MultiHop Radios

Instruction Manual

BANNER ®

151317

Contents

1 MultiHop Radio Overview

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

The MultiHop networks are self-forming and self-healing networks constructed around a parent-child communication relationship. A MultiHop Radio is either a master radio, a repeater radio, or a slave radio.

- The master radio controls the overall wireless network.
- The repeater radios extend the range of the wireless network.
- The slave radios are the end point of the wireless network.

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

For the simple example network shown below, the following relationships exist:
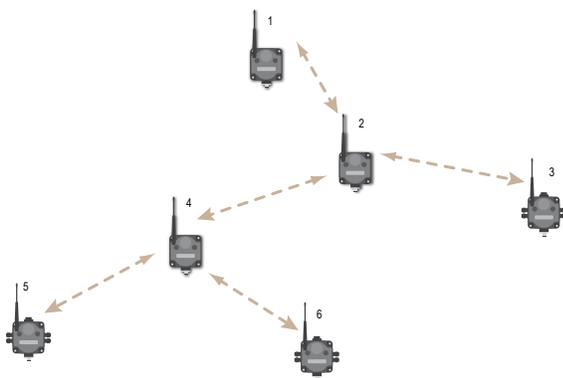
- Radio 1 is the master radio and is parent to radio 2 (repeater).
- Radio 2 (repeater) is child to radio 1 (master), but is parent to radios 3 (slave) and 4 (repeater).
- Radio 4 (repeater) is child to radio 2 (repeater), but is parent to radios 5 and 6 (both slaves).

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

MultiHop Master Radio. Within a network of MultiHop data radios, there is only one master radio. The master radio controls the overall timing of the network and is always the parent device for other MultiHop radios. The host system connects to this master radio.

MultiHop Repeater Radio. When a MultiHop radio is set to repeater mode, it acts as both a parent and a child. The repeater receives data packets from its parent, then re-transmits the data packet to the children within the repeater's network. The incoming packet of information is re-transmitted on both the radio link and the local serial link.

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

1.1 MultiHop Application Modes

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

1.1.1 Modbus Mode

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

1.1.1 Packet Routing

In Modbus application mode, the master radio first discovers all connected Modbus slaves in the network, then uses the Modbus slave ID contained in the incoming Modbus message to wirelessly route the packet only to the radio attached to the target Modbus slave. The packet is then passed via the radio's serial interface to the Modbus device where it is processed. This is entirely transparent to the user. Direct packet by packet routing offers an advantage over broadcast addressing with MultiHop paths because each hop in the path can be retried independently in the event of a packet error. This results in significantly more reliable packet delivery over MultiHop paths.
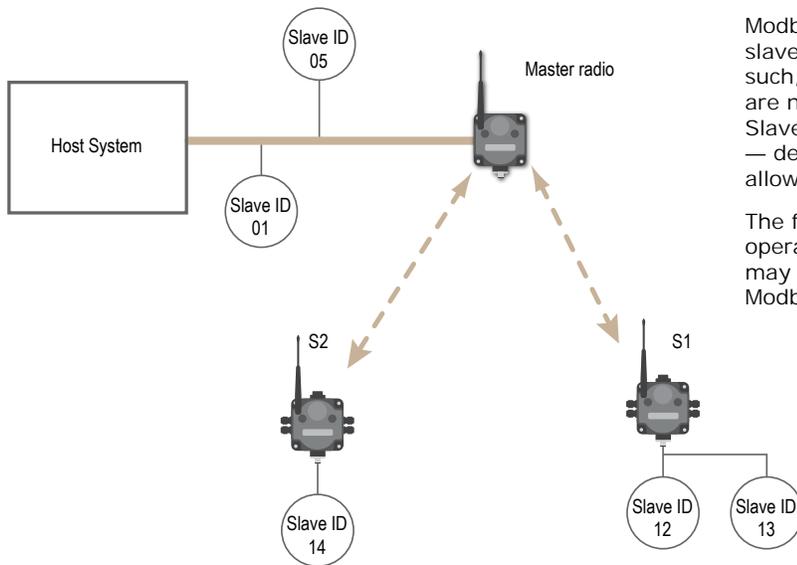
Modbus Slave IDs 01 through 10 are reserved for slaves directly connected to the host (local I/O). As such, polling messages addressed to these devices are not relayed over the wireless link. Use Modbus Slaves IDs 11 through 60 for remote Modbus slaves — devices serially connected to a data radio — allowing a maximum of 50 attached devices.

The figure 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.

1.1.1 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
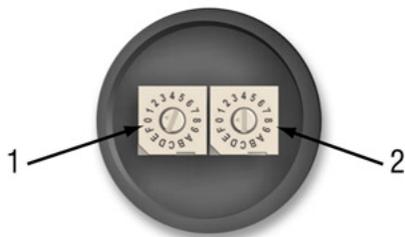
1   Left dial - Represents the tens unit of the slave or device ID.

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 60; a Slave ID setting of 0xFF disables access to the MultiHop radio's internal registers but still delivers addressed messages to Modbus slaves that are serially connected to the radio. Detailed information about the contents and functions of the radio's Modbus registers is provided in table 2.

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

*Note: The radio's rotary dial address must not be a duplicate of an attached Modbus slave ID.
- Rotary dial positions 11 through 60. Valid wireless Modbus Slave IDs or MultiHop Radio IDs
- Rotary dial position FF. Devices set to FF are not directly addressed by the Modbus host system but can deliver the message to the serially connected Modbus slaves
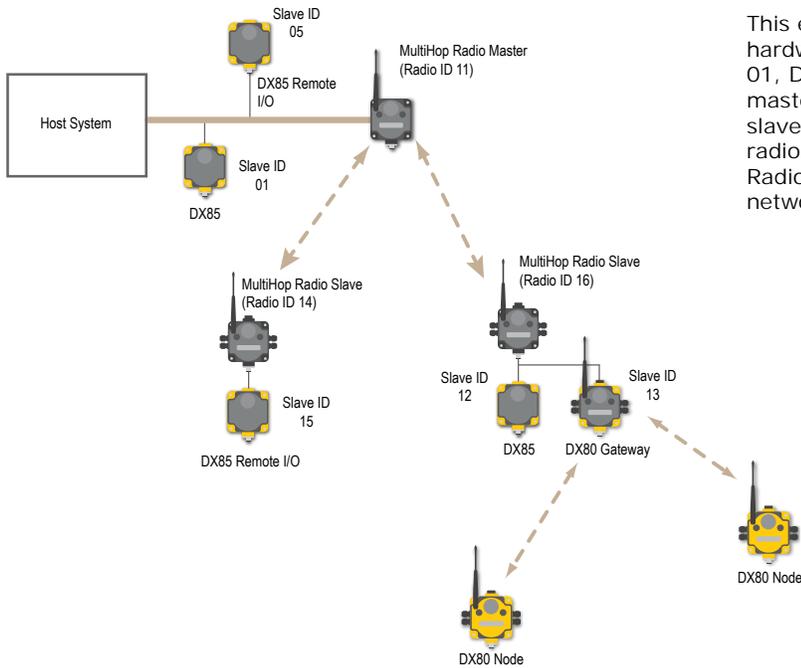
This example host system is connected to three hardwired devices: DX85 Remote I/O Modbus slave 01, DX85 Remote I/O Modbus slave 05, and the master MultiHop Radio. Host messages for Modbus slaves 01 through 10 are ignored by the master radio. Messages for Modbus Slaves or MultiHop Radios 11 through 60 are sent out the wireless network.

1.1.2 Transparent Mode

Use transparent mode for communication protocols other than Modbus.

In transparent mode, the MultiHop radio packetizes data received from the hardwired serial connection and transmits the packet to all radios within range. 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.

2 Radio Features

1. **Rotary Dials.** Set the Modbus Slave ID when operating in Modbus mode. (Not used on the Ethernet Data Radio.)

2. **Push Button 1.** Single-click to advance across all top-level data radio menus. Single-click to move down interactive menus, once a top-level menu is chosen. (See MultiHop Radio Menu System.)

3. **Push Button 2.** Double-click to select a menu and to enter manual scrolling mode. Double-click to move up one level at a time. Triple click to enter binding mode.

4. **LED 1 and 2.** Provide real-time feedback to the user regarding RF link status, serial communications activity, and the error state.

5. **LCD Display.** Six-character display provides run mode user information such as the number of packets sent and received. This display allows the user to conduct a site survey.

6. **5-pin M12 Euro-style Quick-disconnect Port.** The Euro-style power is used for serial connections and power. (Not available on the Ethernet Data Radio.)

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3 Setting Up Your MultiHop Network

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

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

3.1 Configure the MultiHop Radios

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

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

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

3.1.1 Wiring for MultiHop Radios

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

The FlexPower 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 30 V dc used to power the radio.

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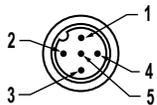
3.2 Set the MultiHop Radio (Slave) ID

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 60 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 60.

3.3 Bind the MultiHop Radios to Form Networks

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

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

   - For two button master radios, triple-click button 2.
   - For one button master radios, triple-click the button.

   For the two LED/button models, both LEDs flash red and the LCD shows *BINDNG and *MASTER. For single LED/button models, the LED flashes alternatively red and green.
3. Put the MultiHop repeater or slave radio into binding mode.

   - For two button radios, triple-click button 2.
   - For one button radios, triple-click the button.

   The child radio enters binding mode and searches for any Master radio in binding mode. While searching for the Master radio, the two red LEDs flash alternately. When the child radio finds the Master radio and is bound, both red LEDs are solid for four seconds, then both red LEDs flash simultaneously four times. For M-GAGE Nodes, both colors of the single LED are solid (looks orange), then flash. After the slave/repeater receives the binding code transmitted by the master, the slave and repeater radios automatically exit binding mode.
4. Repeat step 3 for as many slave or repeater radios as are needed for your network.
5. When all MultiHop radios are bound, exit binding mode on the master.

   - For two button master radios, double-click button 2.
   - For one button master radios, double-click the button.

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

Child Radios Synchronize to the Parent Radios

The synchronization process enables a 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.

3.3.1 Slave and Repeater LED Behavior

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

		Two Button/LED Models		Single Button/LED Models
Process Steps	Response	LED 1	LED 2	LED
1	Apply power to the radio	-	Solid amber (briefly)	Amber
2	The slave/repeater searches for a parent device.	Flashes red	-	Flashes red (1 per 3 sec)
3	A parent device is detected. The slave/repeater searches for other parent radios within range.	Solid red	-	Solid red
4	The slave/repeater selects a suitable parent.	-	Solid amber	Solid amber
5	The slave/repeater attempts to synchronize to the selected parent.	-	Solid red	Solid red
6	The slave/repeater is synchronized to the parent.	Flashes green	-	Flashes green
7	The slave/repeater enters RUN mode.	Solid green, then flashes green		Solid green, then flashes green
	Serial data packets begin transmitting between the slave/repeater and its parent radio.	-	Flashes amber	Flashes amber

3.3.2 Master LED Behavior

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

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

3.4 Conduct a Site Survey

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

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

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

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

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

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

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

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

3.5 Installing Your Sure Cross® Radios

Follow these recommendations to install your wireless network components.

3.5.1 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.
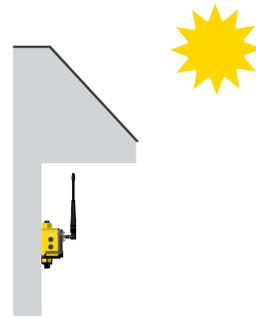
Mount Vertically to Avoid Collecting Rain. When possible, mount the devices where rain or snow will drain away from the device.

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

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

Watertight Glands and NPT Ports

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

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

Seal any unused 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.

Seal the 1/2-inch or 3/4-inch NPT port(s) 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 crescent wrench, turn the plug until all the plug's threads are engaged by the housing port or until the resistance doubles. Do not over-tighten as this will damage the Sure Cross unit. These threads are tapered and will create a waterproof seal without over-tightening.

3.5.2 Other Installation Requirements

3.5.2 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.

3.5.2 Minimize Mechanical Stress

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

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[1] 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.

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

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

3.5.2 When Installing Performance or MultiHop 1-Watt Radios

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

3.5.3 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.
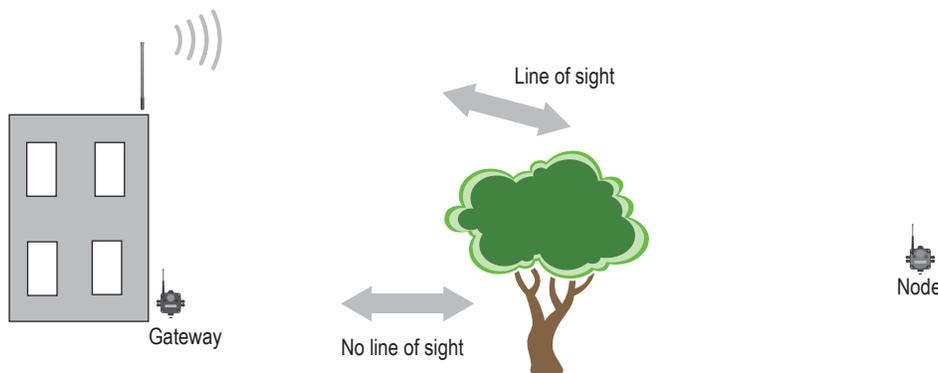
Collocated Radios

When the radio network's master device is located too close to another radio device, communications between all devices is interrupted. For this reason, always assign a unique Network ID to your wireless networks. The Network ID (NID) is a unique identifier you assign to each wireless network to minimizes the chances of two collocated networks interfering with each other. Assigning different NIDs to different networks improves collocation performance in dense installations.

Be Aware of Seasonal Changes

When conducting the initial Site Survey, the fewest possible missed packets for a given link is better. However, seasonal changes may affect the signal strength and the total signal quality. Radios installed outside with 50% missed packets in the winter months may have 80% or more missed packets in the summer when leaves and trees interfere with radio reception.
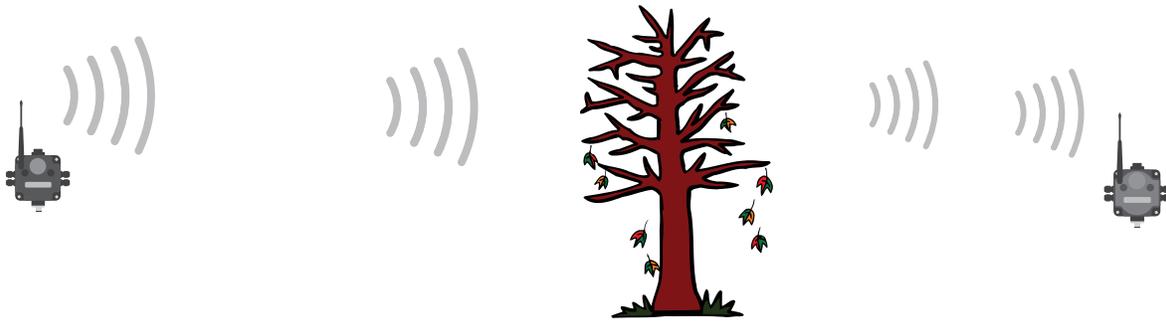
Figure 1. A good signal in winter doesn't always mean you will get the same signal strength the rest of the year.
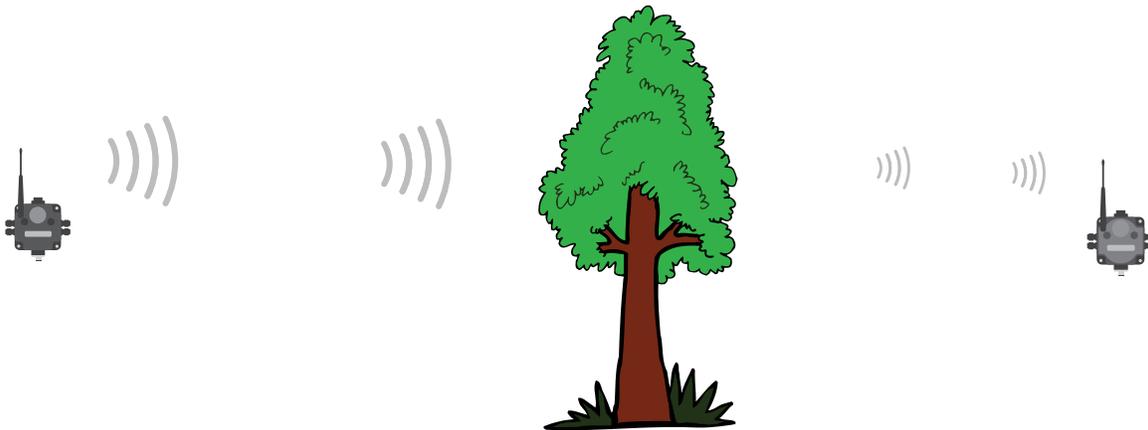
Figure 2. During spring and summer, leaves may block more of the radio signal.

3.5.4 Basic Remote Antenna Installation

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

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

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

For more detailed information about how antennas work and how to install them, refer to *Antenna Basics* (p/n 132113) (also included as a chapter within the product manual).
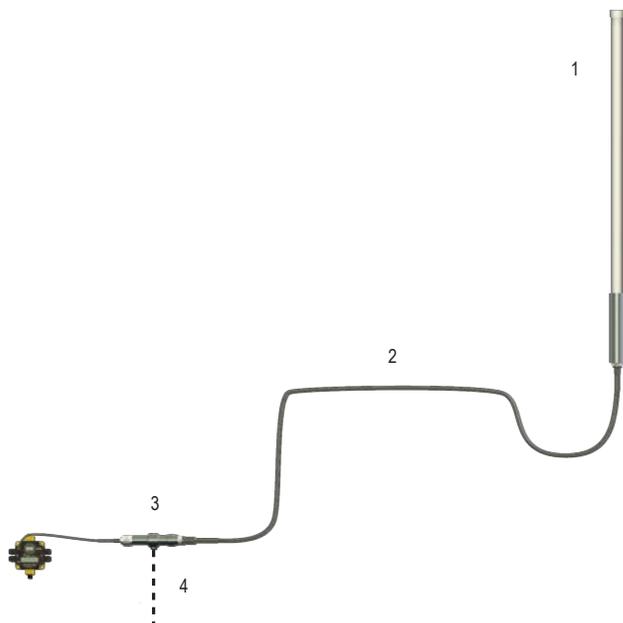
1. Antenna mounted remotely from the radio device.
2. Coaxial cable
3. Surge suppressor
4. Ground wire to a single-point ground system

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

Seal the connections with rubber splicing tape and electrical tape to prevent water damage to the cable and connections.
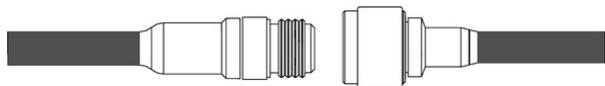
Step 1: Verify both connections are clean and dry before connecting the antenna cable to the antenna or other cable. Hand-tighten the cable connections.
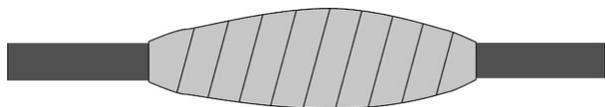
Step 2: Tightly wrap the entire connection with rubber splicing tape. Begin wrapping the rubber splicing tape one inch away from the connection and continue wrapping until you are one inch past the other end of the connection. Each new round of tape should overlap about half the previous round.

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

Installing Remote Antennas

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

Mount a Dome Antenna to the Enclosure

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

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

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

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

Models	Description	List Price
BWA-9O2-D	Antenna, Omni, 900 MHz, 2 dBd, Dome, RP-SMA MALE Box mount, 18-inch antenna cable	$95
BWA-2O2-D	Antenna, Omni, 2.4 GHz, 2 dBd, Dome, RP-SMA MALE Box mount, 18-inch antenna cable	$95

Use an N-Type, Pole-Mounted Antenna

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

Ground the surge suppressor and antenna. Keep the ground wire as short as possible and make all ground connections to a single-point ground system to ensure no ground loops are created.
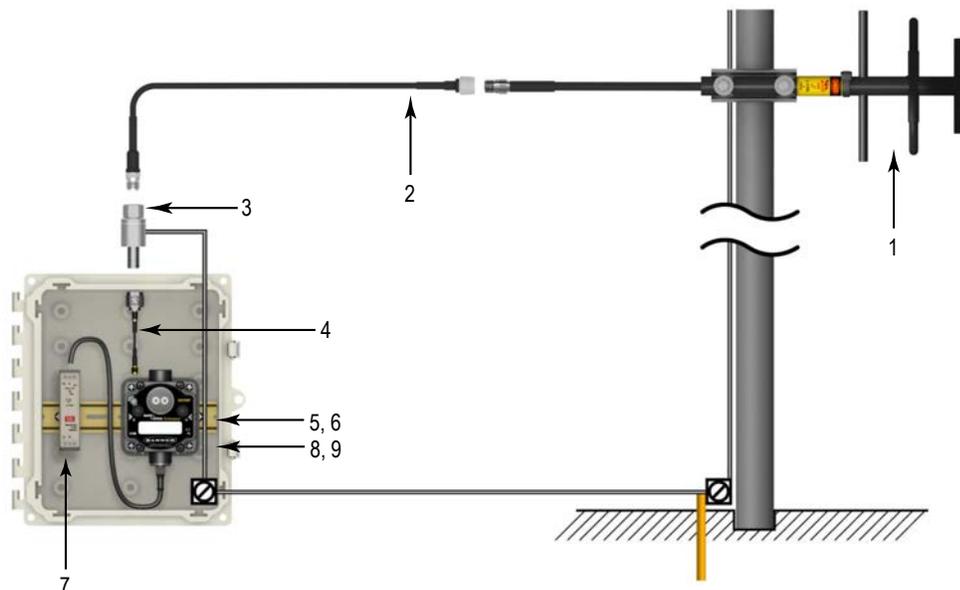
1. N-type Yagi antenna
2. N-Type to N-Type antenna cable
3. Surge suppressor
4. RP-SMA to N-Type male antenna cable
5 and 6. DIN rail and DIN rail bracket
7. Power supply
8 and 9. Enclosure and enclosure cover/plate, etc

Models	Frequency	Description	List Price
BWA-9Y6-A	900 MHz	6.5 dBd, 6.8 × 13 inches Outdoor	$135
BWA-9Y10-A		10 dBd, 6.8 × 24 inches Outdoor	$150

Models	Frequency	Description	List Price
BWA-9O6-A	900 MHz	6 dBd, Fiberglass, Full wave, 71.5 inches	$355
BWA-2O8-A	2.4 GHz	8.5 dBi, Fiberglass, 24 inches	$200
BWA-2O6-A		6 dBi, Fiberglass, 16 inches (shown)	$125
BWA-9O6-AS	900 MHz	6 dBi, Fiberglass, 1/4 Wave, 23.6 inches (1.3 inch dia.)	$120
BWA-9O8-AS		8 dBi, Fiberglass, 3/4 Wave, 63 inches (1.5 inch dia.)	$215

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

Models	Description	List Price
BWC-4MNFN3	LMR400 N-Type Male to N-Type Female, 3 m	$77
BWC-4MNFN6	LMR400 N-Type Male to N-Type Female, 6 m	$92
BWC-4MNFN15	LMR400 N-Type Male to N-Type Female, 15 m	$156

MultiHop Radios

Models	Description	List Price
BWC-4MNFN30	LMR400 N-Type Male to N-Type Female, 30 m	$296

Model	Description	Connection	List Price	
BWC-LMRSFRPB	Surge Suppressor, Bulkhead, RP-SMA Type	RP-SMA to RP-SMA	$111	
BWC-LFNBMN-DC	Surge Suppressor, bulkhead, N-Type, dc Blocking	N-Type Female, N-Type Male	$120	

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

Model	Description	List Price
BWC-1MRSMN05	LMR100 RP-SMA to N-Type Male, 0.5 m	$40
BWC-1MRSMN2	LMR100 RP-SMA to N-Type Male, 2 m	$50

4 Modbus Register Configuration

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

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

4.1 00000s Standard Physical Inputs

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

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

4.1.1 00400s Extra Inputs

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

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

4.2 00500s Standard Physical Outputs

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

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

4.2.1 00900s Extra Outputs

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

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

4.3 01000s Input Parameters

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

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

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

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

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

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

Sample Interval (Low Word)
See Sample Interval (High Word).

1xx4 through 1xx7
See *Switch Power Input Parameters*.

4.3.1 Switch Power Input Parameters

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

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

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

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

Switch Power Enable
The bit mask can select any number of switch power outputs 1 through 4. Switch power enable works with the warm-up and voltage parameters to define the switch power output. Some devices have only two switch power outputs. Refer to your model's datasheet to confirm which switch power outputs are active for your MultiHop radio.
- 0x0 - No switch power enabled
- 0x1 - Enable SP1
- 0x2 - Enable SP2
- 0x3 - Enable SP1 and SP2
- 0x4 - Enable SP3
- 0x8 - Enable SP4
- 0xC - Enable SP3 and SP4

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

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

Switch Power Warm-up
When the data radio supplies power to external sensors, the Switch Power Warm-up parameter defines how long power is applied to the external sensor before the input point is examined for changes. The register value is the number of time units.
A unit of time for a 900 MHz data radio is 40 milliseconds. A unit of time for a 2.4 GHz data radio is 20 milliseconds.

4.4 02000s Output Parameters

The following characteristics are configurable for each output.

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

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

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

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

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

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

4.5 02950s Default Output Parameters

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

2951 Enable Default Out Of Sync
> When a radio is "out of sync," it is not communicating with its parent radio.
> Set this value to 1 to enable the default condition when the device is not communicating with its parent radio. Set to 0 to disable.

2952 Enable Default Communication Timeout
> A "communication timeout" refers to the communication between the host system and this radio. Set this register to 1 to enable the default condition when the host has not communicated with this radio for the period of time defined by the Communication Default IO Timeout.

2953 Communication Default I/O Timeout (100 ms/Count)
> This parameter defines the host timeout period in 100 millisecond increments. If a host does not communicate within this timeout period, the device outputs are set to the default values.

2954 Enable Default on Power Up
> Setting this parameter to 1 sends the device outputs to their default condition when the radio is powered up. Set to 0 to disable this feature.

4.6 03000s Discrete Input Parameters

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

Parameters for Discrete Input 1 start at 3001 through 3004. Parameters for Discrete Input 2 start at 3021 through 3024. Each following input is offset from the previous one by 20 registers.

Parameter Registers for Discrete Inputs (4xxxx)				
IN 1	IN 2	IN 3	IN 4	Parameters
3001	3021	3041	3061	PNP/NPN
3002	3022	3042	3062	Sample High
3003	3023	3043	3063	Sample Low
3004	3024	3044	3064	Enable Latch on Change of State
3007	3027	3047	3067	Enable Discrete Input Time Active Counter
3008	3028	3048	3068	Discrete Input Time Active Count
3009	3029	3049	3069	Discrete Input Time Active Count

Parameter Registers for Discrete Inputs (4xxxx)				
IN 1	IN 2	IN 3	IN 4	Parameters
3013	3033	3053	3073	Enable Rising Edge
3014	3034	3054	3074	Enable Falling Edge
3015-3016	3035-3036	3055-3056	3075-3076	Digital Counter Value

Digital Counter Value

The 32-bit counter results are placed in registers 3015 and 3016 for input #1. To clear or preset the counter value, write a zero value or the preset value into registers 4015 and 4016.

Cycling the power sets the counter values back to zero. The host system is responsible for saving the counter values in case of a power failure or power reset condition.

A discrete input will not count when the device is not in sync with a parent MultiHop device. To allow for counting when out of sync, set configuration register 1008 to 1 for input #1.

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

Discrete Input Time Active Count

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

Enable Discrete Input Time Active Counter

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

Enable Latch on Change of State

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

Enable Falling Edge

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

Enable Rising Edge

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

PNP or NPN

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

Sample High

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

Sample Low

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

4.7 03300s Analog Input Parameters

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

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

Registers for Analog Parameters (4xxxx)				Parameters
IN 1 (3301-3320)	IN 2 (3321-3340)	IN 3 (3341-3360)	IN 4 (3361-3380)	
3301	3321	3341	3361	Maximum Analog Value
3302	3322	3342	3362	Minimum Analog Value
3303	3323	3343	3363	Enable Register Full Scale
3304	3324	3344	3364	Temperature Degrees C/F

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

Change of State Push Enable

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

Delta

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

Enable Register Full Scale

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

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.)

4.7 Temperature Parameters

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

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

Temperature Degrees C/F
   Set to 1 to represent temperature units in degrees Fahrenheit, and set to 0 (default) to represent temperature
   units in degrees Celsius.

Temperature Resolution
   Thermocouples and RTDs may record temperatures in either high resolution (tenths of a degree) or low resolution
   (whole degree).
   Write a 0 to select high resolution (default) or a 1 to select low resolution. Choosing high or low resolution
   changes the range of temperatures that can be written to the register.

Temperature Scaling
   Set to 1 to store temperatures the same way as the DX80 devices (measured temp × 20) represent temperature.
   Set to 0 (default) to store temperature values in tenths of a degree (measured temp × 10).
   For example, if the measured temperature is 20.5 degrees, using temperature scaling set to 1 would store the
   temperature value as 410; using temperature scaling set to 0 would store the temperature as 205.

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

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

4.8 03500s Counter Input Parameters

The following parameters are configurable for the counter input.

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

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

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

Enable Frequency/Event Counter
 A counter input can be defined to calculate the frequency of the input in hertz or as a counter that increments with every input change (event counter) from 0 to 1 (for PNP inputs).
 Set this parameter to 1 to configure the input to calculate frequency. Set to 0 to configure the counter to count input changes, for example, an event counter or totalizer. Because the counter is reset to zero when power is cycled to the device, it is up to the host system to save count data.

Enable Read Counter State
 Manufacturing/test register only

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

4.9 03600s H-Bridge Output Parameters

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

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

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

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

H-Bridge Active Current Time
 Set how long, in 40 millisecond increments, the capacitor is switched into and supplying power to the solenoid circuit.

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

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

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

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

4.9.1 03600s Switch Power Output Parameters

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

Efficient power management technology enables some FlexPower devices to include an internal power supply, called switch power (SP), that briefly steps up to power sensors requiring 5, 10, or 15 V power (ideally, 4 to 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 3601 through 3603. Parameters for SP 2 start at 3621 through 3623. Each following switch power is offset from the previous one by 20 registers.

Parameter Registers for Switch Power Outputs (4xxxx)				
SP1	SP2	SP3	SP4	Parameters
3601	3621	3641	3661	Continuous Voltage Setting
3602	3622	3642	3662	Default Output State
3603	3623	3643	3663	Hold Last State Enable

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

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

Default Output State
>   The Default Output State parameter represents the default condition of the switch power output. When communication is lost to the host or the wireless link is lost for the I/O data radio, the data radio can set the outputs and switch power outputs in this default state.
>   When set to 0, the switch power is turned off. When set to 1, the switch power is set to the voltage established by the Continuous Voltage Setting.

Hold Last State Enable
>   Set Hold Last State Enable to 1 to set the switch power output to its last known value when communications are lost.
>   Set this parameter to 0 to disable the Host Last State Enable and use the Default Output State settings.

4.10 03700s Discrete Output Parameters

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

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

Parameter Registers for Discrete Outputs (4xxxx)				
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.

4.11 04000s Analog Output Parameters

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

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

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

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

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

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

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

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

4.12 04150s Initialization Controls

4151 Reset Device
>   Write a 1 to this register to trigger a device reset of the parameters selected by the next three registers.

4152 Default I/O Configuration
>   Returns all I/O configuration parameters to their factory default settings.

4153 Default System Parameters
>   Returns all system-level parameters to their factory default settings.

4154 Initialize Variables from the Serial Number
>   Returns all variables that are normally calculated (or seeded) from the serial number to values seeded from the
>   serial number.

4.13 O4400s Output Flash Pattern Parameters

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

Flash patterns are established by selecting specific timeslots to turn the output on or off. While originally the flash pattern was designed to turn on and off an indicator light, the flash pattern can be set for any discrete output or switch power. Each slot represents one frame size, which may vary from radio to radio. The default frame is 40 milliseconds. Users may configure up to four different flash patterns.

4401-4408 Flash Pattern Index 1.

4411-4418 Flash Pattern Index 2.

4421-4428 Flash Pattern Index 3.

4431-4438 Flash Pattern Index 4.

4.14 O4500s M-GAGE Parameters

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

4501 Set Baseline
Write a 1 to this register to set the baseline. The baseline function of the M-GAGE stores the ambient magnetic field values of the X, Y, and Z axes as a baseline value. Once this baseline is established, any deviation in the magnetic field represents the presence of a ferrous object and will be reflected in the M-GAGE register. The more disruption in the magnetic field, the larger the M-GAGE register value.

4502 Disable Axes
A bit-wise register (0000). Write a one to disable the selected axis where bit 0 is the x axis, bit 1 is the y axis, and bit 2 is the z axis.

4503 Disable Compensation Median Filter
Write a 1 to this register to disable the compensation median filter.

4504 Disable Sensing Median Filter
Write a 1 to this register to disable the sensing median filter.

4505 Low Pass Filter
The filters T0 through T6 are parameter settings that define the degree of input digital signal filtering for analog inputs. T0 is the least amount of filtering. T6 is the highest filter setting and has the least amount of fluctuation between readings. Write the following values to select a low pass (tau) filter.

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

4506 Sample High
The sample high counter parameter defines the number of consecutive samples the input signal must be above the threshold before a signal is considered active. The default value is 0, which disables this feature. The value range is 1 through 255. The Sample High parameter refers to the number of samples (1 through 255) a discrete input must be detected high (1) before it is considered to be a change of state.

4507 Sample Low
The default value of 0 disables this feature. The value range is 1 through 255. The Sample Low parameter refers to the number of samples (1 through 255) a discrete input must be detected low (0) before it is considered to be a change of state.

4509 Delta
Rate of change filter.

4510 Threshold and 4511 Hysteresis

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

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

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

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

4512 Baseline (Drift) Filter Time

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

4513 Baseline (Drift) Filter Threshold

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

4514 Baseline (Drift) Filter Tau

Baseline filter's low pass filter.

4521 Baseline Difference Signal Value Total

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

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

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

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

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

4525–4527 Baseline Value

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

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

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

4528–4530 Raw Signal Value

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

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

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

4.15 04800s Ultrasonic Input Parameters

The following characteristics are configurable for the Ultrasonic input devices.

0001 Temperature Measured

Temperature is measured in 0.1 °C increments.

0002 Distance Measured

Distance is measured in mm.

The least significant bit indicates threshold status
Value 65535 or 65534: Alarm, No Reflection Detected
Value 65533 or 65532: Alarm, Reflection Mismatch
Value 65531 or 65530: Alarm, Thermistor Error

1051 Enable

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

1053 Sample Interval

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

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

4801 Drive Pulses

Defines the number of cycles the transducer is pulsed.

4808 Receive Pulses

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

4810 Max Scale Value

The Maximum Value register stores the maximum allowed analog value. The specific units of measure apply to the register value. For example, the register may contain 20000, for 20 mA, or for a voltage input the register may contain 8000, for 8 volts.
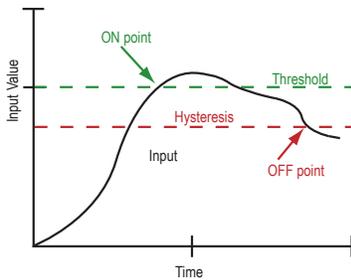
4811 Min Scale Value

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

4812 Enable Register Full Scale

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

4813 Threshold and 4814 Hysteresis

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

In the example shown 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.

4815 Delta

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

4816 Sample High and 4817 Sample Low

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

4818 Change of State Push Enable

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

4819 Median Filter Enable

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

4820 Low Pass (Tau) Filter

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

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

4823 Window Range

Measured in mm.

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

4825 Ultrasonic Teach
Write a 1 to initiate a threshold teach.
When ultrasonic teach is active, the threshold is set to the distance measured minus the window range.

4826 Invert Digital Logic
If the set distance measures below the threshold, the transition has an LSB of 1.
If the clear distance measures below the threshold, the transition has an LSB of 0.

4827 Boost Enable
Controls the ultrasonic transducer power level.

Set to 0 for low power level, a longer battery life, less noise, and a shorter range.
Set to 1 for higher power levels, a shorter battery life, more noise, and a longer range.

4828 Ultrasonic Sensitivity Control
Adjusts ultrasonic reflection sensitivity.

Write a 0 to disables the control feature
Start control at 0x8000 to match default
Control below 0x8000 is more sensitive
Control above 0x8000 is less sensitive

4831 Set Alarm as Logic 0
If set, an alarm is treated is if it is below the threshold.
If cleared, an alarm is treated is if it is above the threshold.

7909-7912 Push Registers
7909 Push Register 1 — Pushes the value of register 0002 (Distance Measured).
7910 Push Register 2 — Pushes the value of register 0001 (Temperature in 0.1 °C increments).
7911 Push Register 3 — Pushes the value of register 4813 (Current threshold setting).
7912 Push Register 4 — Pushes the value of register 4823 (Current teach window range).

4.16 06050s Battery Monitoring Parameters

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

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

6051 Enable Battery Read
Set to zero to disable the battery read function. Set to 1 to enable the battery read function.

6052 Battery Read Sample Interval
Use this parameter to set the time interval at which the incoming voltage is read. Sample Interval (in seconds) = 0.040 seconds × 2^RegValue. Default register value: 9 (20 seconds).

6053 Battery Voltage Threshold
Use this parameter to define the incoming voltage threshold at which register 44061 will be set to a zero or one. Set this value in number of 100 mA increments. The default value is 38 (or 3.8 V).

6054 Hardware Reference Select
Use this parameter to allow for the correct calibration reference for different hardware platforms. Set to zero for 3.0 V PCB Vcc. Set to one for 3.3 V PCB Vcc. Default value is zero.

6061 Battery Threshold Reading
When zero (0), the incoming voltage is below the threshold defined by parameter 6053 (powered by battery).
When one (1), the incoming voltage reading is above the defined threshold (powered by a solar panel or 10 to 30 V dc).

6062 Battery Voltage Reading
Actual incoming voltage reading in units of 100 mV.

4.17 Configure the SDI-12 Inputs

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

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

4.17.1 Basic SDI-12 Interface Parameters

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

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

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

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

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

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

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

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

4.17.2 Result Registers Configuration Parameters

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

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

- Enable. Enable or disable for each device. To enable, set to 1. To disable, set to 0.
- Decimal point Move: Moves the decimal point 0 to 7 places.

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

- Decimal point Direction: To move the decimal point to the right, set to 0. To move the decimal point to the left, set to 1.
- Register Sign: For an unsigned value, set to 0. For a signed value, set to 1.
- Register Size: For a 16-bit word, set to 0. For a 32-bit word, set to 1. Select 32-bit when using floating point.
- Floating Point Enable: For an integer, set to 0. For a floating point number, set to 1.

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

SDI-12 Device 1 / CMD 1	Register 1	Register 2	Register 3	Register 4	Register 5	Register 6
Result Register Enable	11011 (1)	11021 (1)	11031 (1)	11041 (1)	11051 (1)	11061 (1)
Decimal Point Move	11012 (0)	11022 (0)	11032 (0)	11042 (0)	11052 (0)	11062 (0)
Decimal Point Direction	11013 (0)	11023 (0)	11033 (0)	11043 (0)	11053 (0)	11063 (0)
Register Sign	11014 (0)	11024 (0)	11034 (0)	11044 (0)	11054 (0)	11064 (0)
Register Size	11015 (1)	11025 (1)	11035 (1)	11045 (1)	11055 (1)	11065 (1)
Floating Point Enable	11016 (1)	11026 (1)	11036 (1)	11046 (1)	11056 (1)	11066 (1)
	Register 7	Register 8	Register 9	Register 10	Register 11	Register 12
Result Register Enable	11071 (1)	11081 (1)	11091 (1)	11141 (0)	11151 (0)	11161 (0)
Decimal Point Move	11072 (0)	11082 (0)	11092 (0)	11142 (0)	11152 (0)	11162 (0)
Decimal Point Direction	11073 (0)	11083 (0)	11093 (0)	11143 (0)	11153 (0)	11163 (0)
Register Sign	11074 (0)	11084 (0)	11094 (0)	11144 (0)	11154 (0)	11164 (0)
Register Size	11075 (1)	11085 (1)	11095 (1)	11145 (1)	11155 (1)	11165 (1)
Floating Point Enable	11076 (1)	11086 (1)	11096 (1)	11146 (1)	11156 (1)	11166 (1)

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

SDI-12 Device 2 / CMD 2	Register 1	Register 2	Register 3	Register 4	Register 5	Register 6
Register Size	11275 (1)	11285 (1)	11295 (1)	11345 (1)	11355 (1)	11365 (1)
Floating Point Enable	11276 (1)	11286 (1)	11296 (1)	11346 (1)	11356 (1)	11366 (1)

SDI-12 Device 3 / CMD 3	Register 1	Register 2	Register 3	Register 4	Register 5	Register 6
Result Register Enable	11411 (1)	11421 (1)	11431 (1)	11441 (1)	11451 (1)	11461 (1)
Decimal Point Move	11412 (0)	11422 (0)	11432 (0)	11442 (0)	11452 (0)	11462 (0)
Decimal Point Direction	11413 (0)	11423 (0)	11433 (0)	11443 (0)	11453 (0)	11463 (0)
Register Sign	11414 (0)	11424 (0)	11434 (0)	11444 (0)	11454 (0)	11464 (0)
Register Size	11415 (1)	11425 (1)	11435 (1)	11445 (1)	11455 (1)	11465 (1)
Floating Point Enable	11416 (1)	11426 (1)	11436 (1)	11446 (1)	11456 (1)	11466 (1)
	Register 7	Register 8	Register 9	Register 10	Register 11	Register 12
Result Register Enable	11471 (1)	11481 (1)	11491 (1)	11541 (0)	11551 (0)	11561 (0)
Decimal Point Move	11472 (0)	11482 (0)	11492 (0)	11542 (0)	11552 (0)	11562 (0)
Decimal Point Direction	11473 (0)	11483 (0)	11493 (0)	11543 (0)	11553 (0)	11563 (0)
Register Sign	11474 (0)	11484 (0)	11494 (0)	11544 (0)	11554 (0)	11564 (0)
Register Size	11475 (1)	11485 (1)	11495 (1)	11545 (1)	11555 (1)	11565 (1)
Floating Point Enable	11476 (1)	11486 (1)	11496 (1)	11546 (1)	11556 (1)	11566 (1)

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

SDI-12 Device 4 / CMD 4	Register 1	Register 2	Register 3	Register 4	Register 5	Register 6
Floating Point Enable	11676 (1)	11686 (1)	11696 (1)	11746 (1)	11756 (1)	11766 (1)

SDI-12 Device 5 / CMD 5	Register 1	Register 2	Register 3	Register 4	Register 5	Register 6
Result Register Enable	11811 (1)	11821 (1)	11831 (1)	11841 (1)	11851 (1)	11861 (1)
Decimal Point Move	11812 (0)	11822 (0)	11832 (0)	11842 (0)	11852 (0)	11862 (0)
Decimal Point Direction	11813 (0)	11823 (0)	11833 (0)	11843 (0)	11853 (0)	11863 (0)
Register Sign	11814 (0)	11824 (0)	11834 (0)	11844 (0)	11854 (0)	11864 (0)
Register Size	11815 (1)	11825 (1)	11835 (1)	11845 (1)	11855 (1)	11865 (1)
Floating Point Enable	11816 (1)	11826 (1)	11836 (1)	11846 (1)	11856 (1)	11866 (1)
	Register 7	Register 8	Register 9	Register 10	Register 11	Register 12
Result Register Enable	11871 (1)	11881 (1)	11891 (1)	11941 (0)	11951 (0)	11961 (0)
Decimal Point Move	11872 (0)	11882 (0)	11892 (0)	11942 (0)	11952 (0)	11962 (0)
Decimal Point Direction	11873 (0)	11883 (0)	11893 (0)	11943 (0)	11953 (0)	11963 (0)
Register Sign	11874 (0)	11884 (0)	11894 (0)	11944 (0)	11954 (0)	11964 (0)
Register Size	11875 (1)	11885 (1)	11895 (1)	11945 (1)	11955 (1)	11965 (1)
Floating Point Enable	11876 (1)	11886 (1)	11896 (1)	11946 (1)	11956 (1)	11966 (1)

4.17.3 SDI-12 Device Result Registers

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

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

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

Result Registers	Register 7	Register 8	Register 9	Register 10	Register 11	Register 12
SDI-12 Device/CMD 1 Result Upper	11113	11115	11117	11119	11121	11123

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

4.17.4 SDI-12 Device Settings

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

- Sample Rate. Formed using two 16-bit parameters, a HI word and a LOW word. The sample rate is how often the SDI-12 device is powered up, then interrogated for data. The value in the registers is the number of 0.040 second counts. For example, the default value is 22,500, which calculates to 22500 × 0.040, or 15 minutes. Adjusting this value affects the battery life.
- Warmup time. Amount of time to wait, in 0.040 second increments, from powering on the device to the time to send communications to the device. The default value is 50, or 2 seconds. Adjusting this value affects the battery life.
- Voltage. The default voltage setting is 6 volts or a register value of 168. Adjusting this value affects the battery life.

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

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

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

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

4.17.5 Configuring for Acclima SDI-12 Sensors

Table 1: Acclima SDI-12 Parameter Registers

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

Table 2: Acclima SDI-12 Results Registers

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

4.17.6 Configuring for Decagon 5T3 SDI-12 Sensors

Table 3: Decagon SDI-12 Parameter Registers

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

Table 4: Decagon SDI-12 Results Registers

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

4.18 Manufacturer Parameter Registers

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

4.18 04100s Manufacturing Information

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

4.18 04200s Device Name

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

4.18 04300s Software Information

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

4.18 06400s Message Parameters

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

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

Storing a Model Number
For example, the model number 148691 is stored as shown below.

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

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

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

4.19 Device and System Parameters

4.19.1 08200s Sample On Demand

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

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

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

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

8201 Input 1-16 Sample on Demand Latch (bit field)
Use this bit field register to trigger a sample on demand to more than one input using a single register. For example, to trigger a sample on demand for inputs 1 and 5, write 0000 0000 0001 0001 (0x0011) to this register.

8221 Input 1 Sample on Demand Latch
Write a one (1) to this register to sample input 1.

8222 Input 2 Sample on Demand Latch
Write a one (1) to this register to sample input 2.

8236 Input 16 Sample on Demand Latch
Write a one (1) to this register to sample input 16.

5 Certified For Use in the Following Countries

The Sure Cross® 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
El Salvador			x
Estonia			x
Egypt			x
Finland			x
France			x
Germany			x
Greece			x
Guatemala	x		x
Hungary			x
Iceland			x
India			x
Ireland			x
Israel			x *
Italy			x
Korea, Republic of (South)			x
Latvia			x
Liechtenstein			x
Lithuania			x
Luxembourg			x
Malta			x
Mexico	x	x	x
Netherlands			x
New Zealand			x
Norway			x
Oman, Sultanate of			x
Pakistan			x
Panama	x		x
Poland			x

	Radio Modules		
Country	900 MHz (150 mW)	900 MHz (1 Watt)	2.4 GHz (65 mW)
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 (Republic of China)			x **
Thailand			x
Turkey			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.

5 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.

5 Transmit Power Levels

The Sure Cross 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.

5.1 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.

5.1 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.

5.1 Note

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

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

Antenna WARNING: This device has been tested with Reverse Polarity SMA connectors with the antennas listed in Table 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).

5.1 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
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

5.2 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.

5.2 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.

5.2 Note

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

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

Antenna Warning 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).

5.2 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

6 Dimensions

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"]
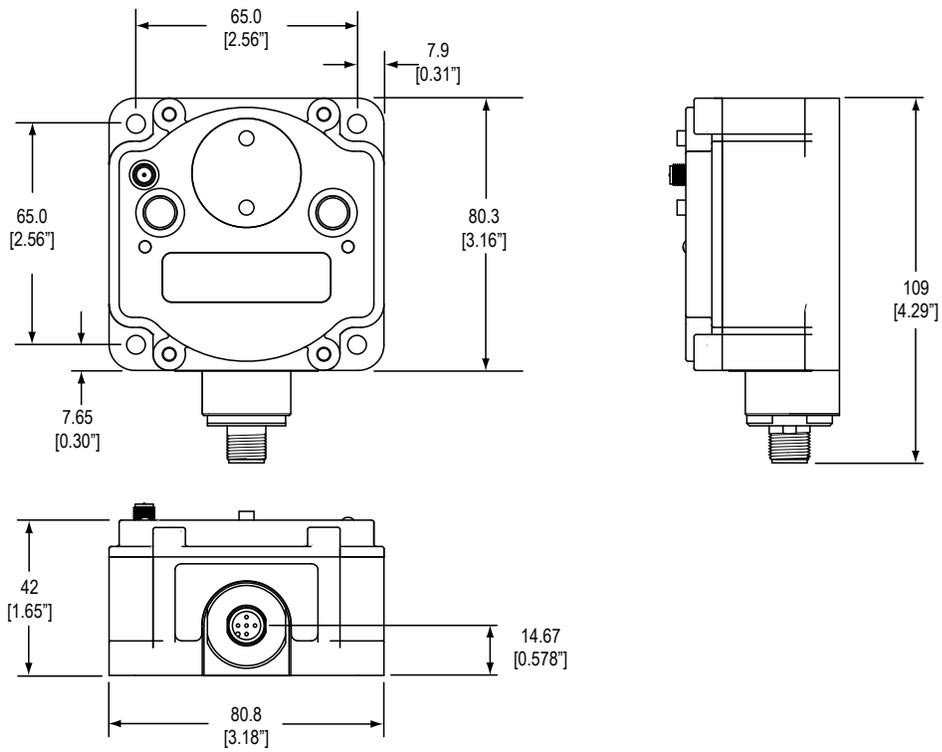
Figure 3. MultiHop Radio, Low Profile Housing
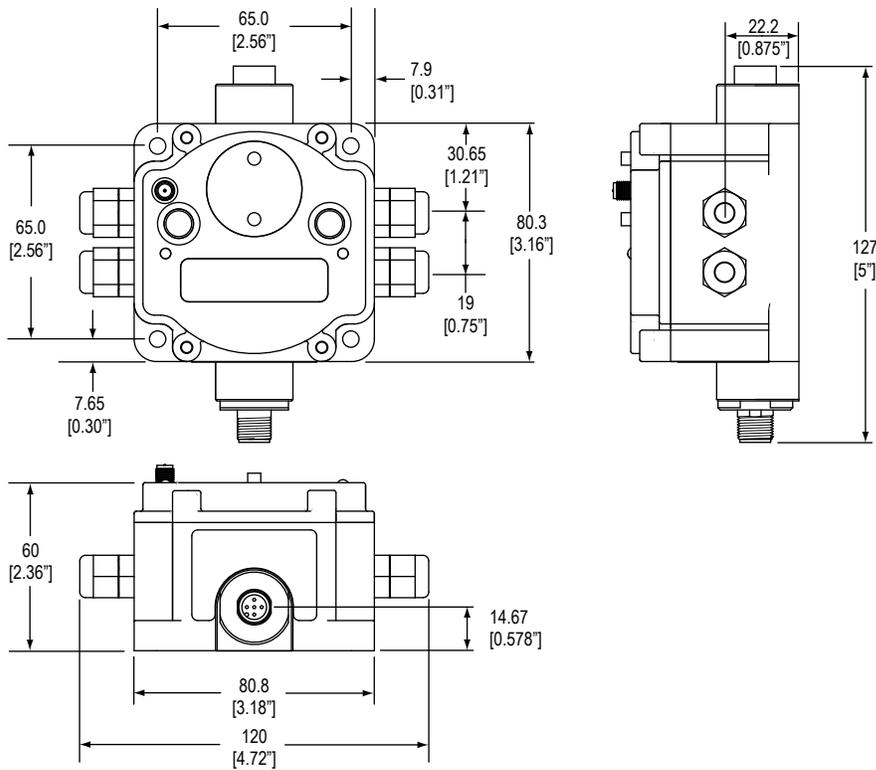
Figure 4. MultiHop Radio with I/O

6.1 DX80...E Housings
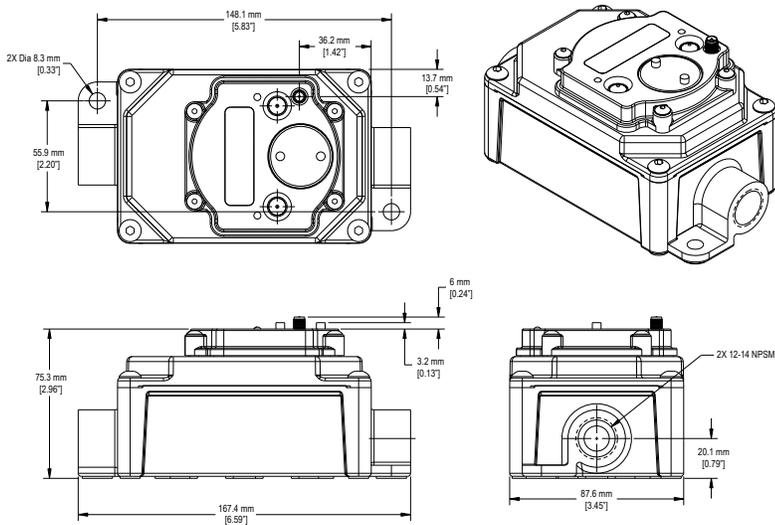
7 Advanced Setup

7.1 MultiHop Radio Menu System

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

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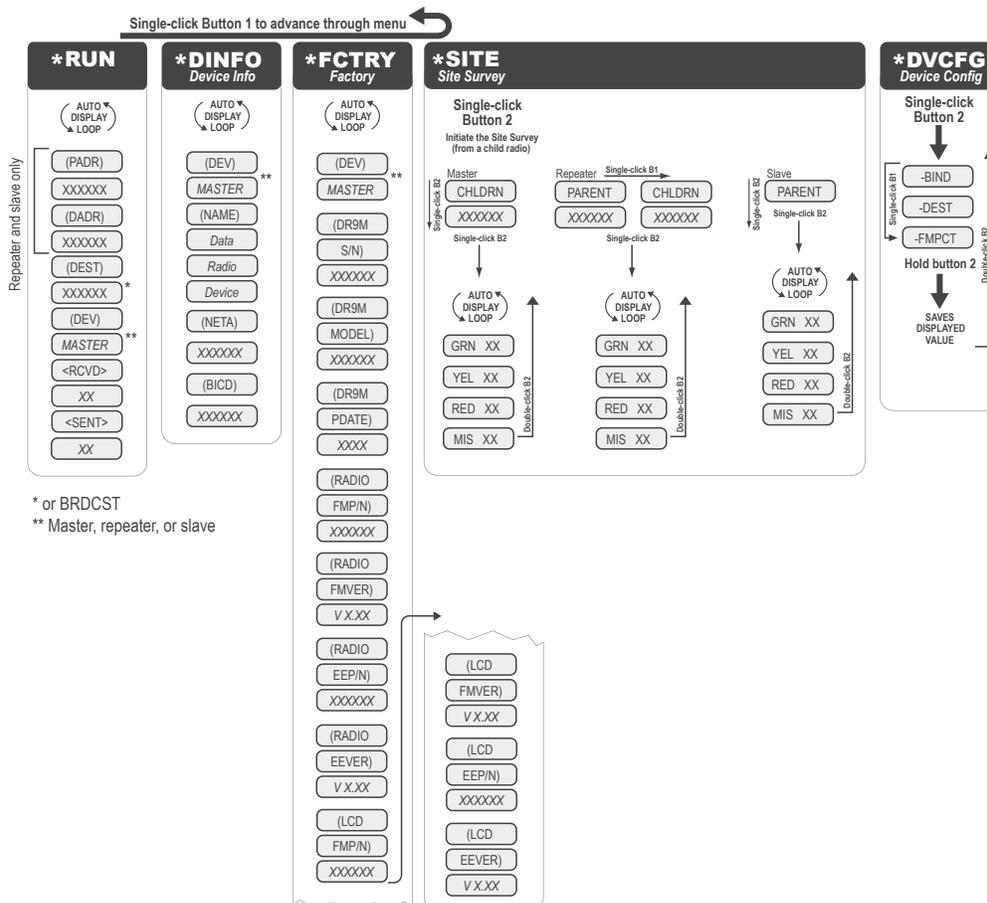
From the *RUN Menu (or any menu), single-click button 1 to advance through the top-level menus. Top-level menus are displayed on the LCD with an asterisk (*) in front of the menu name.

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

7.1 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.

7.1 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).

7.1 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.

7.1 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.

7.1 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.

7.2 Binding Mode: What Does MultiHop Binding Do?

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

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

7.2.1 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.
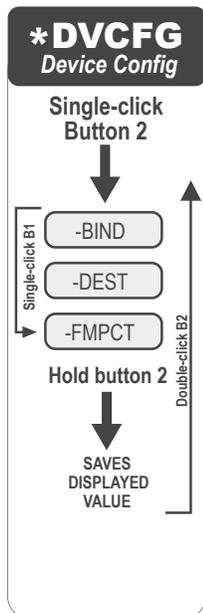
Normally, all devices are bound together before they are physically installed. In a replacement situation, the master device may not always be accessible. Using the manual binding process eliminates the need to put the master device into binding mode and allows the wireless network to remain operational.

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.

7.3 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.

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

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

1   CSB-M1240M1241. Splitter cable, 4-pin Euro-style QD, No trunk male, two female branches, yellow. Use to connect the data radio to the Gateway.

2   DX80DR9M-H*x*. MultiHop Data Radio powered by 10 to 30 V dc (Outside the USA: 12 to 24 V dc, ± 10%)

3   DX80 Gateway, powered by 10 to 30 V dc (Outside the USA: 12 to 24 V dc, ± 10%)

7.5 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

8 Accessories

The accessories list includes FCC approved antennas, antenna cabling, surge suppressors, power supplies, replacement batteries, enclosures, cables, and other hardware.

8.1 Selecting an Enclosure

Select the enclosure size based on what you intend to mount inside it. Always select the largest enclosure you can to allow for future expansion.

6 × 6 inch: Fits a single DX80.

10 × 8 inch: Fits a power supply, surge suppressor, a single DX80, and a few relays. This is a popular size but can get cramped.

12 × 10 inch: This is the recommended size; provides ample room for multiple radios and accessories.

8.1.1 Enclosures

8.1.1 Polycarbonate Enclosures

With Opaque Covers		
Models	Description	List Price
BWA-AH664	Enclosure, Polycarbonate, with Opaque Cover, 6 × 6 × 4	$93
BWA-AH864	Enclosure, Polycarbonate, with Opaque Cover, 8 × 6 × 4	$98
BWA-AH1084	Enclosure, Polycarbonate, with Opaque Cover, 10 × 8 × 4	$120
BWA-AH12106	Enclosure, Polycarbonate, with Opaque Cover, 12 × 10 × 6	$166
BWA-AH14126	Enclosure, Polycarbonate, with Opaque Cover, 14 × 12 × 6	$195
BWA-AH16148	Enclosure, Polycarbonate, with Opaque Cover, 16 × 14 × 8	$220
BWA-AH181610	Enclosure, Polycarbonate, with Opaque Cover, 18 × 16 × 10	$260

With Clear Covers		
Models	Description	List Price
BWA-AH664C	Enclosure, Polycarbonate, with Clear Cover, 6 × 6 × 4	$100
BWA-AH864C	Enclosure, Polycarbonate, with Clear Cover, 8 × 6 × 4	$111
BWA-AH1084C	Enclosure, Polycarbonate, with Clear Cover, 10 × 8 × 4	$141

With Clear Covers		
Models	Description	List Price
BWA-AH12106C	Enclosure, Polycarbonate, with Clear Cover, 12 × 10 × 6	$185
BWA-AH14126C	Enclosure, Polycarbonate, with Clear Cover, 14 × 12 × 6	$204
BWA-AH16148C	Enclosure, Polycarbonate, with Clear Cover, 16 × 14 × 8	$250
BWA-AH181610C	Enclosure, Polycarbonate, with Clear Cover, 18 × 16 × 10	$290

Swing Panel Kits		
Models	Description	List Price
BWA-AH66SPK	Swing Panel Kit, 6 × 6, Includes Mounts, Screws, and Panel	$54
BWA-AH86SPK	Swing Panel Kit, 8 × 6, Includes Mounts, Screws, and Panel	$55
BWA-AH108SPK	Swing Panel Kit, 8 × 10, Includes Mounts, Screws, and Panel	$60
BWA-AH1210SPK	Swing Panel Kit, 12 × 10, Includes Mounts, Screws, and Panel	$65
BWA-AH1412SPK	Swing Panel Kit, 14 × 12, Includes Mounts, Screws, and Panel	$70
BWA-AH1614SPK	Swing Panel Kit, 16 × 14, Includes Mounts, Screws, and Panel	$75
BWA-AH1816SPK	Swing Panel Kit, 18 × 16, Includes Mounts, Screws, and Panel	$80

Back Panel Kits		
Models	Description	List Price
BWA-BP66A	Back Panel, Aluminum, 6 × 6	$16
BWA-BP86A	Back Panel, Aluminum, 8 × 6	$17
BWA-BP108A	Back Panel, Aluminum, 10 × 8	$21
BWA-BP1210A	Back Panel, Aluminum, 12 × 10	$24
BWA-BP1412A	Back Panel, Aluminum, 14 × 12	$28
BWA-BP1614A	Back Panel, Aluminum, 16 × 14	$32
BWA-BP1816A	Back Panel, Aluminum, 18 × 16	$38

DIN Rail Kits (Self-Threading Screws)		
Models	Description	List Price
BWA-AH6DR	DIN Rail Kit, 6", Includes 2 Trilobular/Self-Threading Screws, and DIN Rail	$12
BWA-AH8DR	DIN Rail Kit, 8", Includes 2 Trilobular/Self-Threading Screws, and DIN Rail	$14
BWA-AH10DR	DIN Rail Kit, 10", Includes 2 Trilobular/Self-Threading Screws, and DIN Rail	$16
BWA-AH12DR	DIN Rail Kit, 12", Includes 2 Trilobular/Self-Threading Screws, and DIN Rail	$18
BWA-AH14DR	DIN Rail Kit, 14", Includes 2 Trilobular/Self-Threading Screws, and DIN Rail	$20
BWA-AH16DR	DIN Rail Kit, 16", Includes 2 Trilobular/Self-Threading Screws, and DIN Rail	$22
BWA-AH18DR	DIN Rail Kit, 18", Includes 2 Trilobular/Self-Threading Screws, and DIN Rail	$24
BWA-AHTBS	Trilobular/Self-Threading Screws, #10-32 × 0.375 PHL PH ZINC, 10 pack	$6

DIN Rail Kits (Machine Screws and Slot Nuts)		
Models	Description	List Price
BWA-AH6DRK	DIN Rail Kit, 6", Includes 2 Slot Nuts, 2 Machine Screws, and DIN Rail	$30
BWA-AH8DRK	DIN Rail Kit, 8", Includes 2 Slot Nuts, 2 Machine Screws, and DIN Rail	$31.50
BWA-AH10DRK	DIN Rail Kit, 10", Includes 2 Slot Nuts, 2 Machine Screws, and DIN Rail	$33
BWA-AH12DRK	DIN Rail Kit, 12", Includes 2 Slot Nuts, 2 Machine Screws, and DIN Rail	$35
BWA-AH14DRK	DIN Rail Kit, 14", Includes 2 Slot Nuts, 2 Machine Screws, and DIN Rail	$36
BWA-AH16DRK	DIN Rail Kit, 16", Includes 2 Slot Nuts, 2 Machine Screws, and DIN Rail	$38
BWA-AH18DRK	DIN Rail Kit, 18", Includes 2 Slot Nuts, 2 Machine Screws, and DIN Rail	$39

Accessories		
Models	Description	List Price
BWA-AHSNK	Slot Nut Kit, Includes 2 Nuts and 2 Screws	$25
BWA-AHSPM	Swing Panel Mounts (4 per Kit)	$35
BWA-AHLK	Latch Kit, 2 Latches per Kit, Replacement Only	$12
BWA-AHAK	Accessory Kit, Includes all screws, inserts, and mounting feet, Replacement Only	$15

8.1.1 Fiberglass Enclosures

Models	Description	List Price	
BWA-EF14128	Enclosure Fiberglass Hinged 14" × 12" × 8"	$180	
BWA-EF1086	Enclosure Fiberglass Hinged 10" × 8" × 6"	$95	
BWA-EF866	Enclosure Fiberglass Hinged 8" × 6" × 6"	$120	
BWA-PANEL-1412	Panel, 14 × 12	$26	
BWA-PANEL-108	Panel, 10 × 8	$22	
BWA-PANEL-86	Panel, 8 × 6	$10	
BWA-PM12	Pole Mount, 12 inch	$73	
BWA-PM8	Pole Mount, 8 inch	$55	
BWA-PM6	Pole Mount, 6 inch	$52	

8.2 Selecting an Antenna

Select your antenna based on your specific application needs. There are three basic antenna solutions:

- Use the supplied rubber duck antenna inside the enclosure. DX80 products come with a 2 dBi rubber duck antenna. Often simply attaching the supplied antenna to the radio provides enough radio range to meet your needs.
- Mount a dome antenna to the enclosure. The -D antennas can be mounted directly on the enclosure.
- Use an N-type pole-mounted antenna, with surge suppressor. The -A and -AS antennas can be mounted remotely from the enclosure and require the BWC-LFNBMN-DC surge suppressor.

8.2.1 Antennas: Rubber RP-SMA

The following rubber, or rubber duck, antennas have an RP-SMA male connection.

Omni-Directional Antennas with RP-SMA Male Connections

Models	Frequency	Description	List Price
BWA-9O2-C	900 MHz	2 dBi, Rubber swivel (ships with 900 MHz radios)	$25
BWA-9O5-C		5 dBi, Rubber swivel	$60
BWA-2O2-C	2.4 GHz	2 dBi, Rubber swivel, 3 1/4 inches (ships with 2.4 GHz radios)	$25
BWA-2O5-C		5 dBi, Rubber swivel, 6 1/2 inches	$28
BWA-2O7-C		7 dBi, Rubber swivel, 9 1/4 inches	$37

Models	Frequency	Description	List Price
BWA-9O2-RA	900 MHz	2 dBi, Rubber fixed right angle	$25

Models	Frequency	Description	List Price
BWA-2O1-001	2.4 GHz	1 dBi, Rubber, 1 inch tall	$15

8.2.2 Antennas: Dome

Omni-Directional Dome Antennas

Models	Frequency	Description	Connection	List Price
BWA-9O2-D	900 MHz	2 dBi, 18-inch cable	RP-SMA Box Mount [4]	$95
BWA-2O2-D	2.4 GHz			$95

8.2.3 Antennas: Other

Models	Frequency	Description	Connection	List Price
BWA-2O5-M	2.4 GHz	5 dBi, Magnetic whip antenna, 12 ft cable	RP-SMA Male	$80

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[4] For remote mounting options, use bracket SMBAMS18RA listed in the *Brackets and Mounting Options* on page 57 section.

8.2.4 Antennas: Fiberglass N-Type

The following fiberglass antennas are typically used outdoors.

Omni-Directional Fiberglass Antennas with N-Type Female Connections

Models	Frequency	Description	List Price
BWA-9O6-A	900 MHz	6 dBd, Fiberglass, Full wave, 71.5 inches	$355
BWA-2O8-A	2.4 GHz	8.5 dBi, Fiberglass, 24 inches	$200
BWA-2O6-A		6 dBi, Fiberglass, 16 inches (shown)	$125
BWA-9O6-AS	900 MHz	6 dBi, Fiberglass, 1/4 Wave, 23.6 inches (1.3 inch dia.)	$120
BWA-9O8-AS		8 dBi, Fiberglass, 3/4 Wave, 63 inches (1.5 inch dia.)	$215

8.2.5 Antennas: Yagi N-Type

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

Models	Frequency	Description	List Price
BWA-9Y6-A	900 MHz	6.5 dBd, 6.8 × 13 inches Outdoor	$135
BWA-9Y10-A		10 dBd, 6.8 × 24 inches Outdoor	$150

8.2.6 Antenna Cables: RP-SMA to RP-SMA

Use these cables to connect a radio to a bulkhead surge suppressor or a bulkhead surge suppressor to an RP-SMA antenna. These cables are typically used inside an enclosure or without an enclosure.

RP-SMA to RP-SMA Antenna Cables

Models	Description	List Price
BWC-1MRSFRSB0.2	RG58, RP-SMA Male to RP-SMA Female Bulkhead, 0.2 m	$29
BWC-1MRSFRSB1	RG58, RP-SMA Male to RP-SMA Female Bulkhead, 1 m	$31
BWC-1MRSFRSB2	RG58, RP-SMA Male to RP-SMA Female Bulkhead, 2 m	$33
BWC-1MRSFRSB4	RG58, RP-SMA Male to RP-SMA Female Bulkhead, 4 m	$36

Models	Description	List Price
BWC-2MRSFRS3	LMR200, RP-SMA Male to RP-SMA Female, 3 m	$50
BWC-2MRSFRS6	LMR200, RP-SMA Male to RP-SMA Female, 6 m	$60
BWC-2MRSFRS9	LMR200, RP-SMA Male to RP-SMA Female, 9 m	$70
BWC-2MRSFRS12	LMR200, RP-SMA Male to RP-SMA Female, 12 m	$80

8.2.7 Antenna Cables: RP-SMA to N-Type

Use an LMR100 cable to connect a radio to an N-type antenna, N-type antenna extension cable, or N-type surge suppressor. These cables may be used inside or outside the enclosure or without an enclosure.

Model	Description	List Price
BWC-1MRSMN05	LMR100 RP-SMA to N-Type Male, 0.5 m	$40
BWC-1MRSMN2	LMR100 RP-SMA to N-Type Male, 2 m	$50

8.2.8 Antenna Cables: N-Type

These LMR400 cables are antenna extension cables, connecting an N-type antenna to another N-type antenna cable. These cables are usually used outside the enclosure.

Models	Description	List Price
BWC-4MNFN3	LMR400 N-Type Male to N-Type Female, 3 m	$77
BWC-4MNFN6	LMR400 N-Type Male to N-Type Female, 6 m	$92
BWC-4MNFN15	LMR400 N-Type Male to N-Type Female, 15 m	$156
BWC-4MNFN30	LMR400 N-Type Male to N-Type Female, 30 m	$296

8.2.9 Surge Suppressors

Always install and properly ground a qualified surge suppressor when installing a remote antenna system (antenna not directly connected to the SureCross radio). Remote antenna configurations installed without a surge suppressor invalidate the manufacturer's warranty.

Model	Description	Connection	List Price	
BWC-LMRSFRPB	Surge Suppressor, Bulkhead, RP-SMA Type	RP-SMA to RP-SMA	$111	
BWC-LFNBMN-DC	Surge Suppressor, bulkhead, N-Type, dc Blocking	N-Type Female, N-Type Male	$120	

8.3 Power Supplies

8.3.1 DC Power Supplies

Models	Description	List Price	
PS24W	DC Power Supply, 500 mA, 24 V dc, Demo kit power supply	$49	

Models	Description	List Price	
PSDINM-24-04	DC Power Supply, 0.4 Amps, 24 V dc, with DIN Rail Mount	$35	
PSDINM-24-10	DC Power Supply, 1.0 Amps, 24 V dc, with DIN Rail Mount	$40	
PSDINM-24-17	DC Power Supply, 1.7 Amps, 24 V dc, with DIN Rail Mount	$54	
PSDINM-24-25	DC Power Supply, 2.5 Amps, 24 V dc, with DIN Rail Mount	$60	
PSDINP-24-06	DC Power Supply, 0.63 Amps, 24 V dc, with DIN Rail Mount, Class I Division 2 (Groups A, B, C, D) Rated	$80	
PSDINP-24-13	DC Power Supply, 1.3 Amps, 24 V dc, with DIN Rail Mount, Class I Division 2 (Groups A, B, C, D) Rated	$127	
PSDINP-24-25	DC Power Supply, 2.5 Amps, 24 V dc, with DIN Rail Mount, Class I Division 2 (Groups A, B, C, D) Rated	$160	

8.3.2 FlexPower Supplies and Replacement Batteries

Power Supplies			
Models	Description	List Price	
DX81-LITH	Battery Supply Module with mounting hardware	$75	
DX81H	Battery Supply Module with mounting hardware, for DX99 polycarbonate housing devices	$145	
DX81P6	Battery Supply Module, six "D" cells, with mounting hardware	$395	
BWA-SOLAR PANEL 3W	Solar Panel, 12 V, 3 W, Multicrystalline, 188 × 195 × 15, Wall/Pole clamp style mounting bracket included	$60	
BWA-SOLAR PANEL 5W	Solar Panel, 12 V, 5 W, Multicrystalline, 270 × 222 × 17, Wall/Pole clamp style mounting bracket included	$75	
BWA-SOLAR PANEL 20W	Solar Panel, 12 V, 20 W, Multicrystalline, 573 × 357 × 30, "L" style mounting bracket included	$165	
BWA-SOLAR CNTRL-12V	Solar Controller, 6 A Load Current 12 V System Voltage, recommended for 20 watts or less solar panel AND Sealed Lead Acid Battery (SLA)	$125	

Replacement Batteries for DX81x Models			
Model	Description	List Price	
BWA-BATT-001	Lithium "D" cell, single, for DX81-LITH and DX81H Battery Supply Module	$36	

Replacement Batteries for Wireless Q45 Sensor Models			
Model	Description	List Price	
BWA-BATT-006	Lithium "AA" cell, single, for Wireless Q45 Sensors	$24	

8.4 Relays

Models	Description	List Price	
IB6RP	Interface Relay Box, 18 to 26 V dc inputs, isolated relay outputs (not shown)	$233	
BWA-RELAY-12V	Relay, Blade Style with Base, 12 V	$29	
BWA-RELAY-24V	Relay, Blade Style with Base, 24 V	$29	
BWA-RH1B-UDC12V	Relay, Blade Style, No Base, 12 V (replacement part)	$21	
BWA-RH1B-UDC24V	Relay, Blade Style, No Base, 24 V (replacement part)	$21	
BWA-SH1B-05	Relay Base Only (replacement part)	$13	

8.5 Brackets and Mounting Options

BWA-HW-001 Mounting Hardware Kit	List Price
Screw, M5-0.8 x 25 mm, SS (4) Screw, M5-0.8 x 16 mm, SS (4) Hex nut, M5-0.8 mm, SS (4) Bolt, #8-32 x 3/4", SS (4)	$4

Brackets	List Price
SMBDX80DIN Black reinforced thermoplastic Bracket for mounting on a 35 mm DIN rail	$14

Brackets	List Price
DIN-35-.. 35 mm DIN Rail <table><tr><td>Model</td><td>Length</td></tr><tr><td>DIN-35-70</td><td>70</td></tr><tr><td>DIN-35-105</td><td>105</td></tr><tr><td>DIN-35-140</td><td>140</td></tr></table> L = 70, 105 or 140 mm Hole center spacing: 35.1 Hole size: 25.4 x 5.3	70 mm ($10) 105 mm ($11) 140 mm ($12)
BWA-HW-034 • DIN rail clip, black plastic	$10
This standard Banner bracket can also be used to remotely mount dome antennas. **SMBAMS18RA** • Right-angle SMBAMS series bracket with 18 mm hole • Articulation slots for 90+° rotation • 12-ga. (2.6 mm) cold-rolled steel Hole center spacing: A = 26.0, A to B = 13.0 Hole size: A = 26.8 × 7.0, B = ø 6.5, C = ø 19.0	$12
BWA-BK-001 • Includes magnetic mounting bracket SMB42FLM12 and 2 mounting screws	$50
BWA-BK-002 • Includes SMB42FL stainless steel bracket, 1/4"-28 screw mount, and 1 piece of 3M™ thermally conductive adhesive transfer tape	$25
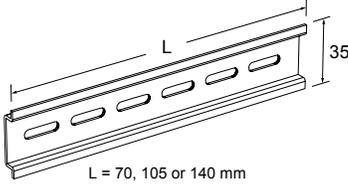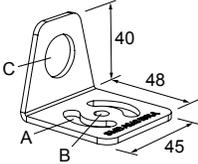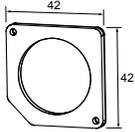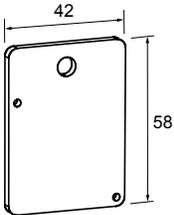
Brackets		List Price
BWA-BK-004 • Mounts both the K50U Ultrasonic sensor and a Wireless Q45U Node or DX80 Node		
BWA-BK-006 • Mounts both the K50U Ultrasonic sensor and a Wireless Q45U Node		
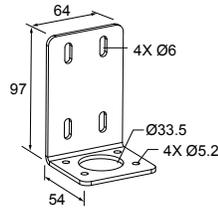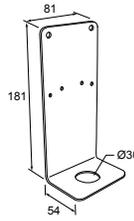
8.6 Other Accessories

8.6.1 Other Accessories

The following are other accessories available for the SureCross product line or available as stand-alone devices.

8.6.1 GPS Modules

Models	Description	Connection
GPS50M	Global Positioning System using Modbus RTU to communicate data	2 meter integral cable
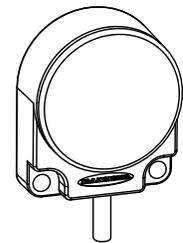
8.6.2 DX85 Modbus RTU Remote I/O Devices

These remote I/O devices have a Modbus interface and are used to expand the I/O of the Gateway or the Modbus host.

DX85 IP67 Housing Model

DX85..C IP20 Housing Model

Models	Description	List Price
DX85M6P6	DX85 Modbus RTU Remote I/O, 6 Discrete IN, 6 Discrete OUT	$475
DX85M4P4M2M2	DX85 Modbus RTU Remote I/O, 4 Discrete IN, 4 Discrete OUT, 2 Analog IN, 2 Analog OUT (0 to 20 mA)	$475
DX85M4P8	DX85 Modbus RTU Remote I/O, 4 Discrete IN, 8 Discrete OUT	$475
DX85M8P4	DX85 Modbus RTU Remote I/O, 8 Discrete IN, 4 Discrete OUT	$475
DX85M0P0M4M4	DX85 Modbus RTU Remote I/O, 4 Analog IN, 4 Analog OUT (0 to 20 mA)	$475
DX85M-P7	DX85 Modbus RTU Remote I/O, Up to 12 sinking inputs or up to 12 NMOS sinking outputs (for a total of 12 I/O)	$475
DX85M-P8	DX85 Modbus RTU Remote I/O, Up to 12 sourcing inputs or up to 12 sourcing outputs (for a total of 12 I/O)	$475

Note: Add a "C" to the end of any DX85 model to order that I/O mix with an IP20 housing. The IP20 models are Class I, Division 2 certified when installed in a suitable enclosure.

8.6.3 Sensors

8.6.3 Sensors Optimized for Use with FlexPower Devices

Models	Description	Datasheet	List Price	
SM312LPQD-78447	MINI-BEAM, Low Power, 5V, Polarized Retroreflective, 3 m	134420	$112	
SM312DQD-78419	MINI-BEAM, Low Power, 5V, Diffuse, 38 cm		$105	
QT50ULBQ6-75390	Ultrasonic, QT50U, 200 mm to 8 m Range		$626	
QS30WEQ	WORLD-BEAM Photoelectric Emitter, QS30 (Max Range: 100 feet, 10x excess gain at 50 feet), 1-wire serial interface	140987	$70	
QS30WRQ	WORLD-BEAM Photoelectric Receiver, QS30 (Max Range: 100 feet, 10x excess gain at 50 feet), 1-wire serial interface		$91	

Models	Description	Datasheet	List Price	
M12FTH3Q	Temperature and Humidity Sensor, RS-485 Modbus interface	163751	$185	
M12FT3Q	Temperature Sensor, RS-485 Modbus interface		$125	

8.6.3 Other Sensors

Models	Description	List Price
BWA-THERMISTOR-001	NTC Thermistor, 2.2 KOhms, +/-0.2%C, blue bead (For models: DX80N9X2S2N2T/C, DX99N9X2S2N0T4X0A0, and DX99N9X1S2N0T4X0D0)	$9
BWA-THERMISTOR-002	NTC Thermistor, 10 KOhms, +/-0.2%C, black bead (For Performance models -P1/C/E, and MultiHop models M-H1/C/E), 2 pack	$12
BWA-S612-30-100	NoShok Series 612 Submersible Level Transmitter, model 612-30-1-1-N-100, 0 to 30 psig, 100' cable	$979
BWA-S612-15-100	NoShok Series 612 Submersible Level Transmitter, model 612-15-1-1-N-100, 0 to 15 psig, 100' cable	$979
BWA-625-5000-1-1-8-25	NoShok Series 625 Intrinsically Safe Pressure Transmitter, model 625-5000-1-1-8-25, 0 to 5000 psig, 1/2" NPT,4–20mA, M12 QD	$753
BWA-625-10000-1-1-8-25	NoShok Series 625 Intrinsically Safe Pressure Transmitter, model 625-10000-1-1-8-25, 0 to 10000 psig, 1/2" NPT, 4–20mA, M12 QD	$753
BWA-P-RKGV 5.33T-1727-2.0	Cable, female M12 4-pin, blue PVC, SS connector, for NoShok Series 625 IS Pressure Transmitter	
BWA-ACC-SEN-SDI	Acclima SDI-12 Soil Moisture Transducer	$224

Sensors with a Serial Interface

The following sensors are designed to be used with any of the 1-Wire Serial Interface Nodes.

Models	Description	Datasheet	List Price	
M12FTH4Q	Temperature and Humidity Sensor, ±2% Accuracy, 1-wire serial interface (Requires a 5-pin threaded M12/Euro-style double-ended cordset less than 3 meters long, such as model DEE2R-5xD.)	162669	$175	
M12FT4Q	Temperature Sensor with 1-wire serial interface (Requires a 5-pin threaded M12/Euro-style double-ended cordset less than 3 meters long, such as model DEE2R-5xD.)		$115	
QM42VT1	Vibration and Temperature Sensor with 1-wire serial interface	186209	$195	
K50UX2RA	U-GAGE Ultrasonic Sensor with 1-wire serial interface	191599		

Replacement Filters

Replacement Filters	Description	
FTH-FIL-001	Aluminum grill filter cap (factory default, ships with M12FT*Q sensors)	
FTH-FIL-002	Stainless steel, sintered to 10 micrometer porosity (for high dust environments.)	

8.6.4 Cables

Ethernet Cables

Use a crossover cable to connect the GatewayPro or DX83 Ethernet Bridge to a host system without using an Ethernet switchbox or hub. When using a switchbox or hub, use a straight cable.

RSCD RJ45 Ethernet to 4-Pin M12/Euro-Style Cordsets				
Model	Length	Style	Dimensions	Pinout
BWA-E2M	2 m (6.6 ft)	Straight RSCD RJ45 440		1 = White/Orange (+Tx) 2 = Orange (-Tx) 3 = White/Blue (+Rx) 4 = N/C 5 = N/C 6 = Blue (-Rx) 7 = N/C 8 = N/C
BWA-E8M	8 m (26.2 ft)			
BWA-EX2M	2 m (6.6 ft)	Crossover RSCD RJ45CR 440		1 = White/Orange (+Tx) 2 = White/Blue (+Rx) 3 = Orange (-Tx) 4 = Blue (-Rx)
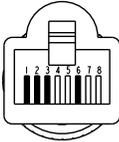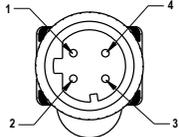
Adapter Cables

Models	Description	List Price	
BWA-HW-006	Adapter cable, USB to RS-485, for use with the User Configuration Tool software (UCT)	$132	
BWA-UCT-900 (shown)	Adapter cable with power, USB to RS-485, for use with the User Configuration Tool software (UCT), supplies power to 1 Watt radios	$132	

Splitter Cables

Use CSRB-M125OM125.47M125.73 to split power between two *Flex*Power or solar powered devices. DO NOT use this cable to connect a FlexPower devices to a 10 to 30 V dc powered device.

Use CSRB-M1253.28M1253.28M1253.28 to connect one *Flex*Power device (data radio, *Flex*Power Gateway, etc) to two power sources, such as the *Flex*Power Solar Supply and DX81P6 Battery Pack.

5-Pin Threaded M12/Euro-Style Splitter Cordsets—Rounded Junction			
Model	Length	Style	Pinout
CSRB-M1250M125.47M125.73	Trunk: 0 m (male) / Branches: 0.14 m and 0.22 m (female)	Straight	Male / Female
CSRB-M1253.28M1253.28M1253.28	Trunk: 1 m (female) / Branches: 1 m (male)		
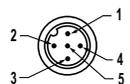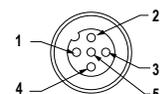
1 = Brown
2 = White
3 = Blue
4 = Black
5 = Gray
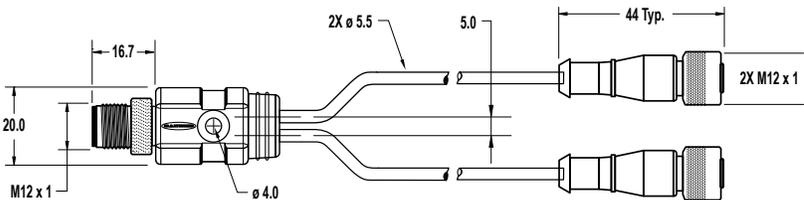
Use the following 4-pin splitter cables to split power between two 10 to 30 V dc powered devices, such as a data radio and Gateway, or between a DX85 and Gateway.

4-Pin Threaded M12/Euro-Style Splitter Cordsets—Flat Junction			
Model	Branches (Female)	Trunk (Male)	Pinout
CSB-M1240M1240	No branch	No trunk	Female / Male
CSB-M1240M1241	2 x 0.30 m (1 ft)	No trunk	
CSB-M1241M1241		0.30 m (1 ft)	
CSB-M1248M1241		2.50 m (8 ft)	
CSB-M12415M1241		4.57 m (15 ft)	
CSB-M12425M1241		7.60 m (25 ft)	
CSB-UNT425M1241		7.60 m (25 ft) Unterminated	
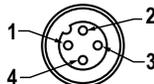
1 = Brown
2 = White
3 = Blue
4 = Black

Models	Description	List Price	
BWA-HW-026	Splitter cable, wall wart for external power split to 5-pin M12/Euro-style male and 5-pin M12/Euro-style female (to power a M-H at 1 Watt while configuring it through the MHCT)	$75	

Other Splitter Cables		
Models	Description	List Price
BWA-DRSPLITTER	Splitter cable, DB9 Female (RS232) trunk to 5-pin M12/Euro-style male and female	$43

Euro-Style Cordsets - Single Ended

Right-angle cordsets are not compatible with the DX70 devices. When facing the Node or Gateway toward you and the quick disconnect connection is facing down, the right-angle cables exit to the right.

When using the FlexPower Node with integrated battery, use a double ended cordset. For a FlexPower Node with external power supply, use a single ended cordset. If using the communication lines, the cable length cannot exceed 3 meters, or 10 feet.

5-Pin Threaded M12/Euro-Style Cordsets—Single Ended				
Model	Length	Style	Dimensions	Pinout (Female)
MQDC1-501.5	0.50 m (1.5 ft)	Straight		
MQDC1-506	1.83 m (6 ft)			
MQDC1-515	4.57 m (15 ft)			1 = Brown
MQDC1-530	9.14 m (30 ft)			2 = White
MQDC1-506RA	1.83 m (6 ft)	Right-Angle		3 = Blue
MQDC1-515RA	4.57 m (15 ft)			4 = Black
MQDC1-530RA	9.14 m (30 ft)			5 = Gray

Models	Description
BWA-QD5.5	Prewired 5-pin M12/Euro-style quick disconnect (QD), 1/2-14 NBSM
BWA-QD8.5	Prewired, 8-pin M12/Euro-style quick disconnect (QD), 1/2-14 NBSM
BWA-QD12.5	Prewired 12-pin M12/Euro-style quick disconnect (QD), 1/2-14 NBSM
FIC-M12F4	4-pin M12/Euro-style straight female field-wireable connector
DEUR-506.6C	1.83 m (6 ft) cordset with a 5-pin M12/Euro-style straight male quick disconnect (QD) and straight female QD
MQDMC-401	300 mm (12 in) cordset with a 4-pin M12/Euro-style straight male quick disconnect (QD), single ended, longer for DX80...C models

Euro-Style Cordsets - Double Ended

When using the FlexPower Node with integrated battery, use a double ended cordset. When using a FlexPower Node with external power supply, use a single ended cordset. If using the communication lines, the cable length cannot exceed 3 meters (10 ft).

5-Pin Threaded M12/Euro-Style Cordsets—Double Ended and Less Than 3 m Long				
Model	Length	Style	Dimensions	Pinout
DEE2R-51D	0.31 m (1 ft)	Female Straight/ Male Straight		Male
DEE2R-53D	0.91 m (3 ft)			Female
DEE2R-58D	2.44 m (8 ft)			1 = Brown
				2 = White
				3 = Blue
				4 = Black
				5 = Green/Yellow

Other Cables

Models	Description	List Price
BWA-RIBBON-001	Ribbon cable, 20-pin DBL socket	$9
BWA-HW-010	Cable, FlexPower Current Monitoring	$59

8.6.5 Hardware and Replacement Parts

Models	Description	List Price
BWA-HW-002	DX80 Access Hardware Kit Plastic threaded plugs, PG-7 (4) Nylon gland fittings, PG-7 (4) Hex nuts, PG-7 (4) Plug, 1/2-inch NPT Nylon gland fitting, 1/2-inch NPT	$25
BWA-HW-003	PTFE Tape, 1/4 inches wide, 600 inches long	$4
BWA-HW-004	Replacement Seals O-ring, rotary access cover, PG21 (2) O-ring, body gasket (2) Access cover, rotary dials, clear plastic (2)	$5
BWA-HW-009	Solar assembly hardware pack, includes brackets, bolts, and set screws	$12
BWA-HW-007	Housing Kit, DX80, top and bottom, 10 pieces	$100
BWA-HW-008	Housing Kit, DX81, top and bottom, 10 pieces	$100
BWA-HW-044	Terminal header for the MultiHop Ethernet Data Radio	$15
BWA-HW-011	Terminal Block Headers, IP20, 2 pack	$22
BWA-HW-012	DX99 Antenna Extension Pack Screw, M4-0.7 x 20, pan head, black steel Flexible Antenna Cable, 12 inches, SMA male to SMA female	$42
BWA-HW-032	Access hardware for the E housing, one 1/2-inch plug, one 1/2-inch gland	$15
BWA-HW-037	Clear plastic retaining ring for DX99 metal housings, 10 pack	$20

8.6.6 Cable Glands and Plugs

Models	Description	List Price	
BWA-HP.5-10	Dummy Hole Plugs, 1/2-inch NPT, 10 pieces	$5	
BWA-HW-031	Vent Plug, 1/2" NPT, IP67	$50	
BWA-CG.5-10	Cable Glands, 1/2-inch NPT, 10 pieces, Cordgrips for cable diameters 0.17'' to 0.45''	$32	
BWA-CG.5-3X5.6-10	Cable Glands, 1/2-inch NPT, Cordgrip for 3 holes of 2.8 to 5.6 mm diam, 10 Pack	$32	
BWA-CG.5-2X2.5-10	Cable Glands, 1/2-inch NPT, Cordgrip for 2 holes of 1.2 to 2.5 mm diam, 10 Pack	$32	
BWA-CG.5-6X4.0-10	Cable Glands, 1/2-inch NPT, Cordgrip for 6 holes of 2 to 4 mm diam, 10 Pack	$32	
BWA-CG.5-6X3.0-10	Cable Glands, 1/2-inch NPT, Cordgrip for 6 holes of 1.5 to 3 mm diam, 10 Pack	$32	

[5] Shown with PTFE tape wrapping

8.6.7 Metal Housing Accessories

Model No.	Description	List Price	
BWA-HW-016	Antenna Feedthrough, Stainless Steel, 1/2" NPT	$62	
BWA-HW-017	Antenna Feedthrough, Stainless Steel, 3/4" NPT	$66	
BWA-HW-012	DX99 Antenna Extension Pack (M4-0.7 × 20 black steel pan head screw, flexible antenna cable 12" SMA male to SMA female)	$42	
BWA-HW-037	Clear plastic retaining ring for DX99 metal housings (10 pack)	$20	
BWA-AXFS0130	AXF™ Explosion-Proof Antenna Coupler		

Omni-Directional Dome Antennas					
Models	Frequency	Description	Connection	List Price	
BWA-9O2-001	900 MHz	2 dBi, 18-inch cable	1/2" SS NPT Port	$140	
BWA-9O2-002	900 MHz	2 dBi, 18-inch cable	3/4" SS NPT Port	$140	
BWA-2O2-001	2.4 GHz	2 dBi, 18-inch cable	1/2" SS NPT Port	$140	
BWA-2O2-002	2.4 GHz	2 dBi, 18-inch cable	3/4" SS NPT Port	$140	

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