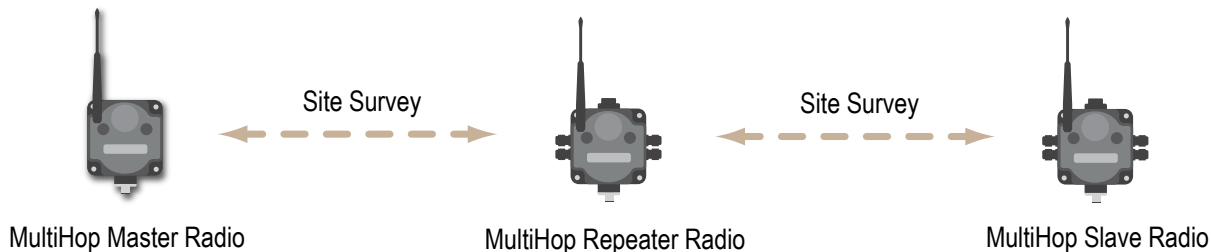
Other radios bound within the same network remain synchronized to the network, but are blocked from sending data while the site survey is running. The site survey analyzes the signal strength between the selected child and its parent radio only. Disable site survey on one radio before initiating it from 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 displays 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.

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.

Installing Your SureCross® Radios

The following are some recommendations for installing your wireless network components.

Mounting SureCross Devices Outdoors

Use a Secondary Enclosure

For most outdoor applications, we recommend installing your SureCross devices inside a secondary enclosure. For a list of available enclosures, refer to the *Accessories* list.

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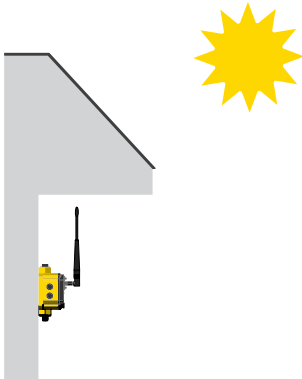
- Mount under an overhang or other source of shade,
- Install indoors, or
- Face the devices north when installing outside.

For harsh outdoor applications, consider installing your radio inside a secondary enclosure. For a list of available enclosures, refer to the *Accessories* list.

Avoid Collecting Rain

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" NPT port of the SureCross radios.

Watertight Glands and NPT Ports

Watertight Glands and Plugs

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.*

Seal any unused PG-7 access holes with one of the supplied black plastic plugs. To install a watertight PG-7 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.

* This is not a lot of torque and 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.

Watertight NPT Plugs

Seal the 1/2" NPT port if it is not used. To install a watertight NPT plug:

1. Wrap 12 to 16 passes of PTFE tape evenly across the length of the threads.
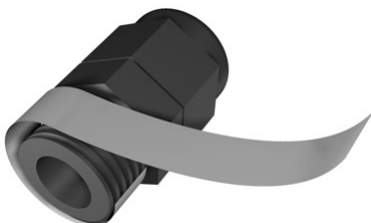2. Manually thread the plug into the housing port until reaching some resistance.
3. Using a 9/16" crescent wrench, turn the plug until all the plug's threads are engaged by the housing port or until the resistance doubles. Do not overtighten as this will damage the SureCross unit. These threads are tapered and will create a waterproof seal without overtightening.

* This is not a lot of torque and is equivalent to the torque generated without using tools. If a wrench is used, apply only very light pressure. Rotating these fittings excessively damages the device.

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.

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

Installation Quick Tips

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

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.

Increase the Height of the Antennas

Position the external antenna vertically for optimal RF communication. If necessary, consider changing the height of the SureCross 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.
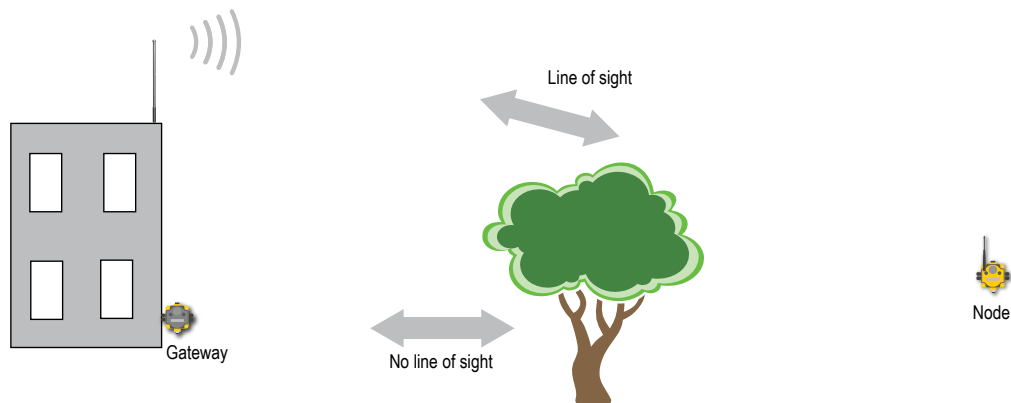
Avoid Collocating Radios

When the radio network's master device is located too close to another radio device, communications between all devices is interrupted. For this reason, do not install a Gateway device within two meters of another Gateway or Node.

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.

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

During spring and summer, leaves may block more of the radio signal.
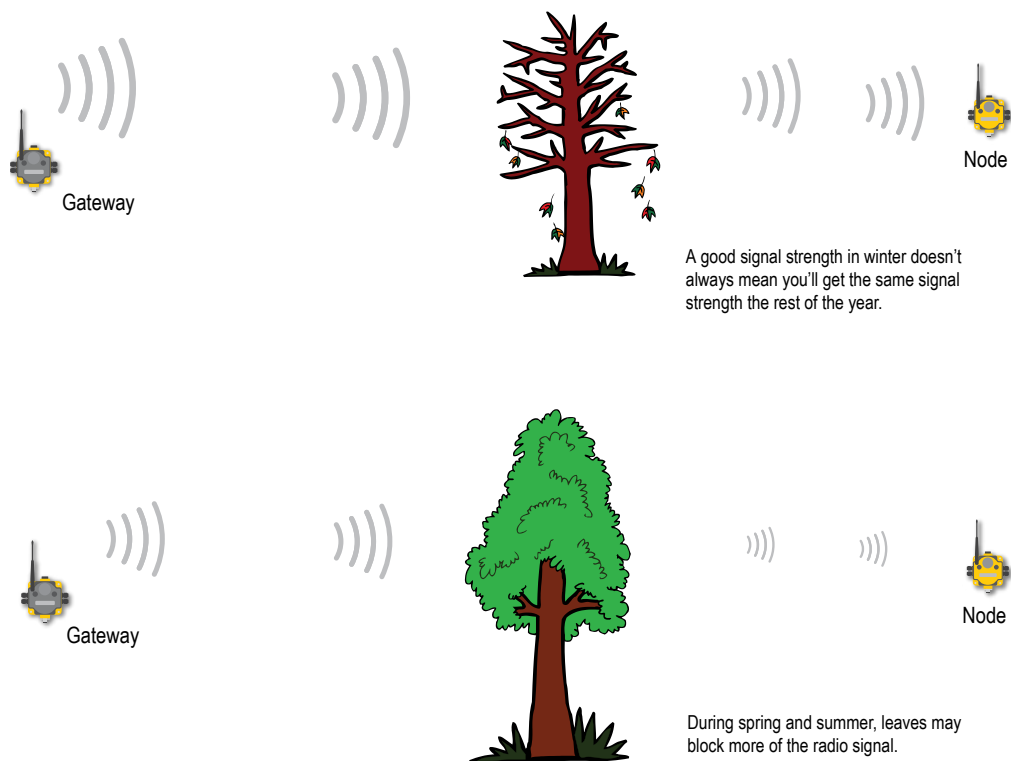
Basic Remote Antenna Installation

A remote antenna system is any antenna system where the antenna is not connected directly to the radio. These systems typically use coaxial cable to connect 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*, Banner document 132113 (also included as a chapter within the product manual).
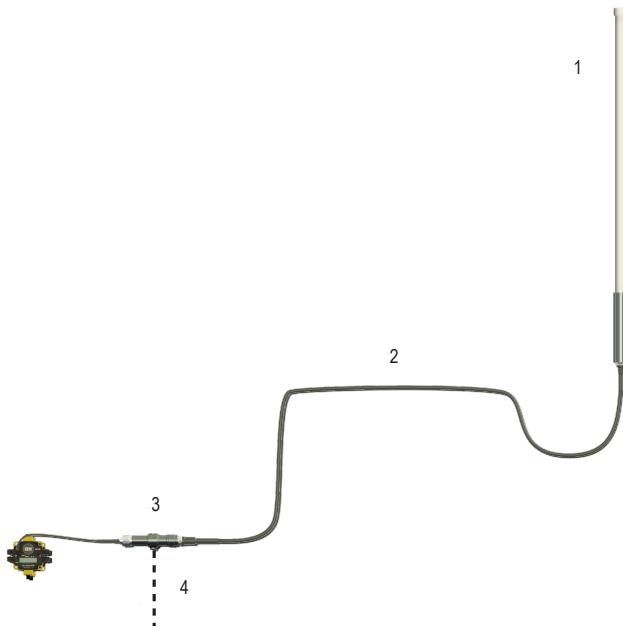
1	Antenna mounted remotely from the radio device.
2	Coaxial cable
3	Surge suppressor
4	Ground wire to a single-point ground system

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.

Weatherproof Remote Antenna Installations

Prevent water damage to the cable and connections by sealing the connections with rubber splicing tape and electrical tape.
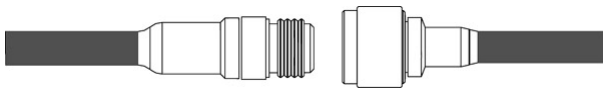
Step 1: Verify both connections are clean and dry before connecting the antenna cable to the antenna or other cable and hand-tightening.
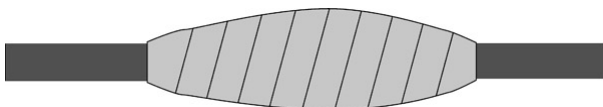
Step 2: Tightly wrap the entire connection with rubber splicing tape. Begin wrapping the rubber splicing tape one inch away from the connection and continue wrapping until you are one inch past the other end of the connection. Each new round of tape should overlap about half the previous round.
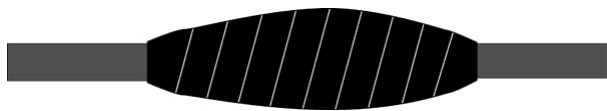
Step 3: Protect the rubber splicing tape from UV damage by tightly wrapping electrical tape on top of the rubber splicing tape. The electrical tape should completely cover the rubber splicing tape and overlap the rubber tape by one inch on each side of the connection.

Antenna Installation

Always 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.

Always 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 SureCross™ device or any equipment connected to the SureCross device during a thunderstorm.

Mounting an RP-SMA Antenna Directly to the Cabinet
This antenna mounts directly to the outside of the box, with the SureCross device mounted inside the box.
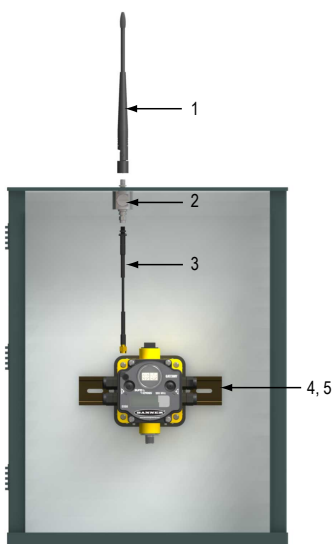
	Model Number	Description
1	BWA-9O2-C	Antenna, Omni, 902-928 MHz, 2 dBd, Rubber Swivel, RP-SMA MALE
	BWA-2O2-C	Antenna, Omni, 2.4 GHz, 2 dBd, Rubber Swivel, RP-SMA MALE
	BWA-2O5-C	Antenna, Omni, 2.4 GHz, 5 dBd, Rubber Swivel, RP-SMA MALE
	BWA-2O7-C	Antenna, Omni, 2.4 GHz, 7 dBd, Rubber Swivel, RP-SMA MALE
2	BWC-LMRSFRPB	Surge Suppressor, Bulkhead, RP-SMA Type, 900 MHz/2.4 GHz
3	BWC-1MRSFRSB02	RG58 Cable, RP-SMA TO RP-SMA Female Bulkhead, 0.2 m
	BWC-1MRSFRSB1	RG58 Cable, RP-SMA TO RP-SMA Female Bulkhead, 1 m
	BWC-1MRSFRSB2	RG58 Cable, RP-SMA TO RP-SMA Female Bulkhead, 2 m

	Model Number	Description
	BWC-1MRSFRSB4	RG58 Cable, RP-SMA TO RP-SMA Female, Bulkhead, 4 m
4	DIN-35-105	DIN Rail section, 105 mm long, 35 mm design
5	SMBDX80DIN	DIN Rail Bracket Assembly for DX70 and DX80 models.

Mounting an RP-SMA Antenna Remotely

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

This configuration may be used either inside or outside the building, though a Yagi antenna is usually used in outdoors applications while an omni-directional antenna may be used either inside or outside a building.
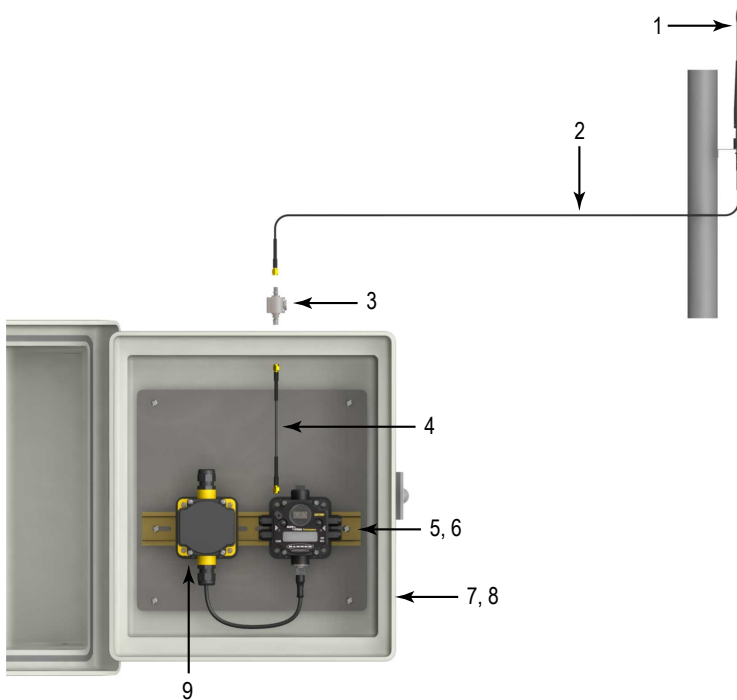
	Model Number	Description
1	BWA-9O2-C	Antenna, Omni, 902-928 MHz, 2 dBd, Rubber Swivel, RP-SMA MALE
	BWA-9O5-C	Antenna, Omni, 902-928 MHz, 5 dBd, Rubber Swivel, RP-SMA MALE
	BWA-2O2-C	Antenna, Omni, 2.4 GHz, 2 dBd, Rubber Swivel, RP-SMA MALE
	BWA-2O5-C	Antenna, Omni, 2.4 GHz, 5 dBd, Rubber Swivel, RP-SMA MALE
	BWA-2O7-C	Antenna, Omni, 2.4 GHz, 7 dBd, Rubber Swivel, RP-SMA MALE
2	BWC-1MRSFRSB02	RG58 Cable, RP-SMA TO RP-SMA Female Bulkhead, 0.2 m
	BWC-1MRSFRSB1	RG58 Cable, RP-SMA TO RP-SMA Female Bulkhead, 1 m
	BWC-1MRSFRSB2	RG58 Cable, RP-SMA TO RP-SMA Female Bulkhead, 2 m
	BWC-1MRSFRSB4	RG58 Cable, RP-SMA TO RP-SMA Female, Bulkhead, 4 m

	Model Number	Description
3	BWC-LMRSFRPB	Surge Suppressor, Bulkhead, RP-SMA Type, 900 MHz/2.4 GHz
4	BWC-1MRSFRSB02	RG58 Cable, RP-SMA TO RP-SMA Female Bulkhead, 0.2 m
	BWC-1MRSFRSB1	RG58 Cable, RP-SMA TO RP-SMA Female Bulkhead, 1 m
	BWC-1MRSFRSB2	RG58 Cable, RP-SMA TO RP-SMA Female Bulkhead, 2 m
	BWC-1MRSFRSB4	RG58 Cable, RP-SMA TO RP-SMA Female, Bulkhead, 4 m
5	DIN-35-105	DIN Rail section, 105 mm long, 35 mm design
6	SMBDX80DIN	Bracket Assembly, DIN Rail, for DX80
7	BWA-EF14128	Fiberglass enclosure, 14"x 12" x 8"
8	BWA-PA1412	Internal panel, 14" x 12"
9 *	DX81	DX81 FlexPower Battery Supply Module
	DX81P6	DX81P6 FlexPower Battery Supply 6-Pack

* This example image depicts a DX80 radio with a 10-30V dc power supply. The example installation may also work with the DX70 radios or MultiHop radios. However, the DX81 and DX81P6 FlexPower Battery Supply Modules can only power FlexPower devices. The battery supply modules cannot be used with any 10-30V dc-only powered devices and cannot be used with the DX70 radios.

Mounting N-Type Antennas Remotely

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

This configuration may be used either inside or outside the building, though a Yagi antenna is usually used in outdoors applications while an omni-directional antenna may be used either inside or outside a building.
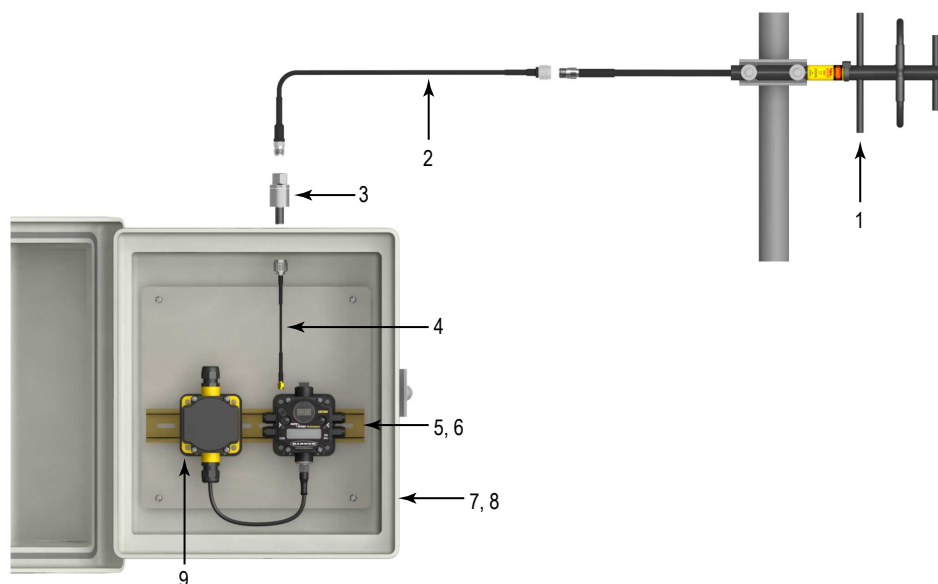
	Model Number	Description
1	BWA-9Y6-A	Antenna, Yagi, 900 MHz, 6.5 dBd, N Female

	Model Number	Description
	BWA-9Y10-A	Antenna, Yagi, 900 MHz, 10 dBd, N Female
	BWA-9O6-A	Antenna, Omni, 900 MHz, 6 dBd, Fiberglass, N Female
	BWA-9O5-B	Antenna, Omni, 900 MHz, 5 dBd/7.2 dBi, With ground plane, N Female
	BWA-2O8-A	Antenna, Omni, 2.4 GHz, 8.5 dBi, N Female, Fiberglass 24"
	BWA-2O6-A	Antenna, Omni, 2.4 GHz, 6 dBi, N Female, Fiberglass 16"
2	BWC-4MNFN3	LMR400 Cable, N-Male to N-Female, 3 Meters
	BWC-4MNFN6	LMR400 Cable, N-Male to N-Female, 6 Meters
	BWC-4MNFN15	LMR400 Cable, N-Male to N-Female, 15 Meters
	BWC-4MNFN30	LMR400 Cable, N-Male to N-Female, 30 Meters
3	BWC-LFNBMN-DC	Surge Suppressor, Bulkhead, N-Type, 900 MHz/2.4 GHz, dc-Blocking
4	BWC-1MRSMN05	LMR200 Cable, RP-SMA to N-Male, 0.5 Meters
	BWC-1MRSMN2	LMR200 Cable, RP-SMA to N-Male, 2 Meters
5	DIN-35-105	DIN Rail section, 105 mm long, 35 mm design
6	SMBDX80DIN	Bracket Assembly, DIN Rail, for DX80
7	BWA-EF14128	Fiberglass enclosure, 14"x 12" x 8"
8	BWA-PA1412	Internal panel, 14" x 12"
9 *	DX81	DX81 FlexPower Battery Supply Module
	DX81P6	DX81P6 FlexPower Battery Supply 6-Pack

* This example image depicts a DX80 radio with a 10-30V dc power supply. The example installation may also work with the DX70 radios or MultiHop radios. However, the DX81 and DX81P6 FlexPower Battery Supply Modules can only power FlexPower devices. They battery supply modules cannot be used with any 10-30V dc-only powered devices and cannot be used with the DX70 radios.

Modbus Register Configuration

The factory default settings for the inputs, outputs, and device operations can be changed by the user through the device Modbus registers.

To change parameters, the data radio network must be set to Modbus mode and the data radio must be assigned 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 data sheet.

For more information about registers, refer to the MultiHop Product Manual, Banner part number 151317.

40000s Standard Physical Inputs

Registers 40001 through 40016 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 data sheet.

40400s Extra Inputs

Registers 40401 through 40500 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 data sheet.

40500s Standard Physical Outputs

Registers 40501 through 40516 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 data sheet.

40900s Extra Outputs

Registers 40901 through 41000 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 data sheet.

41000s 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 41001 through 41008. Parameters for input 2 are at 41051 through 41058. Each following input is offset from the previous one by 50 registers.

Parameter Registers for Inputs									
1	2	3	4	5	6	7	8	9	Parameters
41001	41051	41101	41151	41201	41251	41301	41351	41401	Enable
41002	41052	41102	41152	41202	41252	41302	41352	41402	Sample Interval (high word)
41003	41053	41103	41153	41203	41253	41303	41353	41403	Sample Interval (low word)
41008	41058	41108	41158	41208	41258	41308	41358	41408	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 900MHz 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*.

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 41004 through 41007. Switch power parameters for input 2 are at 41054 through 41057. Each following input is offset from the previous one by 50 registers.

Parameter Registers for Inputs									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Parameters**
41004	41054	41104	41154	41204	41254	41304	41354	41404	Switch Power Enable
41005	41055	41105	41155	41205	41255	41305	41355	41405	Switch Power Warm-up
41006	41056	41106	41156	41206	41256	41306	41356	41406	Switch Power Voltage
41007	41057	41107	41157	41207	41257	41307	41357	41407	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 data sheet 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
0V	255
5V	204
7V	125
10V	69
15V	32
20V	12
24V	03

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.

42000s Output Parameters

The following characteristics are configurable for each output.

Parameters for Output 1 start at 42001 through 42004. Parameters for output 2 start at 42051 through 42054. Each following output is offset from the previous one by 50 registers.

Parameter Registers for Outputs									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Parameters**
42001	42051	42101	42151	42201	42251	42301	42351	42401	Enable
42002	42052	42102	42152	42202	42252	42302	42352	42402	Flash Output Enable
42003	42053	42103	42153	42203	42253	42303	42353	42403	Flash Index
42004	42054	42104	42154	42204	42254	42304	42354	42404	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 44401, 44411, 44421, or 44431.

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).

42950s 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.

42951 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.

42952 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.

42953 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.

42954 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.

43000s 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 43001 through 43004. Parameters for Discrete Input 2 start at 43021 through 43024. Each following input is offset from the previous one by 20 registers.

Parameter Registers for Discrete Inputs				
IN 1	IN 2	IN 3	IN 4	Parameters
43001	43021	43041	43061	PNP/NPN
43002	43022	43042	43062	Sample High
43003	43023	43043	43063	Sample Low
43004	43024	43044	43064	Enable Latch on Change of State
43007	43027	43047	43067	Enable Discrete Input Time Active Counter
43008	43028	43048	43068	Discrete Input Time Active Count
43009	43029	43049	43069	Discrete Input Time Active Count

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.

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.

43300s Analog Input Parameters

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

Analog input parameters for input 1 start at 43301. Analog input parameters for input 2 start at 43321. Each following input is offset from the previous one by 20 registers.

Registers for Analog Parameters				Parameters
IN 1 43301-43320	IN 2 43321-43340	IN 3 43341-43360	IN 4 43361-43380	
43301	43321	43341	43361	Maximum Analog Value
43302	43322	43342	43362	Minimum Analog Value
43303	43323	43343	43363	Enable Register Full Scale
43304	43324	43344	43364	Temperature Degrees C/F
43305	43325	43345	43365	Temperature Scaling
43306	43326	43346	43366	Thermocouple Type
43307	43327	43347	43367	Temperature Resolution
43308	43328	43348	43368	Threshold
43309	43329	43349	43369	Hysteresis

Registers for Analog Parameters				Parameters
IN 1 **43301-43320**	**IN 2** **43321-43340**	**IN 3** **43341-43360**	**IN 4** **43361-43380**	
43310	43330	43350	43370	Delta
43311	43331	43351	43371	
43312	43332	43352	43372	
43313	43333	43353	43373	
43314	43334	43354	43374	
43315	43335	43355	43375	
43316	43336	43356	43376	Sample High
43317	43337	43357	43377	Sample Low
43318	43338	43358	43379	Change of State Push Enable
43319	43339	43359	43379	Median Filter Enable
43320	43340	43360	43380	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 µA (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 graphically, 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.

Threshold. See **Hysteresis and Threshold**.

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.)

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				Parameters
IN 1 **43301-43320**	**IN 2** **43321-43340**	**IN 3** **43341-43360**	**IN 4** **43361-43380**	
43304	43324	43344	43364	Temperature Degrees C/F
43305	43325	43345	43365	Temperature Scaling
43306	43326	43346	43366	Thermocouple Type
43307	43327	43347	43367	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

43500s Counter Input Parameters

The following parameters are configurable for the counter input.

Counter Input parameters for Counter Input 1 start at 43501 through 43505. Counter Input parameters for Counter Input 2 start at 43521 through 43525. Each following counter input is offset from the previous one by 20 registers.

Parameter Registers for Counter Inputs	
IN 1	**Parameters**
43501	Enable Frequency/Event Counter
43502	Enable Read Counter State
43503	Set Preset Value
43504	Counter Preset Value
43505	Counter Preset Value

Counter Preset Value. Registers 43504 (high word) and 43505 (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, e.g. 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 43504 and 43505. When the task is complete, the value is written to 0.

43600s H-Bridge Output Parameters

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

Parameters for H-bridge 1 start at 43604 through 43609. Parameters for H-bridge 2 start at 43624 through 43629. Each following H-bridge parameter set is offset from the previous one by 20 registers.

Parameter Registers for H-Bridge Outputs	
H-Bridge 1	**Parameters**
43604	Enable H-Bridge
43605	H-Bridge Warmup Cap Time
43606	H-Bridge Active Current Time
43607	H-Bridge Switches
43608	H-Bridge Switches
43609	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
43607 Rising Switch (ON)	0	0	1	0	0	0	0	1
43608 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.

43600s 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 requiring 5, 10, or 15V power (ideally, 4–20 mA loop-powered sensors). When the switch power output cycles on, the voltage is boosted to the voltage needed to power the sensor for a specific warmup time. This 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 43601 through 43603. Parameters for SP 2 start at 43621 through 43623. Each following switch power is offset from the previous one by 20 registers.

Parameter Registers for Switch Power Outputs				
SP1	**SP2**	**SP3**	**SP4**	**Parameters**
43601	43621	43641	43661	Continuous Voltage Setting
43602	43622	43642	43662	Default Output Voltage
43603	43623	43643	43663	Hold Last Voltage 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
0V	255	15V	32
5V	204	20V	12
7V	125	24V	03
10V	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.

43700s Discrete Output Parameters

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

Parameters for Output 1 start at 43701 through 43703. Parameters for Output 2 start at 43721 through 43723. Each following input is offset from the previous one by 20 registers.

Parameter Registers for Discrete Outputs				
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.

44000s Analog Output Parameters

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

Parameters for Analog Output 1 start at 44001 through 44005. Parameters for Analog Output 2 start at 44021 through 44025. Each following input is offset from the previous one by 20 registers.

Parameter Registers for Analog Outputs				
OUT 1	OUT 2	OUT 3	OUT 4	Parameters
44001	44021	44041	44061	Maximum Analog Value
44002	44022	44042	44062	Minimum Analog Value
44003	44023	44043	44063	Enable Register Full Scale
44004	44024	44044	44064	Hold Last State Enable
44005	44025	44045	44065	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 4-20 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 (0-20 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.

44150s Initialization Controls

44151 Reset Device. Write a 1 to this register to trigger a device reset of the parameters selected by the next three registers.

44152 Default I/O Configuration. Returns all I/O configuration parameters to their factory default settings.

44153 Default System Parameters. Returns all system-level parameters to their factory default settings.

44154 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.

44400s 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.

44401-44408 Flash Pattern Index 1.

44401-44408 Flash Pattern Index 2.

44401-44408 Flash Pattern Index 3.

44401-44408 Flash Pattern Index 4.

44500s M-GAGE Parameters

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

44501 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.

44502 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.

44503 Disable Compensation Median Filter. Write a 1 to this register to disable the compensation median filter.

44504 Disable Sensing Median Filter. Write a 1 to this register to disable the sensing median filter.

44505 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			

44506 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.

44507 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.

44509 Delta. Rate of change filter.

44510 Threshold and **44511 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.

44512 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.

44513 Baseline (Drift) Filter Threshold. Baseline filter threshold is used with the baseline filter time to account for the natural fluctuations on the magnetic field.

44514 Baseline (Drift) Filter Tau. Baseline filter's low pass filter.

44521 Baseline Difference Signal Value Total. A combination of the x-, y-, and z-axis baseline different signal values.

44522 Baseline Difference Signal Value [x-axis]. The difference between the ambient magnetic field and the current magnetic field reading for the x axis.

44523 Baseline Difference Signal Value [y-axis]. The difference between the ambient magnetic field and the current magnetic field reading for the y axis.

44524 Baseline Difference Signal Value [z-axis]. The difference between the ambient magnetic field and the current magnetic field reading for the z axis.

44525 Baseline Value [x-axis]. Ambient magnetic field reading for the x axis.

44526 Baseline Value [y-axis]. Ambient magnetic field reading for the y axis.

44527 Baseline Value [z-axis]. Ambient magnetic field reading for the z axis.

44528 Raw Signal Value [x-axis]. The actual magnetic field reading for the x axis.

44529 Raw Signal Value [y-axis]. The actual magnetic field reading for the y axis.

44530 Raw Signal Value [z-axis]. The actual magnetic field reading for the z axis.

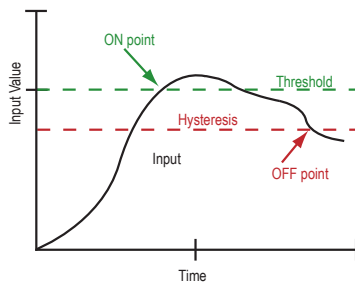# 44800s Ultrasonic Input Parameters

The following characteristics are configurable for the Ultrasonic input devices.

44810 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.

44811 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.

44812 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 μA (micro Amps) and voltage values are stored as mV (millivolts).

44813 Threshold and **44814 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 graphically, 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.

44815 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.

44816 Sample High and 44817 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.

44818 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.

44819 Median Filter Enable. Set to zero (0) to turn off the median filter. Set to one (1) to turn on the median filter.

44820 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			

46050s 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 3.6V dc from a battery input or 4.2V dc from the 10 to 30V dc input. These parameters allow users to determine which power source is powering the MultiHop device.

46051 Enable Battery Read. Set to zero to disable the battery read function. Set to 1 to enable the battery read function.

46052 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).

46053 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 3.8V).

46054 Hardware Reference Select. Use this parameter to allow for the correct calibration reference for different hardware platforms. Set to zero for 3.0V PCB Vcc. Set to one for 3.3V PCB Vcc. Default value is zero.

46061 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 30V dc).

46062 Battery Voltage Reading. Actual incoming voltage reading in units of 100 mV.

51000s SDI-12 Parameter Descriptions

The following characteristics are configurable for the SDI-12 devices. Device A refers to the first SDI-12 device and device B refers to the second SDI-12 device. We are using A and B instead of numbers to avoid confusion with the actual assigned device IDs of the SDI-12 devices.

51001 SDI-12 Device Address for Device A. Assign the SDI-12 device address for the first SDI-12 device to register 51001.

51201 SDI-12 Device Address for Device B. Assign the SDI-12 device address for the second SDI-12 device to register 51201.

An SDI-12 Device Address may be an alphanumeric value of 0 through 9, 'a' through 'z,' or 'A' through 'Z.' For this reason, store its ASCII value in the Device Address register. For example, an SDI-12 address of 0 is stored as its ASCII value of 0x30.

51002 SDI-12 Mode Select for Device A. By default, the code supports the M! command. Enter a one (1) to support the C! command.

51202 SDI-12 Mode Select for Device B. By default, the code supports the M! command. Enter a one (1) to support the C! command.

Configuration Registers for SDI-12 Devices

There are nine registers for each SDI-12 device. The parameters are used to configure the properties of the information coming back from the SDI-12 device.

Parameter numbering for the first SDI-12 device (device A) begins at 51011, with each Modbus register number offset from the previous one by 20 Modbus registers. For example, the first parameter for the first SDI-12 register begins at Modbus register 51011. The first parameter for the second SDI-12 register begins at Modbus register 51021.

Parameter numbering for the second SDI-12 device (device B) begins at 51211. The registers for the second SDI-12 device are offset from the first device by 200.

	Configuration Registers for SDI-12 Device A				
	Register Enable	**Decimal Point Move**	**Move Right or Left**	**Signed or Un-signed**	**16 or 32 bit**
Register 1	51011	51012	51013	51014	51015
Register 2	51021	51022	51023	51024	51025
Register 3	51031	51032	51033	51034	51035
Register 4	51041	51042	51043	51044	51045
Register 5	51051	51052	51053	51054	51055
Register 6	51061	51062	51063	51064	51065
Register 7	51071	51072	51073	51074	51075
Register 8	51081	51082	51083	51084	51085
Register 9	51091	51092	51093	51094	51095

16-bit or 32-bit Registers. Write a 0 for a 16-bit value; write a 1 for a 32-bit value.

Decimal Point Move. Enter a value from 0 to 7 to indicate the number of places to move the decimal point to convert from the SDI-12 value to an integer.

Move Right or Left. Write a 0 to move the decimal point to the right; write a 1 to move the decimal point to the left.

Register Enable. Use this register or enable (1) or disable (0) each register.

Signed or Unsigned. Write a 1 for a signed value; write a 0 for an unsigned value.

Configuration Examples

Configuring an Analog IN to use SP3

Example 1: Enable the first analog input to power an external sensor using switched power 3 and change the parameters based on the requirements of the external sensor.

This data radio model has analog 1 associated to input 5.

The parameters to adjust and their Modbus registers are:

- Sample interval (reg 1202 hi word, 1203 low word): Change from factory default of 1 second to 15 minute sample interval
- Switch Power Enable (reg 1204): Turn on switch power 3 for this input, using the bit mask
- Switch Power Warm-up (reg 1205): Based on the sensor requirements, turn on the switched power for a certain time before it is sampled.
- Switch Power Voltage (reg 1206): Set the voltage for the sensor operation.

The values to set in the registers are:

- Sample Interval: 15 min, (900 seconds)
- Switch Power Enable: 0x4
- Switched Power Warm-up: 1 second
- Switched Power Voltage: 15 Volts

Set the following registers to the values shown.

Modbus Register	Value	Description
1202	0	
1203	22,500	This register contains the number of 40 ms time units. 900 seconds ÷ 0.040 seconds = 22,500
1204	4	Enable switch power 3 for this input, see parameter description for bit mask.
1205	25	Set warm-up time to 1 second, the register contains the number of 40 ms time units. 1 seconds ÷ 0.040 seconds = 25
1206	32	Set switch power voltage to 15V. Value from table next to parameter description.

Configuring for Acclima SDI-12 Sensors

Use the following configuration for Acclima SDI-12 devices.

Use the following parameters for Acclima SDI-12 sensors.

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

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%

Acclima Register No.		Results Registers (high:low)	Integer Conversion Multiplier	Sample Reading	Actual Value
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

Configuring for Decagon 5T3 SDI-12 Sensors

Use the following configuration for Decagon 5T3 SDI-12 devices.

Use the following parameters for Decagon 5T3 SDI-12 sensors.

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

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

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.

44100s Manufacturing Information

Address	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

44200s Device Name

Address	Name	Format
4201–4209	Name characters 1-18	ASCII

44300s Software Information

Address	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

46400s 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	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

Device and System Parameters

48200s 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 48201, or
2. Write a one (1) to any of the individual input's registers 48221 (input 1) through 48236 (input 16).

Do not write to both register 48201 and the registers 48221 through 48236.

48201 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.

48221 Input 1 Sample on Demand Latch. Write a one (1) to this register to sample input 1.

48221 Input 2 Sample on Demand Latch. Write a one (1) to this register to sample input 2.

...

48236 Input 16 Sample on Demand Latch. Write a one (1) to this register to sample input 16.

Agency Certifications

FCC Certification, 900 MHz, 1 Watt Radios

The DX80 Module complies with Part 15 of the FCC rules and regulations.

FCC ID: UE3RM1809 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.

FCC Notices

IMPORTANT: The radio modules have been certified by the FCC 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 radio modules 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 FCC ID: UE3RM1809.

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 1 Appendix A. 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) and Section 15.247 (emissions).

FCC 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.

DX80 Module may be used only with Approved Antennas that have been tested with this module.

Model Number	Antenna Type	Maximum Gain	Minimum Required Cable/Connector Loss
-	Integral Antenna	Unity gain	0
BWA-9O1-x	Omni, 1/4 wave dipole	≤2 dBi	0

Model Number	Antenna Type	Maximum Gain	Minimum Required Cable/Connector Loss
BWA-9O2-C	Omni, 1/2 wave dipole, Swivel	≤2 dBi	0
BWA-9O6-A	Omni Wideband, Fiberglass Radome	≤8.2 dBi	2.2 dB
BWA-9O5-B	Omni Base Whip	≤7.2 dBi	1.2 dB
BWA-9Y10-A	Yagi	≤10 dBi	4 dB

FCC Certification, 2.4GHz

The DX80 Module complies with Part 15 of the FCC rules and regulations.

FCC ID: UE300DX80-2400 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.

FCC Notices

IMPORTANT: The DX80 Modules have been certified by the FCC 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 DX80 Modules 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 FCC ID: UE300DX80-2400.

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 WARNING: This device has been tested with Reverse Polarity SMA connectors with the antennas listed in Table 1 Appendix A. 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) and Section 15.247 (emissions).

FCC 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.

DX80 Module may be used only with Approved Antennas that have been tested with this module.

Model Number	Antenna Type	Maximum Gain
	Integral antenna	Unity gain
BWA-2O2-C	Omni, 1/2 wave dipole, Swivel	≤2 dBi
BWA-2O5-C	Omni, Collinear, Swivel	≤5 dBi
BWA-2O7-C	Omni, Coaxial Sleeve, Swivel	≤7 dBi

Certified For Use in the Following Countries

The SureCross radio devices are approved for use in the following countries.

Country	Radio Modules		
	900 MHz (150 mW)	900 MHz (1 Watt)	2.4 GHz (65 mW)
Australia			x
Austria			x
Bahamas, The	x		x
Bahrain (Kingdom of)			x
Belgium			x
Brazil			x
Bulgaria			x
Canada	x	x	x
Chile			x
China (People's Republic of)			x
Colombia	x		x
Cyprus			x
Czech Republic			x
Denmark			x
Ecuador			x
Estonia			x
Egypt			x
Finland			x
France			x
Germany			x
Greece			x
Hungary			x
Iceland			x
India			x
Ireland			x

	Radio Modules		
Country	**900 MHz (150 mW)**	**900 MHz (1 Watt)**	**2.4 GHz (65 mW)**
Israel			x*
Italy			x
Latvia			x
Liechtenstein			x
Lithuania			x
Luxembourg			x
Malta			x
Mexico	x	x	x
Netherlands			x
New Zealand			x
Norway			x
Panama	x		x
Poland			x
Portugal			x
Romania			x
Saudi Arabia (Kingdom of)			x
Singapore			x
Slovakia			x
Slovenia			x
South Africa			x
Spain			x
Sweden			x
Switzerland			x
Taiwan			x **
Thailand			x
United Arab Emirates			x
United Kingdom			x
United States of America	x	x	x

Bulgaria - Authorization required for outdoor and public service use.

Canada- This Class A digital apparatus meets all requirements of the Canadian Interference Causing Equipment Regulations. 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.

Cet appareil numérique de la classe A respecte toutes les exigences du Règlement sur le matériel brouiller du Canada. Le present appareil numérique n'emet pas de bruits radioélectriques dépassant les limites applicables aux appareils numeriques de le Classe A préscrites dans le Reglement sur le brouillage radioélectrique édits par le ministere des Communications du Canada.

France - In Guyane (French Guiana) and La Réunion (Reunion Island), outdoor use not allowed.

* Israel - DX80 and DX99 models are certified for the external antenna models only.

Italy - If used outside of own premises, general authorization is required.

Luxembourg - General authorization is required for public service.

** Taiwan - Taiwan is certified to operate specific DX70, DX80, and DX99 models. For a list of specific models, refer to the certificate.

Additional Statements - 900 MHz

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 that 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.

Transmit Power Levels

The SureCross wireless products were certified for use in these countries using the standard antenna that ships with the product. When using other antennas, verify you are not exceeding the transmit power levels allowed by local governing agencies.

Dimensions

MultiHop Radio, Low Profile Housing

65.0
[2.56"]

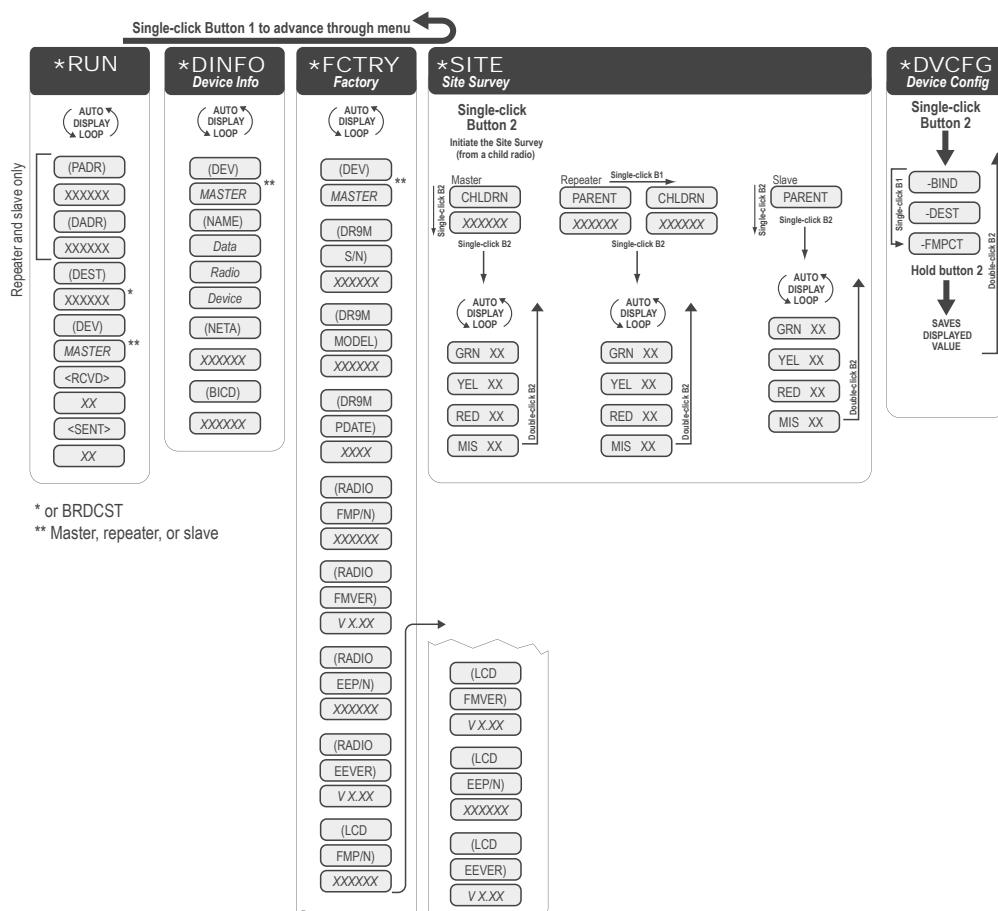7.9
[0.31"]

65.0
[2.56"]

80.3
[3.16"]

7.65
[0.30"]

109
[4.29"]

42
[1.65"]

14.67
[0.578"]

80.8
[3.18"]

MultiHop Radio with I/O

65.0
[2.56"]

7.9
[0.31"]

22.2
[0.875"]

30.65
[1.21"]

65.0
[2.56"]

19
[0.75"]

80.3
[3.16"]

127
[5"]

7.65
[0.30"]

60
[2.36"]

14.67
[0.578"]

80.8
[3.18"]

120
[4.72"]
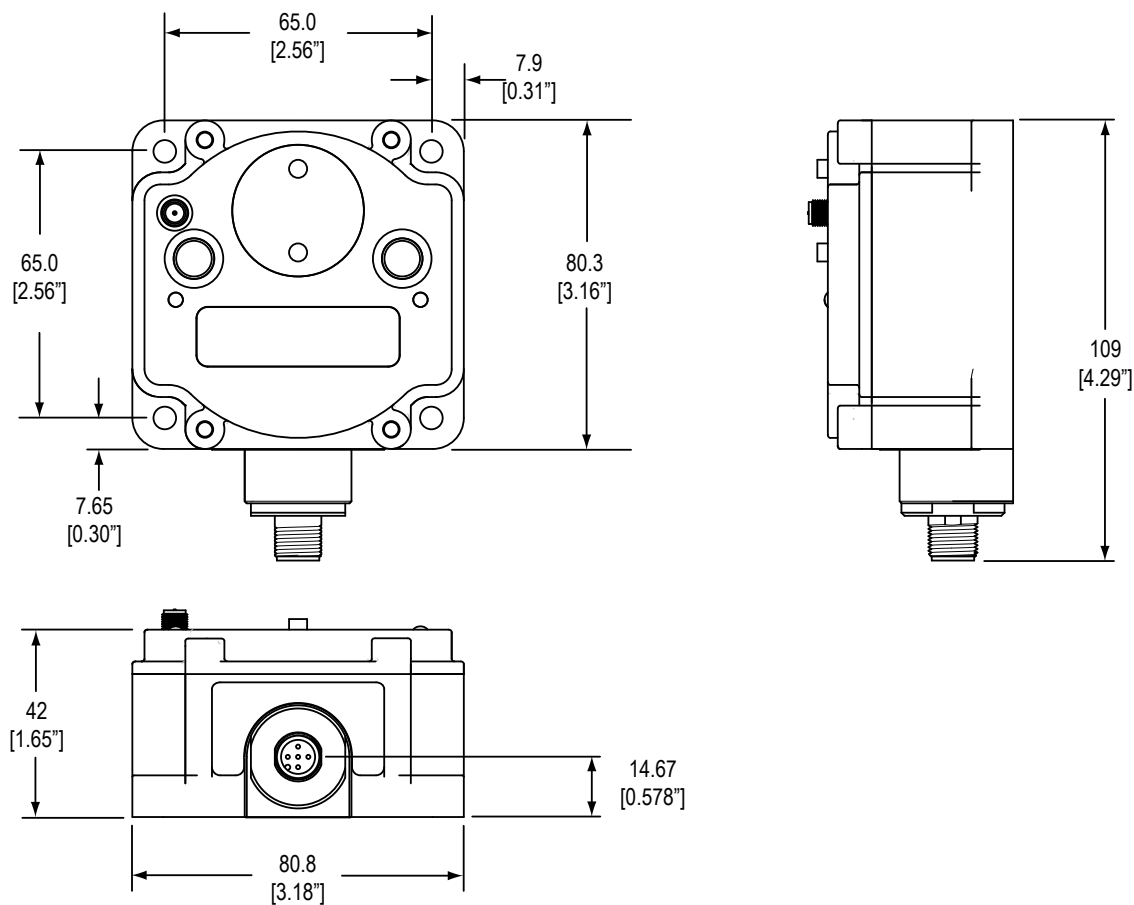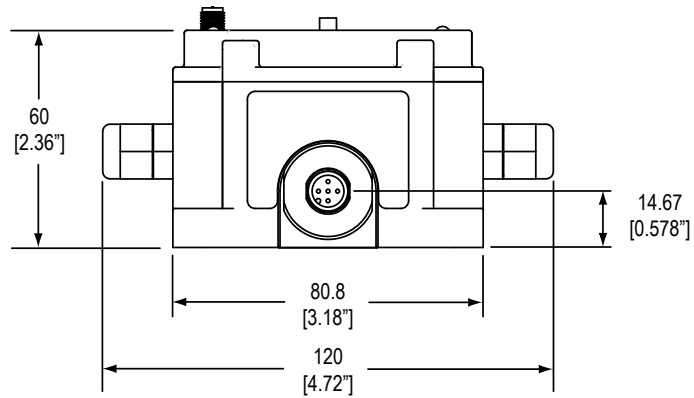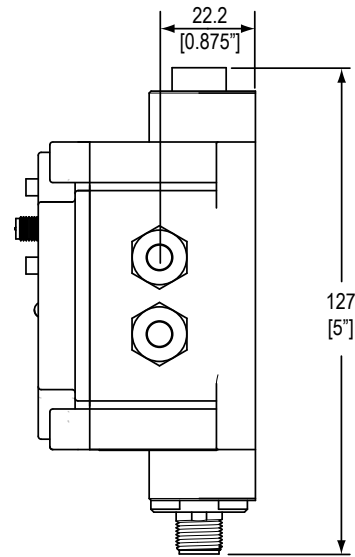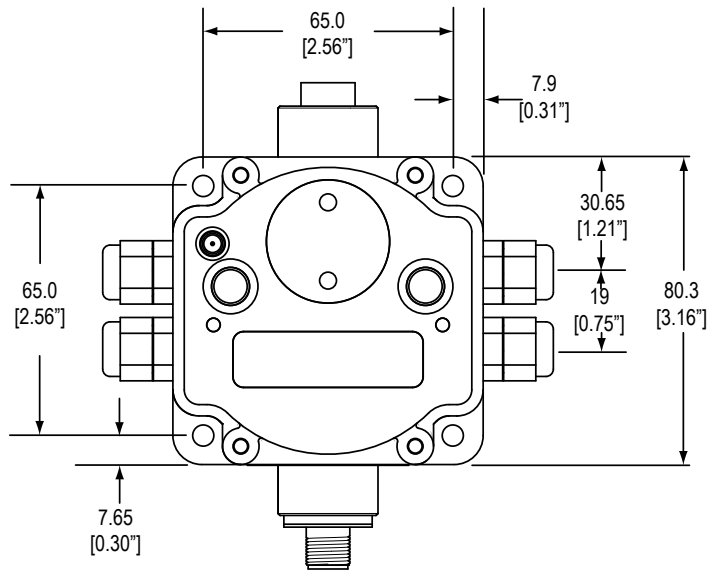
Advanced Setup

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.

Single-click Button 1 to advance through menu

*RUN

AUTO DISPLAY LOOP

Repeater and slave only
- (PADR)
- XXXXXX
- (DADR)
- XXXXXX
- (DEST)
- XXXXXX *
- (DEV)
- MASTER **
- <RCVD>
- XX
- <SENT>
- XX

* or BRDCST
** Master, repeater, or slave

*DINFO
Device Info

AUTO DISPLAY LOOP
- (DEV)
- MASTER **
- (NAME)
- Data
- Radio
- Device
- (NETA)
- XXXXXX
- (BICD)
- XXXXXX

*FCTRY
Factory

AUTO DISPLAY LOOP
- (DEV)
- MASTER **
- (DR9M S/N)
- XXXXXX
- (DR9M MODEL)
- XXXXXX
- (DR9M PDATE)
- XXXX
- (RADIO FMP/N)
- XXXXXX
- (RADIO FMVER)
- V X.XX
- (RADIO EEP/N)
- XXXXXX
- (RADIO EEVER)
- V X.XX
- (LCD FMP/N)
- XXXXXX

- (LCD FMVER)
- V X.XX
- (LCD EEP/N)
- XXXXXX
- (LCD EEVER)
- V X.XX

*SITE
Site Survey

Single-click Button 2
Initiate the Site Survey (from a child radio)

Master
Single-click B2
- CHLDRN
- XXXXXX
Single-click B2

Repeater
Single-click B1
- PARENT
- XXXXXX
- CHLDRN
- XXXXXX
Single-click B2

Slave
Single-click B2
- PARENT
Single-click B2

AUTO DISPLAY LOOP
- GRN XX
- YEL XX
- RED XX
- MIS XX
Double-click B2

AUTO DISPLAY LOOP
- GRN XX
- YEL XX
- RED XX
- MIS XX
Double-click B2

AUTO DISPLAY LOOP
- GRN XX
- YEL XX
- RED XX
- MIS XX
Double-click B2

*DVCFG
Device Config

Single-click Button 2
- -BIND
- -DEST
- -FMPCT
Single-click B1

Hold button 2

SAVES DISPLAYED VALUE

Double-click B2

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.

Rev. A   www.bannerengineering.com - tel: 763-544-3164   45

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.

Manually Bind the MultiHop Radios to Create the Network (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.

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 menu, -BIND submenu on the LCD. Knowing the binding code prevents having to re-bind all radios if the master is ever replaced.

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.1.
2. Single click button 2 to enter the DVCFG menu.2. -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.3.
4. To change this binding code, use button 1 to increment the blinking digit. Use button 2 to advance, from left to 4. 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 5. 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 6. changes.
7. Double-click button 2 to exit the DVCFG menu.

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.

Using 10 to 30V dc to Power the MultiHop Radio and a Gateway

When using 10 to 30V dc to power both the MultiHop radio and a Gateway, use the 4-pin Euro-style splitter cable to avoid damaging the Gateway or MultiHop radio.
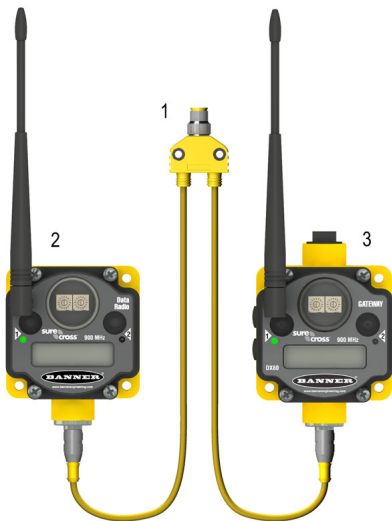
1   CSB-M1240M1241. Splitter cable, 4-pin Euro-style QD, No trunk male, two female branches, yellow. Use to connect the Data Radio to the 10–30V dc DX80 Gateway.

2   DX80DR9M-H*x*. MultiHop Data Radio

3   DX80 Gateway, powered by 10-30V dc

Using the Solar Supply to Power the MultiHop Radio and a FlexPower Gateway

When using the FlexPower Solar Supply to power both the data radio and the FlexPower Gateway, use the 5-pin Euro-style splitter cable.

1   CSRB-M1250M125.47M125.73. Splitter cable, 5-pin Euro-style QD, No trunk male, two female branches, black. Most commonly used with solar and other FlexPower devices.Splitter cable, 5-pin 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

Index