

# Sure Cross<sup>®</sup> DXM100-Sx Wireless Modbus Slave

## Instruction Manual

Original Instructions  
188231 Rev. E  
15 April 2020  
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188231

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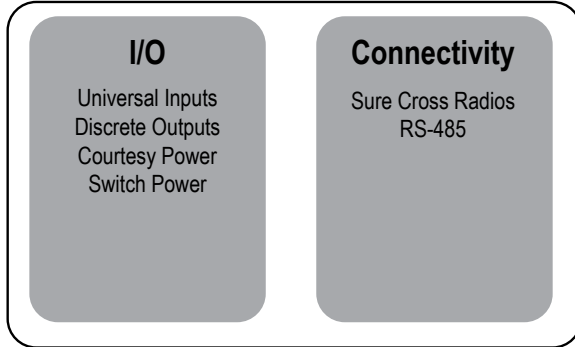
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# 1 DXM100-Sx Overview

## 1.1 DXM100-S1 System Overview

Banner's DXM Logic Controller integrates Banner's wireless radio and local I/O for a remote I/O device.



**Inputs/Outputs**—On-board universal and programmable I/O ports connect to local sensors, indicators, and control equipment.

- Universal Inputs
- Discrete outputs
- Courtesy power
- Switch power
- Battery backup
- Solar controller

**Connectivity**—The integrated Sure Cross® wireless radio enables Modbus connectivity to remote sensors, indicators, and control equipment.

### Wired Connectivity

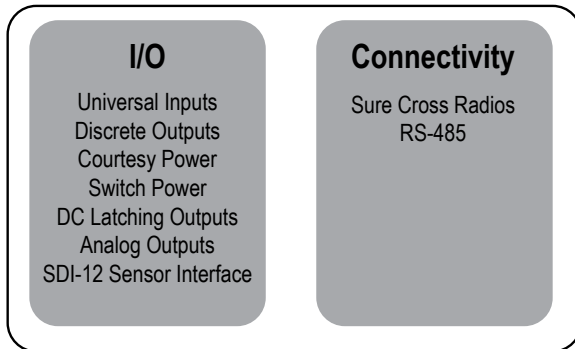
Field Bus: Modbus RS-485

### Wireless Connectivity

Sure Cross MultiHop 900 MHz, or MultiHop 2.4 GHz

## 1.2 DXM100-S2 System Overview

Banner's DXM Logic Controller integrates Banner's wireless radio and local I/O for a remote I/O device.



**Inputs/Outputs**—On-board universal and programmable I/O ports connect to local sensors, indicators, and control equipment.

- Universal Inputs
- Discrete outputs
- Courtesy power
- Switch power
- Battery backup
- Solar controller
- Analog outputs
- DC latching solenoid outputs
- SDI-12 sensor interface

**Connectivity**—The integrated Sure Cross® wireless radio enables Modbus connectivity to remote sensors, indicators, and control equipment.

### Wired Connectivity

Field Bus: Modbus RS-485

### Wireless Connectivity

Sure Cross MultiHop 900 MHz or MultiHop 2.4 GHz

## 1.3 DXM Configuration Software

Download the latest version of all configuration software from <http://www.bannerengineering.com>. For more information on using the DXM Configuration Software, refer to the instruction manual (p/n 209933).

The DXM Configuration Software configures the DXM100 by creating an XML file that is transferred to the DXM100 using a USB or Ethernet connection. The DXM100 can also receive the XML configuration file from a Web server using a cellular or Ethernet connection.

This configuration file governs all aspects of the DXM100 operation.

The wireless network devices are a separate configurable system. Use the DX80 User Configuration Software to configure the internal DX80 wireless Gateway and the attached wireless Nodes. Use the MultiHop Configuration Software if the internal radio is a MultiHop device.

All tools can be connected to the DXM100 using a USB cable or an Ethernet connection.

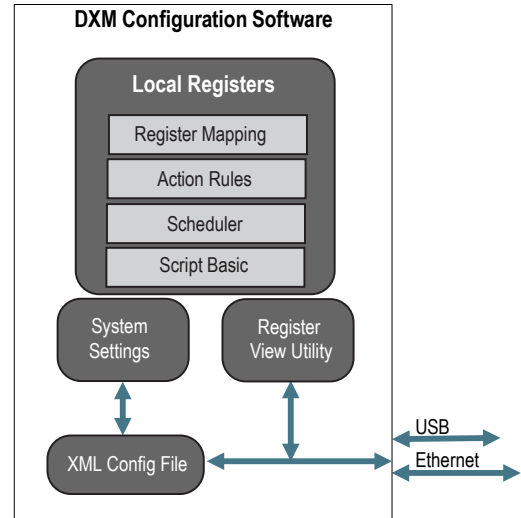


Figure 1. Overview of the DXM Configuration Software features

## 1.4 DXM Hardware Configuration Overview

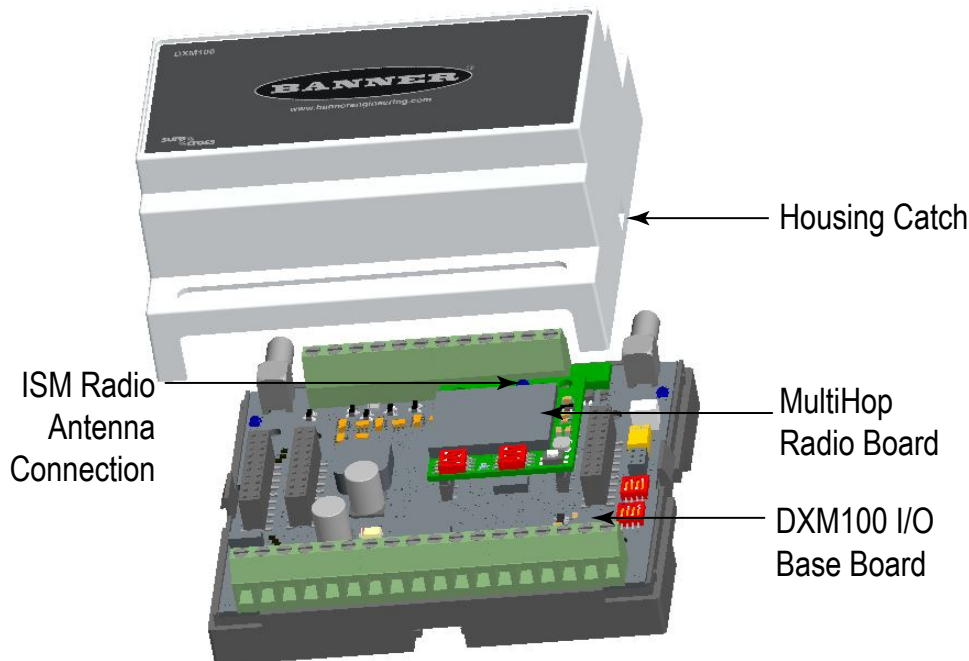
The DXM100 can have multiple configurations. The DXM100 will have a model number label on the housing. Use the model number and model table above to identify which boards are included in the controller.

When opening the DXM100, follow proper ESD grounding procedures.



**Important:**

- **Electrostatic discharge (ESD) sensitive device**
- ESD can damage the device. Damage from inappropriate handling is not covered by warranty.
- Use proper handling procedures to prevent ESD damage. Proper handling procedures include leaving devices in their anti-static packaging until ready for use; wearing anti-static wrist straps; and assembling units on a grounded, static-dissipative surface.

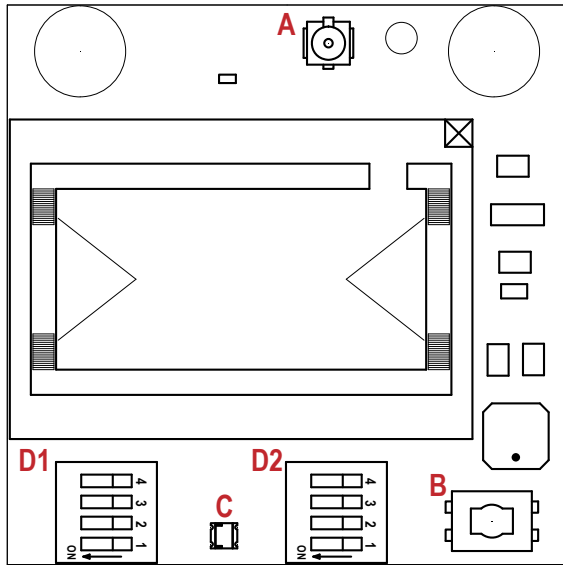


The DXM100 I/O base board provides connections for all inputs, outputs and power. The base board also contains a 12 V solar controller that accepts connections to a solar panel and sealed lead acid (SLA) battery. The battery connection can also be used with line power to provide a battery backup in case of line power outages.

The ISM radio fits on the I/O base board in the parallel sockets. Install the ISM radio so the U.FL antenna connection is to the side with the SMA antenna connectors. Connect the U.FL cable from the ISM radio U.FL to the right side U.FL connector. The ISM radio boards are available with either a 900 MHz (North America) or a 2.4 GHz (International) radio.

## 2 ISM Radio Board (Slave ID 1)

The ISM embedded radio boards are available in either DX80 MultiHop or DX80 Performance.



Plug the ISM radio into the I/O base board with the U.FL antenna connector closest to the SMA connectors.

- A - Antenna connector
- B - Button
- C - LED
- D1 - DIP switches
- D2 - DIP Switches

Typically, users will not need to adjust the DIP switch settings on the physical radio modules. For the DXM1200 models, set the radio options using the LCD menu.

Figure 2. ISM radio board

### Button Operation

For DXM models without a LCD display, use the button (B) to bind the ISM radio. For models with a LCD display, use the ISM menu to bind the radio.

### LED Operation

The LED located on the ISM radio module indicates power and communications traffic.

- Solid green DX80 ISM radio LED indicates power.
- Flashing green MultiHop ISM radio LED indicates operation.
- Red and green combined: Communications traffic and binding.

ISM board LED operations also display on the LED on the right side of the I/O base board.

## 2.1 DIP Switch Settings for the MultiHop HE5 Board Module

Device Settings	D1 Switches				D2 Switches			
	1	2	3	4	1	2	3	4
Serial line baud rate 19200 OR User defined receiver slots	OFF*	OFF*						
Serial line baud rate 38400 OR 32 receiver slots	OFF	ON						
Serial line baud rate 9600 OR 128 receiver slots	ON	OFF						
Serial line baud rate Custom OR 4 receiver slots	ON	ON						
Parity: None			OFF*	OFF*				
Parity: Even			OFF	ON				
Parity: Odd			ON	OFF				
Disable serial (low power mode) and enable the receiver slots select for switches 1-2			ON	ON				

Device Settings	D1 Switches				D2 Switches			
	1	2	3	4	1	2	3	4
Transmit power 900 MHz radios: 1.00 Watt (30 dBm) 2.4 GHz radios: 0.065 Watts (18 dBm) and 60 ms frame					OFF*			
Transmit power 900 MHz radios: 0.25 Watts (24 dBm) 2.4 GHz radios: 0.065 Watts (18 dBm) and 40 ms frame					ON			
Application mode: Modbus						OFF*		
Application mode: Transparent						ON		
MultiHop radio setting: Repeater							OFF*	OFF*
MultiHop radio setting: Master							OFF	ON
MultiHop radio setting: Slave							ON	OFF
MultiHop radio setting: Reserved							ON	ON

\* Default configuration

## 2.1.1 Application Mode

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

**Modbus** mode uses the Modbus protocol for routing packets. In Modbus mode, a routing table is stored in each parent device to optimize the radio traffic. This allows for point to point communication in a multiple data radio network and acknowledgement/retry of radio packets. To access a radio's I/O, the radios must be running in Modbus mode.

In **transparent** application mode, all incoming packets are stored, then broadcast to all connected data radios. The data communication is packet based and not specific to any protocol. The application layer is responsible for data integrity. For one to one data radios it is possible to enable broadcast acknowledgement of the data packets to provide better throughput. In transparent mode, there is no access to the radio's I/O.

## 2.1.2 Baud Rate and Parity

The baud rate (bits per second) is the data transmission rate between the device and whatever it is physically wired to. Set the parity to match the parity of the device you are wired to.

## 2.1.3 Disable Serial

Disable an unused local serial connection to reduce the power consumption of a data radio powered from the solar assembly or from batteries. All radio communications remain operational.

## 2.1.4 Transmit Power Levels/Frame Size

The 900 MHz data radios can be operated at 1 watt (30 dBm) or 0.250 watt (24 dBm). For most models, the default transmit power is 1 watt.

For 2.4 GHz radios, the transmit power is fixed at 0.065 watt (18 dBm) and DIP switch 5 is used to set the frame timing. The default position (OFF) sets the frame timing to 60 milliseconds. To increase throughput, set the frame timing to 40 milliseconds.



**Important:** Prior to date code 15341 and radio firmware version 3.6, the frame timing was 40 ms (OFF) or 20 ms (ON).

## 2.2 Binding the ISM Radio of a Modbus Slave

A DXM100-Sx Modbus Slave (model DXM1x0-S\*R2) contains two boards: a MultiHop ISM radio and an I/O base board. Each board is a separate Modbus device.



- The ISM radio is not required to have a Modbus ID because there are no registers to manage.
- The I/O board must have a Modbus ID to access the I/O register data and configuration data.

To bind the DXM100-Sx Modbus Slave (as either a repeater or slave radio) to its master radio, follow the MultiHop binding instructions. If the binding instructions are not included in the master radio datasheet, refer to the MultiHop Quick Start Guide (p/n [152653](#)) or Instruction Manual (p/n [151317](#)).

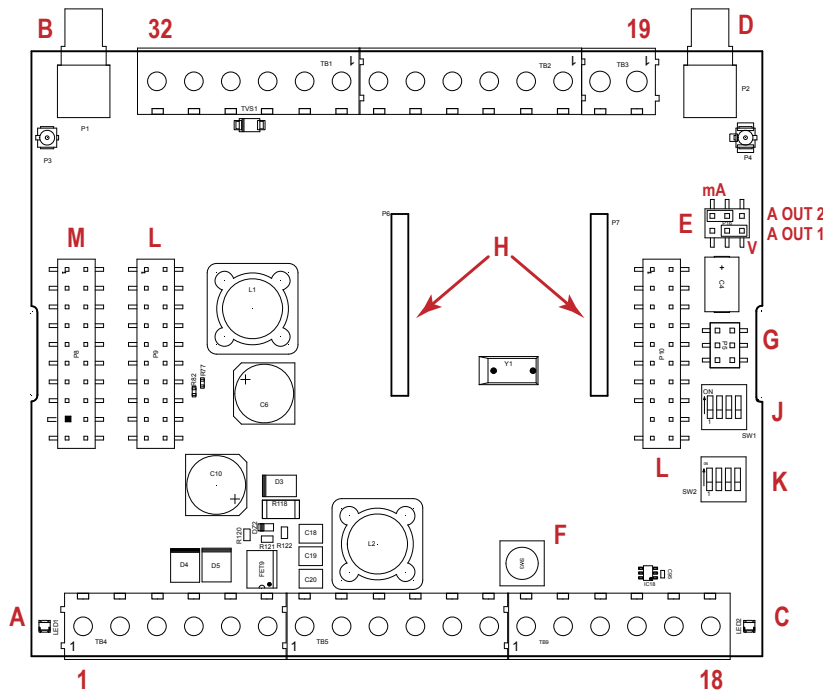
The ISM radio board's Modbus ID is assigned from the master radio during binding using the master radio's rotary dials or the DXM Controller's LCD Binding menu. For example, if the master's binding number is 25, the DXM Slave ISM radio's Modbus ID is set to 25. To reduce the number of Modbus IDs used, set the ISM radio Modbus ID to 01.

By default, the I/O board's Modbus ID is set to 11. To change the Modbus ID, use the I/O board DIP switches. For applications requiring Modbus IDs outside the range of the DIP switches, write a Modbus ID to a Modbus register on the I/O board.

Use the MultiHop Configuration Software to display and configure a MultiHop radio network. With the DXM100-Sx Modbus Slave, only the ISM radio displays on the Network View screen. The Modbus ID of the I/O board is a separate device that is not a part of the radio network. Although the I/O board does not show up in the Network View, it is accessible when using the Register View functions.

# 3 I/O Base Board for the DXM100-S1 Model

## 3.1 DXM100-S1 I/O Base Board Connections



1	No connection	12	Not used	23	N3. NMOS OUT 3
2	PW. 12 to 30 V DC or solar power in (+)	13	Not used	24	N2. NMOS OUT 2
3	GD. Ground	14	Not used	25	N1. NMOS OUT 1
4	B+. Battery in (< 15 V DC)	15	CL. CANL	26	GD. Ground
5	GD. Ground	16	CH. CANH	27	U4. Universal Input 4
6	M-. Primary RS-485 -	17	GD. GND	28	U3. Universal Input 3
7	M+. Primary RS-485 +	18	P3. Courtesy Power 5 V	29	GD. Ground
8	GD. Ground	19	A2. Analog OUT 2	30	P1. Switch Power (5 V or 16 V)
9	Not used	20	A1. Analog OUT 1	31	U2. Universal Input 2
10	Not used	21	P2. Switch Power 2 (5 V or 16 V)	32	U1. Universal Input 1
11	Not used	22	N4. NMOS OUT 4		

A	Base board LED	E	Jumpers - Configures Analog Out 1 and 2 for mA or V	J	Modbus Slave ID DIP Switches
B	A1. Cellular or secondary antenna	F	Radio Binding Button	K	Modbus Slave ID DIP Switches
C	Radio LED	G	Programming header	L	Processor Board Connection
D	A2. ISM Antenna	H	ISM Radio Board Connection	M	Display Connection

### 3.1.1 DIP Switches for the I/O Board

The DXM100-Sx Modbus Slave I/O board DIP switches are set from the factory to Modbus Slave ID 11.

### 3.1.2 I/O Board Jumpers for the B1 and S1 Models

Hardware jumpers on the DXM I/O board allow the user to select alternative pin operations. Turn the power off to the device before changing jumper positions.

Jumper	Function	Positions
E	Analog output characteristics for AO2 (pin 19) and AO1 (pin 20)	<p>Defines current (0–20 mA) or voltage (0–10 V) for analog output 1 and 2.</p> <p>By default, current (0–20 mA) is selected using jumpers 1 and 2 and registers 4008 and 4028 contain a value of 2.</p> <p>To select voltage (0–10 V) for output Aout1, set jumper 1 in the voltage position (V) and set Modbus register 4008 on the I/O board (SID 200) to 3.</p> <p>To select voltage (0–10 V) for output Aout2, set jumper 2 in the voltage position (V) and set Modbus register 4028 on the I/O board (SID 200) to 3.</p>

### 3.1.3 Setting the Modbus Slave ID on the I/O Base Board

Only DXM100-S1 and -S1R2 Slave models require that the Modbus Slave ID to be adjusted on the I/O base board. The DXM100-Sx Modbus Slave models use DIP switches J and K to set the Modbus Slave ID. This device can use a Modbus register 6804 in the I/O board to access the full range of Modbus Slave IDs.

On the DXM100-Sx Modbus Slave models, use the DIP switches at location K to define the lower digit of the Modbus Slave ID.

DIP Switch location J defines the course group of Modbus Slave IDs. DIP Switch 4 must be set to ON for DXM100-S1, DXM100-S2, DXM100-S1R2, and DXM100-S2R2 models.

Settings	Location J DIP Switches			
	1	2	3	4
Modbus Slave ID set to 11 through 19	OFF	OFF		
Modbus Slave ID set to 20 through 29	ON	OFF		
Modbus Slave ID set to 30 through 39	OFF	ON		
Modbus Slave ID set to 40 through 49	ON	ON		
Not Used			-	
Modbus Slave Configuration (DX100-S1 and -S1R2 models only) <sup>1</sup>				ON
Standard Communication Mode				OFF

DIP Switches J		DIP Switch K, Switches 1, 2, 3, 4 (0 is OFF, 1 is ON)									
1	2	0,0,0,0	1,0,0,0	0,1,0,0	1,1,0,0	0,0,1,0	1,0,1,0	0,1,1,0	1,1,1,0	0,0,0,1	1,0,0,1
OFF	OFF	x <sup>2</sup>	11	12	13	14	15	16	17	18	19
ON	OFF	20	21	22	23	24	25	26	27	28	29
OFF	ON	30	31	32	33	34	35	36	37	38	39
ON	ON	40	41	42	43	44	45	46	47	48	49

**DXM100-Sx Modbus Slave Example**—To set the DXM100-Sx Modbus Slave to a Modbus Slave ID of 34, set the following:

- Location J DIP switches set to 1=OFF, 2=ON
- Location K DIP switches set to 1=OFF, 2=OFF, 3=ON, 4=OFF

The location J DIP switches set the upper Modbus Slave ID digit to 3 while the location K DIP switches set the lower digit to 4.

**Setting the DXM I/O Board Modbus Slave ID using Modbus Registers**—Write to the I/O board's Modbus register 6804 to set the Modbus Slave ID to any valid Modbus Slave ID (1 through 245).

- For the DXM100-Sx Modbus Slave model, all switches on DIP switch K should be in the OFF position to use the Modbus register slave ID.

<sup>1</sup> Must be in the ON position for the -S1 and -S1R2 model)

<sup>2</sup> Uses value in Modbus register 6804.

## 3.2 Applying Power to the DXM100-Sx Modbus Slave

Apply power to the DXM100-Sx Modbus Slave using either 12 to 30 V DC or a 12 V DC solar panel and 12 V sealed lead acid battery.

Pin	Description
Pin 1	No connection
Pin 2	12 to 30 V DC input (+) or solar panel connection (+)
Pins 3, 5, 8, 17, 26, 29	Main logic ground for the DXM100-Sx Modbus Slave
Pin 4	Solar or backup battery positive input. Battery voltage must be less than 15 V dc. Use only a sealed lead acid (SLA) battery.

### 3.2.1 Connecting a Battery

When attaching a battery to the DXM100 as a backup battery or as a solar battery, verify the charging algorithm is set properly. The factory default setting for the battery charging algorithm assumes you are using 12 to 30 V DC to recharge the battery.

The charging algorithm is designed to work with a sealed lead acid (SLA) battery only.

- When using 12 to 30 V DC, connect the 12 to 30 V DC + to pin 2 and connect the ground to pin 3.
- When using main dc power with a back up battery (default configuration), connect the incoming main power pin 2 (+) and to pin 3 (-). Connect the 12 V sealed lead acid battery to pin 4 (+) and pin 5 (-). The incoming main power must be 15 to 30 V dc to charge the battery.

### 3.2.2 Supplying Power from a Solar Panel

To power the DXM100-Sx Modbus Slave from a 12 V dc solar panel, connect the solar panel to power pins 2(+) and 3(-). Connect a 12 V dc sealed lead acid (SLA) rechargeable battery to pins 4(+) and 5(-).

The factory default setting for the battery charging configuration assumes you are using 12 to 30 V DC power to recharge the battery. If the incoming power is from a solar panel, you must change the charging configuration.

The battery charging configuration defaults to a battery backup configuration. To change the charging configuration from the menu system:

1. From the DXM100 LCD menu, navigate to **System Config > I/O Board > Charger**.
2. Select **Solar** for solar panel configurations or **DC** for battery backup configurations.

To change the charging configuration by writing to Modbus register 6071 on the I/O base board (Slave ID 11):

1. Write a 0 to select the solar power charging configuration.

## 3.3 Connecting the Communication Pins

The base board communications connection for external Modbus device uses the primary RS-485.

**RS-485.** The primary RS-485 bus is a common bus shared with the ISM radio board (Modbus Slave ID 1).

**RS-232.** The RS-232 bus is not currently defined.

Pin	Parameter	Description
Pin 6	Primary RS-485 -	Use this bus to connect other Modbus Slave devices into the wireless network. Modbus Register 6101 = Baud Rate 0 = 19.2k 1 = 9600 2 = 38400 Modbus Register 6103 = Parity 0 = no parity 1 = odd 2 = even
Pin 7	Primary RS-485 +	
Pin 9	RS-232 Tx	Serial RS-232 connection. This bus must use a ground connection between devices to operate correctly.
Pin 10	RS-232 Rx	

Pin	Parameter	Description
Pin 13	Secondary RS-485 -	Not used
Pin 14	Secondary RS-485 +	
Pin 15	CANL -	
Pin 16	CANH +	

## 3.4 Inputs and Outputs

The I/O base board is a Modbus slave device that communicates using Modbus commands. Refer to the Modbus Registers section for more descriptions of each Modbus register on the DXM100-Sx Modbus Slave.

### 3.4.1 Universal Inputs

The universal inputs on the DXM100-Sx Modbus Slave can be programmed to accept several different types of inputs:

- Discrete NPN/PNP
- 0 to 20 mA analog
- 0 to 10 V analog
- 10k temperature thermistor
- Potentiometer sense
- Bridge
- NPN raw fast

Any input can be used as a synchronous counter by configuring the input as a discrete NPN/PNP input.

Use the DXM Configuration Software tool to write to the appropriate Modbus registers in the I/O board to configure the input type. The universal inputs are treated as analog inputs. When the universal inputs are defined as mA, V, or temperature, use Modbus registers to configure the operational characteristics of the inputs. These parameters are temperature conversion type, enable full scale, threshold and hysteresis. Refer to the DXM100 Controller Instruction Manual (p/n 190037) for the parameter definitions.

When a universal input is configured as an NPN or PNP input type, it can be enabled to be a synchronous counter. Enable the counter function by setting Modbus register 'Enable Rising' or 'Enable Falling' to 1. See [Modbus I/O Registers for the DXM100-S1x I/O Base Board](#) on p. 24 for universal input register definitions.

Pin	Universal Input	Modbus Register	Description
27	4	4	Program the universal inputs to accept input types NPN, PNP, 10k thermistor, 0 to 10 V, 0 to 20 mA, or potentiometer. The default setting is 8: NPN raw fast. To set the input type, write the following values to the Input Type Modbus registers defined in <a href="#">Modbus I/O Registers for the DXM100-S1x I/O Base Board</a> on p. 24.
28	3	3	
31	2	2	
32	1	1	

0 = NPN  
1 = PNP  
2 = 0 to 20 mA  
3 = 0 to 10 V DC  
4 = 10k Thermistor  
5 = Not used  
6 = Not used  
7 = Bridge  
8 = NPN Raw Fast (default)

#### Thermistor Input

A thermistor input must use a 10k temperature thermistor between ground and the universal input. The thermistor must be a 10k NTC (Banner model number BWA-THERMISTOR-002) or equivalent. Select the temperature conversion of degrees C (default) or degrees F by writing Modbus registers defined in [Modbus I/O Registers for the DXM100-S1x I/O Base Board](#) on p. 24.

#### Potentiometer Input

A potentiometer input is created from three inputs: a voltage source (pin 30) that supplies 5 V to the potentiometer and two inputs set to voltage inputs to read the voltage across the potentiometer. See the DXM tech note for setting up a potentiometer.

#### Bridge Input

The bridge input is not implemented yet.

### NPN vs NPN Raw Fast

The difference between NPN and NPN Raw Fast is the amount of settling time given to the input. Switch the input type to NPN if the input is not detecting a transition.

### Synchronous Counters

When an input is configured as a counter (inputs set to NPN/PNP), the input counts the input signal transitions. The count value is stored into two 16-bit Modbus registers for a total count of 32-bits (unsigned). To program an input to capture the edge transition counts, follow [Example: Configure Input 1 as a Synchronous Counter](#) on p. 14.

Synchronous counter sample the inputs every 10 ms. The input logic does not detect rising or falling edges, but instead samples the input every 10 ms to find level changes. The input signals must be high or low for more than 10 ms or the input will not detect transitions. Because most signals are not perfect, a realistic limit for the synchronous counter would be 30 to 40 Hz.

### Example: Configure Input 1 as a Synchronous Counter

1. Change the **Source Register** selection to **I/O Board Registers**.
2. In the **Write Registers** area, write Modbus register 4908 to 1 to enable counting on the rising edge of the input signal.
3. Read Modbus registers 4910 and 4911 to get the 32-bit value of the count.

### Example: Change Universal Input 2 to a 0 to 10 V dc Input

1. Write a 3 to Modbus register 3326 on Modbus Slave ID 11 (I/O board).
2. Cycle power to the device.
3. Using the **Register View** tab, read register 3326 to verify it is set to 3.

### Example: Change Analog Output 1 to a 0 to 10 V dc Output

1. Change the **Source Register** selection to **I/O Board Registers**.
2. Set jumper 1 on the I/O base board to the 0 to 10 V position. Refer to the base board image for the analog output jumper position.
3. Write a 3 to Modbus register 4008 on Modbus Slave ID 11 (I/O board).
4. Cycle power to the device.
5. Using the **Register View** tab, read register 4008 to verify it is set to 3.

## 3.4.2 NMOS Outputs

Pin	NMOS Discrete Outputs	Modbus Register	Description	Wiring
22	4	504	Less than 1 A maximum current at 30 V dc ON-State Saturation: Less than 0.7 V at 20 mA ON Condition: Less than 0.7 V OFF Condition: Open	
23	3	503		
24	2	502		
35	1	501		

## 3.4.3 Analog (DAC) Outputs for the B1 and S1 Models

The B1 and S1 analog outputs may be configured as either 0 to 20 mA outputs (default) or 0 to 10 V outputs.

To change the analog (DAC) output type:

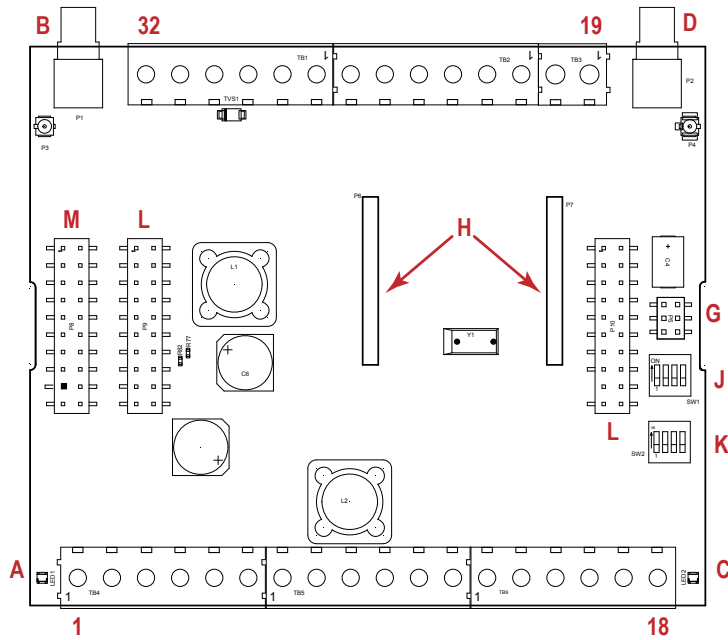
1. Remove power to the device.
2. Remove the DXM cover.
3. Change the hardware jumper position (see the table for the pin number and [I/O Base Board Connections for the B1 Models](#) for the pin locations).
4. Replace the DXM cover.
5. Restore power to the DXM.

- Set the Output Type Select Modbus register (on the I/O board, Slave ID 200) to a value of 2 (default) to select 0 to 20 mA or a value of 3 to select 0 to 10 V. For analog output 1 write to Modbus register 4008, for analog output 2 write to Modbus register 4028 (see the table for the values).

DXM100/1000-B1 and S1 Models			
Pin	Analog Output	Modbus Register	Description
20	1	507	0 to 20 mA or 0 to 10 V dc output (I/O board jumper selectable) Accuracy: 0.1% of full scale +0.01% per °C Resolution: 12-bit
19	2	508	

# 4 I/O Base Board for the DXM100-S2 Model

## 4.1 I/O Base Board for the B2 and S2 Models



1	No connection	12	2B. DLatch 2B	23	N3. NMOS OUT 3
2	PW. 12–30 V DC or solar power in (+)	13	S-. Secondary RS-485 – (not used for the S2)	24	N2. NMOS OUT 2
3	GD. Ground	14	S+. Secondary RS-485 + (not used for the S2)	25	N1. NMOS OUT 1
4	B+. Battery in (< 15 V DC)	15	SP. SDI-12 Courtesy Power	26	GD. Ground
5	GD. Ground	16	SD. SDI-12 Data	27	U4. Universal Input 4
6	M-. Primary RS-485 –	17	GD. GND	28	U3. Universal Input 3
7	M+. Primary RS-485 +	18	P3. Courtesy Power 5 V	29	GD. Ground
8	GD. Ground	19	A2. Analog OUT 2 (0–10 V)	30	P1. Adjustable Courtesy Power (5–24 V)
9	1A. DLatch 1A	20	A1. Analog OUT 1 (0–10 V)	31	U2. Universal Input 2
10	1B. DLatch 1B	21	P2. Adjustable Courtesy Power (5–24 V)	32	U1. Universal Input 1
11	2A. DLatch 2A	22	N4. NMOS OUT 4		

A	Base board LED			J	Modbus Slave ID DIP Switches
B	A1. Cellular or secondary antenna			K	Modbus Slave ID DIP Switches
C	Radio LED	G	Programming header	L	Processor Board Connection
D	A2. ISM Antenna	H	ISM Radio Board Connection	M	Display Connection

### 4.1.1 DIP Switches for the I/O Board

The DXM100-Sx Modbus Slave I/O board DIP switches are set from the factory to Modbus Slave ID 11.



## 4.1.2 Setting the Modbus Slave ID on the I/O Base Board

Only DXM100-S1 and -S1R2 Slave models require that the Modbus Slave ID be adjusted on the I/O base board. The DXM100-Sx Modbus Slave models use DIP switches J and K to set the Modbus Slave ID. This device can use a Modbus register 6804 in the I/O board to access the full range of Modbus Slave IDs.

On the DXM100-Sx Modbus Slave models, use the DIP switches at location K to define the lower digit of the Modbus Slave ID.

DIP Switch location J defines the course group of Modbus Slave IDs. DIP Switch 4 must be set to ON for DXM100-S1, DXM100-S2, DXM100-S1R2, and DXM100-S2R2 models.

Settings	Location J DIP Switches			
	1	2	3	4
Modbus Slave ID set to 11 through 19	OFF	OFF		
Modbus Slave ID set to 20 through 29	ON	OFF		
Modbus Slave ID set to 30 through 39	OFF	ON		
Modbus Slave ID set to 40 through 49	ON	ON		
Not Used			-	
Modbus Slave Configuration (DX100-S1 and -S1R2 models only) <sup>3</sup>				ON
Standard Communication Mode				OFF

DIP Switches J		DIP Switch K, Switches 1, 2, 3, 4 (0 is OFF, 1 is ON)									
1	2	0,0,0,0	1,0,0,0	0,1,0,0	1,1,0,0	0,0,1,0	1,0,1,0	0,1,1,0	1,1,1,0	0,0,0,1	1,0,0,1
OFF	OFF	x <sup>4</sup>	11	12	13	14	15	16	17	18	19
ON	OFF	20	21	22	23	24	25	26	27	28	29
OFF	ON	30	31	32	33	34	35	36	37	38	39
ON	ON	40	41	42	43	44	45	46	47	48	49

**DXM100-Sx Modbus Slave Example**—To set the DXM100-Sx Modbus Slave to a Modbus Slave ID of 34, set the following:

Location J DIP switches set to 1=OFF, 2=ON

Location K DIP switches set to 1=OFF, 2=OFF, 3=ON, 4=OFF

The location J DIP switches set the upper Modbus Slave ID digit to 3 while the location K DIP switches set the lower digit to 4.

**Setting the DXM I/O Board Modbus Slave ID using Modbus Registers**—Write to the I/O board's Modbus register 6804 to set the Modbus Slave ID to any valid Modbus Slave ID (1 through 245).

- For the DXM100-Sx Modbus Slave model, all switches on DIP switch K should be in the OFF position to use the Modbus register slave ID.

## 4.2 Applying Power to the DXM100-Sx Modbus Slave

Apply power to the DXM100-Sx Modbus Slave using either 12 to 30 V DC or a 12 V DC solar panel and 12 V sealed lead acid battery.

Pin	Description
Pin 1	No connection
Pin 2	12 to 30 V DC input (+) or solar panel connection (+)
Pins 3, 5, 8, 17, 26, 29	Main logic ground for the DXM100-Sx Modbus Slave
Pin 4	Solar or backup battery positive input. Battery voltage must be less than 15 V dc. Use only a sealed lead acid (SLA) battery.

<sup>3</sup> Must be in the ON position for the -S1 and -S1R2 model)

<sup>4</sup> Uses value in Modbus register 6804.

## 4.2.1 Connecting a Battery

When attaching a battery to the DXM100 as a backup battery or as a solar battery, verify the charging algorithm is set properly. The factory default setting for the battery charging algorithm assumes you are using 12 to 30 V DC to recharge the battery.

The charging algorithm is designed to work with a sealed lead acid (SLA) battery only.

- When using 12 to 30 V DC, connect the 12 to 30 V DC + to pin 2 and connect the ground to pin 3.
- When using main dc power with a back up battery (default configuration), connect the incoming main power pin 2 (+) and to pin 3 (-). Connect the 12 V sealed lead acid battery to pin 4 (+) and pin 5 (-). The incoming main power must be 15 to 30 V dc to charge the battery.

## 4.2.2 Supplying Power from a Solar Panel

To power the DXM100-Sx Modbus Slave from a 12 V dc solar panel, connect the solar panel to power pins 2(+) and 3(-). Connect a 12 V dc sealed lead acid (SLA) rechargeable battery to pins 4(+) and 5(-).

The factory default setting for the battery charging configuration assumes you are using 12 to 30 V DC power to recharge the battery. If the incoming power is from a solar panel, you must change the charging configuration.

The battery charging configuration defaults to a battery backup configuration. To change the charging configuration from the menu system:

1. From the DXM100 LCD menu, navigate to **System Config > I/O Board > Charger**.
2. Select **Solar** for solar panel configurations or **DC** for battery backup configurations.

To change the charging configuration by writing to Modbus register 6071 on the I/O base board (Slave ID 11):

1. Write a 0 to select the solar power charging configuration.

## 4.3 Connecting the Communication Pins

The base board communications connection for external Modbus device uses the primary RS-485.

**RS-485.** The primary RS-485 bus is a common bus shared with the ISM radio board (Modbus Slave ID 1).

**RS-232.** The RS-232 bus is not currently defined.

Pin	Parameter	Description
Pin 6	Primary RS-485 -	Use this bus to connect other Modbus Slave devices into the wireless network. Modbus Register 6101 = Baud Rate 0 = 19.2k 1 = 9600 2 = 38400 Modbus Register 6103 = Parity 0 = no parity 1 = odd 2 = even
Pin 7	Primary RS-485 +	
Pin 9	RS-232 Tx	Serial RS-232 connection. This bus must use a ground connection between devices to operate correctly.
Pin 10	RS-232 Rx	
Pin 13	Secondary RS-485 -	Not used
Pin 14	Secondary RS-485 +	
Pin 15	CANL -	
Pin 16	CANH +	

## 4.4 Inputs and Outputs

The I/O base board is a Modbus slave device that communicates using Modbus commands. Refer to the Modbus Registers section for more descriptions of each Modbus register on the DXM100-Sx Modbus Slave.

### 4.4.1 Universal Inputs

The universal inputs on the DXM100-Sx Modbus Slave can be programmed to accept several different types of inputs:

- Discrete NPN/PNP
- 0 to 20 mA analog
- 0 to 10 V analog
- 10k temperature thermistor
- Potentiometer sense
- Bridge
- NPN raw fast

Any input can be used as a synchronous counter by configuring the input as a discrete NPN/PNP input.

Use the DXM Configuration Software tool to write to the appropriate Modbus registers in the I/O board to configure the input type. The universal inputs are treated as analog inputs. When the universal inputs are defined as mA, V, or temperature, use Modbus registers to configure the operational characteristics of the inputs. These parameters are temperature conversion type, enable full scale, threshold and hysteresis. Refer to the DXM100 Controller Instruction Manual (p/n 190037) for the parameter definitions.

When a universal input is configured as an NPN or PNP input type, it can be enabled to be a synchronous counter. Enable the counter function by setting Modbus register 'Enable Rising' or 'Enable Falling' to 1. See [Modbus I/O Registers for the DXM100-S1x I/O Base Board](#) on p. 24 for universal input register definitions.

Pin	Universal Input	Modbus Register	Description
27	4	4	Program the universal inputs to accept input types NPN, PNP, 10k thermistor, 0 to 10 V, 0 to 20 mA, or potentiometer. The default setting is 8: NPN raw fast. To set the input type, write the following values to the Input Type Modbus registers defined in <a href="#">Modbus I/O Registers for the DXM100-S1x I/O Base Board</a> on p. 24. 0 = NPN 1 = PNP 2 = 0 to 20 mA 3 = 0 to 10 V DC 4 = 10k Thermistor 5 = Not used 6 = Not used 7 = Bridge 8 = NPN Raw Fast (default)
28	3	3	
31	2	2	
32	1	1	

### Thermistor Input

A thermistor input must use a 10k temperature thermistor between ground and the universal input. The thermistor must be a 10k NTC (Banner model number BWA-THERMISTOR-002) or equivalent. Select the temperature conversion of degrees C (default) or degrees F by writing Modbus registers defined in [Modbus I/O Registers for the DXM100-S1x I/O Base Board](#) on p. 24.

### Potentiometer Input

A potentiometer input is created from three inputs: a voltage source (pin 30) that supplies 5 V to the potentiometer and two inputs set to voltage inputs to read the voltage across the potentiometer. See the DXM tech note for setting up a potentiometer.

### Bridge Input

The bridge input is not implemented yet.

### NPN vs NPN Raw Fast

The difference between NPN and NPN Raw Fast is the amount of settling time given to the input. Switch the input type to NPN if the input is not detecting a transition.

### Synchronous Counters

When an input is configured as a counter (inputs set to NPN/PNP), the input counts the input signal transitions. The count value is stored into two 16-bit Modbus registers for a total count of 32-bits (unsigned). To program an input to capture the edge transition counts, follow [Example: Configure Input 1 as a Synchronous Counter](#) on p. 14.

Synchronous counter sample the inputs every 10 ms. The input logic does not detect rising or falling edges, but instead samples the input every 10 ms to find level changes. The input signals must be high or low for more than 10 ms or the input will not detect transitions. Because most signals are not perfect, a realistic limit for the synchronous counter would be 30 to 40 Hz.

## Example: Configure Input 1 as a Synchronous Counter

1. Change the **Source Register** selection to **I/O Board Registers**.
2. In the **Write Registers** area, write Modbus register 4908 to 1 to enable counting on the rising edge of the input signal.
3. Read Modbus registers 4910 and 4911 to get the 32-bit value of the count.

### Example: Change Universal Input 2 to a 0 to 10 V dc Input

1. Write a 3 to Modbus register 3326 on Modbus Slave ID 11 (I/O board).
2. Cycle power to the device.
3. Using the **Register View** tab, read register 3326 to verify it is set to 3.

### Example: Change Analog Output 1 to a 0 to 10 V dc Output

1. Change the **Source Register** selection to **I/O Board Registers**.
2. Set jumper 1 on the I/O base board to the 0 to 10 V position. Refer to the base board image for the analog output jumper position.
3. Write a 3 to Modbus register 4008 on Modbus Slave ID 11 (I/O board).
4. Cycle power to the device.
5. Using the **Register View** tab, read register 4008 to verify it is set to 3.

## 4.4.2 NMOS Outputs

Pin	NMOS Discrete Outputs	Modbus Register	Description	Wiring
22	4	504	Less than 1 A maximum current at 30 V dc ON-State Saturation: Less than 0.7 V at 20 mA ON Condition: Less than 0.7 V OFF Condition: Open	
23	3	503		
24	2	502		
35	1	501		

## 4.4.3 Analog (DAC) Outputs for the B2 and S2 Models

The B2 and S2 analog outputs are 0 to 10 V dc outputs and cannot be changed.

DXM100/1000-B2 and S2 Models			
Pin	Analog Output	Modbus Register	Description
20	1	509	0 to 10 V dc output
19	2	510	Accuracy: 0.1% of full scale +0.01% per °C Resolution: 12-bit

## 4.4.4 DC Latching Outputs for the B2 and S2 Models

Pin	DC Latching Outputs	Modbus Register	Description	Wiring
9	D1A	507	Write a 1 to the output register to activate the DC Latching output from A to B.	
10	D1B			
11	D2A	508	Write a 0 to the output register to deactivate the DC Latching output from B to A.	
12	D2B			

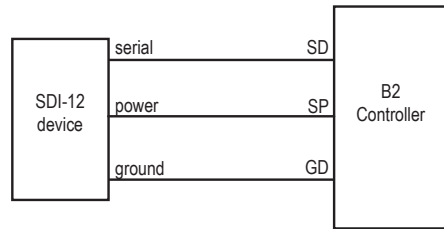
The DXM Configuration Software allows the user to adjust parameters that govern the operation of the DC latch outputs. Most applications will not require any changes for correct operation. Software parameters include:

- **Enable H-Bridge**— Enable or disable the H-bridge output. Default Enabled.
- **Voltage**— The voltage applied to the output when the output is activated. Default 13 V dc.
- **Cap Warmup Time**— The amount of time given to charge the output capacitor. The more time given to charge the output capacitor the more energy will be available to turn on the output. Default 80 ms
- **Switch Time**— The amount of time the output is turned on to be able to change the solenoid output. Default 40 ms

### 4.4.5 SDI-12 Interface for the B2 and S2 Models

The SDI-12 interface on the B2 Wireless Controllers can support up to five devices with twelve 32-bit register values each. The 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!".

Use the configuration software to adjust the SDI-12 parameters.



### 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 DXM100 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) <sup>5</sup>	11002 (10)
SDI-12 Device/CMD 2	1701 (0)	11201 (49)	11202 (10)

<sup>5</sup> The default device addresses 48 through 52 are in ASCII.

Device/CMD Configuration	Registers (Default Value)		
	Enable	Device Address	Device Command
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)

## SDI-12 Device Result Registers

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

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

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

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

## 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 0.010 second counts. For example, the default value is 22,500, which calculates to a sample rate of  $22500 \times 0.010$  seconds. Adjusting this value affects the battery life.

- **Warmup time.** Amount of time to wait, in 0.010 second increments, from powering on the device to the time to send communications to the device. The default value is 50, or 50 × 0.010 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) <sup>6</sup>	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)	<a href="#">SDI-12 and the Acclima TDT SDI-12 Soil Moisture Probe</a>
Adcon Telemetry	HydraProbell	
AquaCheck	Sub-surface Probe	<a href="#">SDI-12 and the AquaCheck Sub-Surface Soil Moisture Probe</a>
Decagon	MPS-2, MPS-6, 5TE, TS1, T8	<a href="#">SDI-12 and the Decagon 5TE Soil Moisture Probe</a> <a href="#">SDI-12 and the Decagon GS3 Soil Moisture Probe</a> <a href="#">SDI-12 and the Decagon MPS-2 Soil Moisture Probe</a>
HSTI	HydraScout	<a href="#">SDI-12 and the HydraScout HSTI Probe</a>
Sentek	EnviroSCAN	<a href="#">SDI-12 and the Sentek EnviroScan Soil Moisture Probe</a>

<sup>6</sup> The default device addresses 48 through 52 are in ASCII.

## 5 Additional Information

### 5.1 Adjusting the Receive Slots and Retry Count Parameters

The number of receive slots governs how often a MultiHop device can communicate on the wireless network.

Battery-powered devices typically have DIP switches that allow the user to set the number of receive slots, which directly affects the battery life of the radio. Adjusting the receive slots changes how often a message can be received. By default, the receive slots are set to 4 (every 1.3 seconds). When the receive slots are set to 32, the radio listens for an incoming message every 0.16 seconds.

Users may also leave the retry mechanism to the application that is accessing the wireless network, in this case the DXM100. Adjust the number of retries in the MultiHop devices by writing the number of retries desired to Modbus register 6012. The factory default setting is 8.

### 5.2 Modbus Register Summary

#### 5.2.1 Modbus I/O Registers for the DXM100-S1x I/O Base Board

The I/O base board stores the input and output values in Modbus holding registers. Since the I/O base board is defined as a separate device, configure the DXM100 to read or write the values on the I/O base board.

Base Board Input Connection		
Modbus Register	Range	Description
1	0-65535	Universal input 1
2	0-65535	Universal input 2
3	0-65535	Universal input 3
4	0-65535	Universal input 4

Universal Input Register Ranges			
Register Types	Unit	Minimum Value	Maximum Value
Discrete input/output		0	1
Universal input 0 to 10 V	mV	0	10000 *
Universal input 0 to 20 mA	µA	0	20000 *
Universal input temperature (-40 °C to +85 °C)	C or F, signed, in tenths of a degree	-400	850
Universal potentiometer	unsigned	0	65535

\* Setting Enable Full Scale to 1 sets the ranges to a linear scale of 0 to 65535.

Base Board Output Connection		
Modbus Register	Range	Description
501	0-1	NMOS Output 1
502	0-1	NMOS Output 2
503	0-1	NMOS Output 3
504	0-1	NMOS Output 4
505	0-1	Switched Power 1 (5 V or 16 V)
506	0-1	Switched Power 2 (5 V or 16 V)
507	0-20000	Analog Output 1 default (0-20.000 mA)
	0-10000	Analog Output 1 (0-10.000 V)



Base Board Output Connection		
Modbus Register	Range	Description
508	0-20000	Analog Output 2 default (0-20.000 mA)
	0-10000	Analog Output 2 (0-10.000 V)

## Modbus Configuration Registers for the Universal Inputs

Each input or output on the I/O base board has associated Modbus registers that configure its operation.

Universal Input Parameters Registers				
Universal Inputs	1	2	3	4
Enable Full Scale Registers	3303	3323	3343	3363
Temperature °C/°F Registers	3304	3324	3344	3364
Input Type Registers	3306	3326	3346	3366
Threshold Registers	3308	3328	3348	3368
Hysteresis Registers	3309	3329	3349	3369
Enable Rising Registers	4908	4928	4948	4968
Enable Falling Registers	4909	4929	4949	4969
High Register for Counter Registers	4910	4930	4950	4970
Low Register for Counter Registers	4911	4931	4951	4971

## Modbus Configuration Registers for the Analog Output

The I/O base board has two analog outputs that are selectable as 0 to 20 mA (factory default) or 0 to 10 V. To change the analog output characteristic, physical jumpers must be change on the I/O board and a parameter Modbus register must be changed. For step by step instructions on changing the output characteristics see [Analog \(DAC\) Outputs for the B1 and S1 Models](#) on p. 14.

Parameters for Analog Output 1 start at 4001 through 4008. Parameters for Analog Output 2 start at 4021 through 4028.

Registers for Analog Output (4xxxx) Parameters			
Analog output 1	Analog output 2	Description	Values
4001	4021	Maximum Analog Value	
4002	4022	Minimum Analog Value	
4003	4023	Enable Register Full Scale	0 = Store readings in unit-specific data 1 = Linear rate from 0 to 65535
4004	4024	Hold Last State Enable	0 = Disables Hold Last State and uses the Default Output State setting during an error condition 1 = Sets the output to its last known value
4005	4025	Default Output State	
4008	4028	Analog Output Type	0 to 20 mA or 0 to 10 V dc output (I/O board jumper selectable) Accuracy: 0.1% of full scale +0.01% per °C Resolution: 12-bit After changing the jumper position, write the appropriate value to the Modbus registers to define your analog output to match the setting selected by the jumper. 2 = 0 to 20 mA output (default) 3 = 0 to 10 V output
2952		Enable Default Communication Timeout	0 = Disable 1 = Enable

Registers for Analog Output (4xxxx) Parameters			
Analog output 1	Analog output 2	Description	Values
	2953	Communication Default I/O Timeout (100 ms/Count)	Number of 100 ms periods
	2954	Enable Default on Power Up	0 = Disable 1 = Sends device outputs to their default condition

**Analog Output Type**—The analog outputs may be configured as either 0 to 20 mA outputs (default) or 0 to 10 V outputs. To change the analog output type change the hardware jumper position and write to the Modbus register that defines the analog output type. For analog output 1, write to Modbus register 4008, for analog output 2 write to Modbus register 4028. Write a value of 2 (default) to select 0 to 20 mA; write a value of 3 to select 0 to 10 V.

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

- **2952 Enable Default Communication Timeout**— A “communication timeout” refers to the communication between any Modbus master host and the DXM baseboard. Set this register to 1 to enable the default condition when the host has not communicated with the DXM baseboard 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 DXM baseboard is powered up. Set to 0 to disable this feature.

**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. To define the error conditions for device outputs, refer to the MultiHop default output parameters 2950-2954.

**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.

## Modbus Configuration Registers for Power

To monitor the input power characteristics of the DXM100, read the following power Modbus registers. The on-board thermistor is not calibrated, but can be used as a non-precision temperature input.

Modbus Register	Description
6071	Battery backup charging algorithm. 0 = Battery is recharged from a solar panel 1 = Battery is recharged from 12 to 30 V dc . (default)
6081	Battery voltage (mV)
6082	Battery charging current (mA)
6083	Incoming supply voltage (mV) (solar or power supply)
6084	On-board thermistor temperature (°C)

### Battery voltage

If no battery is present, the value in this register is less than 5 V. If the value in this register is greater than the incoming voltage register, the battery is powering the system.

**Battery charging current**

The charging configuration charges the battery when the incoming voltage register value is greater than the battery voltage register value. This registers shows the charging current in milliamps.

**Incoming supply voltage**

The incoming power can be from a solar panel or from a power supply. The battery is charging when the incoming voltage register value is greater than the battery voltage register value. The battery is powering the system when the incoming voltage register value is less than the battery voltage register value.

**On-board thermistor temperature**

A thermistor measures the temperature of the solar controller board and its surrounding area and uses the temperature as part of the battery charge calculations. This register stores the thermistor reading in tenths of degrees C. This is not a calibrated input: divide by 10 to calculate the temperature in degrees C.

For calibrated temperature inputs, define one of the universal inputs as a temperature input.

## 5.2.2 Modbus I/O Registers for the DXM100-S2x I/O Base Board

The I/O base board stores the input and output values in Modbus holding registers. Since the I/O base board is defined as a separate device, configure the DXM100 to read or write the values on the I/O base board.

Base Board Input Connection		
Modbus Register	Range	Description
1	0-65535	Universal input 1
2	0-65535	Universal input 2
3	0-65535	Universal input 3
4	0-65535	Universal input 4

Universal Input Register Ranges			
Register Types	Unit	Minimum Value	Maximum Value
Discrete input/output		0	1
Universal input 0 to 10 V	mV	0	10000 *
Universal input 0 to 20 mA	μA	0	20000 *
Universal input temperature (-40 °C to +85 °C)	C or F, signed, in tenths of a degree	-400	850
Universal potentiometer	unsigned	0	65535

\* Setting Enable Full Scale to 1 sets the ranges to a linear scale of 0 to 65535.

Base Board Output Connection		
Modbus Register	Range	Description
501	0-1	NMOS Output 1
502	0-1	NMOS Output 2
503	0-1	NMOS Output 3
504	0-1	NMOS Output 4
505	0-1	Switched Power 1 (5 V or 16 V)
506	0-1	Switched Power 2 (5 V or 16 V)
507	0-20000	Analog Output 1 default (0-20.000 mA)
	0-10000	Analog Output 1 (0-10.000 V)
508	0-20000	Analog Output 2 default (0-20.000 mA)
	0-10000	Analog Output 2 (0-10.000 V)

### 5.2.3 Modbus Configuration Registers for the Universal Inputs

Each input or output on the I/O base board has associated Modbus registers that configure its operation.

Universal Input Parameters Registers				
Universal Inputs	1	2	3	4
Enable Full Scale Registers	3303	3323	3343	3363
Temperature °C/°F Registers	3304	3324	3344	3364
Input Type Registers	3306	3326	3346	3366
Threshold Registers	3308	3328	3348	3368
Hysteresis Registers	3309	3329	3349	3369
Enable Rising Registers	4908	4928	4948	4968
Enable Falling Registers	4909	4929	4949	4969
High Register for Counter Registers	4910	4930	4950	4970
Low Register for Counter Registers	4911	4931	4951	4971

### 5.2.4 Modbus Configuration Registers for the Analog Output

The I/O base board has two analog outputs that are selectable as 0 to 20 mA (factory default) or 0 to 10 V. To change the analog output characteristic, physical jumpers must be change on the I/O board and a parameter Modbus register must be changed. For step by step instructions on changing the output characteristics see [Analog \(DAC\) Outputs for the B1 and S1 Models](#) on p. 14.

Parameters for Analog Output 1 start at 4001 through 4008. Parameters for Analog Output 2 start at 4021 through 4028.

Registers for Analog Output (4xxxx) Parameters			
Analog output 1	Analog output 2	Description	Values
4001	4021	Maximum Analog Value	
4002	4022	Minimum Analog Value	
4003	4023	Enable Register Full Scale	0 = Store readings in unit-specific data 1 = Linear rate from 0 to 65535
4004	4024	Hold Last State Enable	0 = Disables Hold Last State and uses the Default Output State setting during an error condition 1 = Sets the output to its last known value
4005	4025	Default Output State	
4008	4028	Analog Output Type	0 to 20 mA or 0 to 10 V dc output (I/O board jumper selectable) Accuracy: 0.1% of full scale +0.01% per °C Resolution: 12-bit After changing the jumper position, write the appropriate value to the Modbus registers to define your analog output to match the setting selected by the jumper. 2 = 0 to 20 mA output (default) 3 = 0 to 10 V output
2952		Enable Default Communication Timeout	0 = Disable 1 = Enable
2953		Communication Default I/O Timeout (100 ms/Count)	Number of 100 ms periods
2954		Enable Default on Power Up	0 = Disable 1 = Sends device outputs to their default condition

**Analog Output Type**—The analog outputs may be configured as either 0 to 20 mA outputs (default) or 0 to 10 V outputs. To change the analog output type change the hardware jumper position and write to the Modbus register that defines the analog output type. For analog output 1, write to Modbus register 4008, for analog output 2 write to Modbus register 4028. Write a value of 2 (default) to select 0 to 20 mA; write a value of 3 to select 0 to 10 V.

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

- **2952 Enable Default Communication Timeout**— A “communication timeout” refers to the communication between any Modbus master host and the DXM baseboard. Set this register to 1 to enable the default condition when the host has not communicated with the DXM baseboard 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 DXM baseboard is powered up. Set to 0 to disable this feature.

**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. To define the error conditions for device outputs, refer to the MultiHop default output parameters 2950-2954.

**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  $\mu\text{A}$  (micro Amps) and voltage values are stored as mV (millivolts).

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

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

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

## 5.2.5 Modbus Configuration Registers for the I/O (Definitions)

### Enable 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  $\mu\text{A}$  (micro Amps) and voltage values are stored as mV (millivolts).

### Enable Rising/Falling

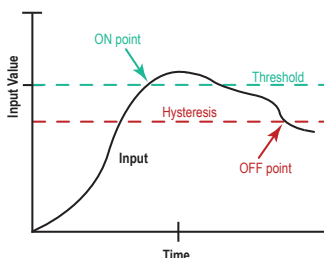
Use these registers to enable the universal input logic to count on a rising transition or a falling transition. Write a one (1) to enable; write a zero (0) to disable.

### High/Low Register for Counter

The low and high registers for the counter hold the 32-bit counter value. To erase the counter, write zeroes to both registers. To preset a counter value, write that value to the appropriate register.

### Hysteresis and Threshold

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



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

### Input Type

Program the universal inputs to accept input types NPN, PNP, 10k thermistor, 0 to 10 V, 0 to 20 mA, or potentiometer. The default setting is 8: NPN raw fast. To set the input type, write the following values to the Input Type Modbus registers.

- 0 = NPN
- 1 = PNP
- 2 = 0 to 20 mA
- 3 = 0 to 10 V dc
- 4 = 10k Thermistor
- 5 = Potentiometer Sense (DXM150 only)
- 6 = Not used
- 7 = Bridge
- 8 = NPN Raw Fast (default)

### Temperature °C/°F

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

## 5.2.6 Modbus Configuration Registers for Power

To monitor the input power characteristics of the DXM100, read the following power Modbus registers. The on-board thermistor is not calibrated, but can be used as a non-precision temperature input.

Modbus Register	Description
6071	Battery backup charging algorithm. 0 = Battery is recharged from a solar panel 1 = Battery is recharged from 12 to 30 V dc . (default)
6081	Battery voltage (mV)
6082	Battery charging current (mA)
6083	Incoming supply voltage (mV) (solar or power supply)
6084	On-board thermistor temperature (°C)

### Battery voltage

If no battery is present, the value in this register is less than 5 V. If the value in this register is greater than the incoming voltage register, the battery is powering the system.

### Battery charging current

The charging configuration charges the battery when the incoming voltage register value is greater than the battery voltage register value. This registers shows the charging current in milliamps.

### Incoming supply voltage

The incoming power can be from a solar panel or from a power supply. The battery is charging when the incoming voltage register value is greater than the battery voltage register value. The battery is powering the system when the incoming voltage register value is less than the battery voltage register value.

### On-board thermistor temperature

A thermistor measures the temperature of the solar controller board and its surrounding area and uses the temperature as part of the battery charge calculations. This register stores the thermistor reading in tenths of degrees C. This is not a calibrated input: divide by 10 to calculate the temperature in degrees C.

For calibrated temperature inputs, define one of the universal inputs as a temperature input.

## 5.3 Using Courtesy Power or Switch Power

Pin 18 of the DXM100-Sx Modbus Slave is a constant power source that supplies 5 volts up to 500 mA.

Pins 21 (switch power 2) and 30 (switch power 1) are switched power outputs. Configure the switched power outputs using Modbus registers or by using the DXM Configuration Software's **Settings > I/O Board** screen. The output voltage can be selected and is controlled using a Modbus register on the I/O board (Modbus slave ID 200). The voltage options are:

- 5 volts or 16 volts for DXM100-B1 models; or
- 5 to 24 V dc for DXM100-B2 models.

Turn the switched power on or off using the output register 505 for switch power 1 or 506 for switch power 2. For continuous power, set the Default Output register to 1, then cycle the power.

Switch Power	Enable Register	Enable Register Value	Voltage Register	Voltage Register Value	Default Output Register	Output Register
1 (pin 30)	2201	Write a 0 to turn OFF Write a 1 to turn ON (default)	3601	Write a 0 to select 5 V (default) Write a 1 to select 16 V Write a __ to select 24 V (DXM100-B2 model only)	3602	505
2 (pin 21)	2251		3621		3622	506

#### Enable Register

Configuration registers that turn on the ability to use the switched power output.

Default setting = ON

#### Voltage Register

Configuration registers that define the output voltage to the switched power output.

Default setting = 5 V

#### Default Output Register

Configuration registers that turn on the switched power outputs for continuous power out.

Set register to 1 for continuous power. Cycle power if this register is changed.

Default setting = 0

#### Modbus Output Register

Turn on or turn off the voltage output. If both outputs 505 and 506 are turned on at the same time but are set to different voltages, the output voltage is 5 V for DXM100-B1 models and set to the lower voltage setting for DXM100-B2 models.

## 5.4 Associating a Switched Power Output to an Input

Use the DXM Configuration Software to associate a switched power output to a universal input.

Switched power 1 and 2 (pins 30 and 21) can be associated to any Universal input to apply power to a sensor, take a reading, and then remove power from the sensor. This conserves power in battery-operated systems. The switched power supply can be used in one of two different ways: supplying courtesy power to an output pin or associated to an input. (Only one method can be active at a time.)

To manually configure the switched power output using I/O board Modbus registers, write the specified value to the listed register.

Courtesy Power Output Configuration Parameters <sup>7</sup>	Modbus Registers to Write To	
	Switched Power 1	Switched Power 2
Switched Power Enable	2201	2251
Voltage	3601	3621
Default Output	3602	3622
Output Register	505	506

#### Default Output

Set the register value to 1 for continuous power. The default setting is 0.

Cycle power if this register value is changed.

#### Output Register

Write to the Output register to turn on or turn off the voltage output.

If both Output Registers 505 and 506 are turned on at the same time, but are set to different voltages, the output voltage is 5 V for DXM100-B1 models and set to the lower voltage setting for DXM100-B2 models.

<sup>7</sup> Only used when supply courtesy power to the output pin, not when associating switched power to an input.

### Switched Power Enable

Enables the switched power supply. Set to 1 to enable; set to 0 to disable.

This does not enable the supply output to the actual output pin. To enable the supply output to the output pin, set Modbus register 505 or 506 to 1. Set to 0 when associating the switched power supply to an input.

### Voltage

For the B1 and S1 models, set the Modbus register value to 0 for a switched power supply at 5 volts. Set the Modbus register value to 1 for a switched power supply at 16 volts.

For the B2 and S2 models, set one of the following register values to select your switched power output voltage.

- For 5 V, set the Modbus register to 204.
- For 7 V, set the Modbus register to 125.
- For 10 V, set the Modbus register to 69.
- For 15 V, set the Modbus register to 32.
- For 20 V, set the Modbus register to 12.
- For 24 V, set the Modbus register to 3.

When associating a switched power supply to an input, set the **Switch Power Output Enable** register to off (0). Set Modbus register 2201 for switched power 1 and Modbus register 2251 for switched power 2. This allows the input sampling mechanism to control the output.

Use the following configuration parameters to define the switch power associated with an input.

Input Parameter	Universal Input Configuration Parameter Modbus Registers to Write To			
	Universal Input 1	Universal Input 2	Universal Input 3	Universal Input 4
Input Enable	1001	1051	1101	1151
Sample Interval (high)	1002	1052	1102	1152
Sample Interval (low)	1003	1053	1103	1153
Switched Power Enable Mask	1004	1054	1104	1154
Switched Power Warmup	1005	1055	1105	1155
Switched Power Voltage	1006	1056	1106	1156
Extended Input Read	1007	1057	1107	1157
Input Out-of-Sync Enable	1008	1058	1108	1158

### 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 the Extended Input Read parameter is set in the Universal input 1 configuration registers, set Universal inputs 2 through 4 **Extended Input Read** and **Sample Interval** parameters to zero.

### Input Enable

Set to 1 to enable the input. Set to 0 to disable the input.

### Out-of-Sync Enable

To enable the input to continue operating when the device is out of sync with the master radio, set to 1.

To disable the input when the device is not synchronized to the master radio, set to 0.

### Sample Interval (high), Sample Interval (low)

The sample interval (rate) is a 32-bit value (requires two Modbus registers) that represents how often the I/O board samples the input.

The register value is the number of time units. One time unit is equal to 0.01 seconds.

For example, a Modbus register value of 1000 represents a sample interval of 10 seconds (1000 × 0.010 seconds = 10 seconds).



### Switch Power Enable Mask

The Switch Power Enable Mask works with the warm-up and voltage parameters to define the switch power output. The bit mask can select any number of switch powers.

- 0x0 - No switch power enabled
- 0x1 - Enable Switch Power 1
- 0x2 - Enable Switch Power 2
- 0x3 - Enable Switch Power 1 and Switch Power 2

### 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 Courtesy Power Voltage parameter to control the voltage.

See *Voltage* entry for Modbus register values used to select the output voltage.

### Switch Power Warm-up

When an input controls 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, and a time unit is 0.01 seconds. For a warm-up time of 1 second, this parameter value is 100 (0.01 seconds × 100 = 1 second).

## Associate Universal Input 1 with Switch Power 1

To associate universal input 1 with switched power 1, follow these instructions. Set Input 1 to sample every 60 seconds, with a warmup time of 10 seconds.

1. Verify Switched Power 1 Output Enable is off (0). Set Modbus Register 2201 = 0
2. Set the **Sample Interval** to 1 minute. Modbus Registers 1002 = 0, 1003 = 6000 (0.01 seconds × 6000 = 60 seconds).
3. Set the **Switched Power Enable Mask** to use Switch Power 1. Modbus Register 1004 = 1
4. Set the **Switched Power Warm-up** time to 10 seconds. Modbus Register 1005 = 1000 (0.01 seconds × 1000 = 10 seconds).
5. Set the **Switched Power Voltage** to 16 volts. Modbus Register 1006 = 1.

## 5.5 Working with Solar Power

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A reliable solar system requires careful planning and monitoring to size the components correctly. The recommendations provided are for the DXM100 system as an autonomous system.

Adding extra components increases the power requirements and likely requires increasing the solar system components. Depending upon the geographical location, the size of the solar panel and battery may vary.

### 5.5.1 Setting the DXM100 for Solar Power

By default, the DXM100 is set from the factory to charge a backup battery from a line power source.

### 5.5.2 Solar Components

The components of a solar system include the battery and the solar panel.

#### Battery

The DXM solar controller is designed to use a 12 V sealed lead acid (SLA) battery. The characteristics of a solar system require the battery to be of a certain type. There are two types of lead acid batteries:

- SLI batteries (Starting Lights Ignition) designed for quick bursts of energy, like starting engines
- Deep Cycle batteries - greater long-term energy delivery. This is the best choice for a solar battery.

Since a solar system charges and discharges daily, a deep cycle battery is the best choice. There are different versions of a lead acid battery: wet cell (flooded), gel cell, and an absorbed glass mat (AGM).

Wet cell batteries are the original type of rechargeable battery and come in two styles, serviceable and maintenance free. Wet cell batteries typically require special attention to ventilation as well as periodic maintenance but are the lowest cost. The gel cell and AGM battery are sealed batteries that cost more but store very well and do not tend to sulfate or degrade as easily as a wet cell. Gel or AGM batteries are the safest lead acid batteries you can use.

**Battery capacity** is a function of the ambient temperature and the rate of discharge. Depending upon the specific battery, a battery operating at -30 °C can have as much as 40 percent less capacity than a battery operating at 20 °C. Choose enough battery capacity based on your geographical location.

A larger capacity battery typically lasts longer for a given solar application because lead-acid batteries do not like deep cycling (discharging a large percentage of its capacity). Depending upon the battery, a battery discharging only 30 percent of its capacity before recharging will have approximately 1100 charge/discharge cycles. The same battery discharging 50 percent of its capacity will have approximately 500 charge/discharge cycles. Discharging 100 percent leaves the battery with only 200 charge/discharge cycles.

Batteries degrade over time based on discharge/charge cycles and environmental conditions. Always monitor the battery system to obtain the best performance of the solar powered system.

Use this as a guide to the approximate state of charge and in determining when to apply conservation measures.

Average Voltage Readings Relative to Battery Change	
State of Charge (%)	Open Circuit Voltage
100	13.0 or higher
75	12.6
50	12.1
25	11.66
0	11.4 or less

## Solar Panel

Banner solar panels come in two common sizes for the DXM100: 5 Watt and 20 Watt. Both panels are designed to work with the DXM100 but provide different charging characteristics. Use the 5 watt panel for light duty operation and use the 20 watt panel when you require greater charging capabilities.

Solar Panel	Voltage	Current	Typical DXM Configurations
5 Watt	17 V	0.29 A	DXM slave controller, ISM radio, I/O base board
20 Watt	21 V	1 A	DXM Controller with ISM radio and Cellular modem

Photovoltaic panels are very sensitive to shading. Unlike solar thermal panels, PV solar panels cannot tolerate shading from a branch of a leafless tree or small amounts of snow in the corners of the panel. Because all cells are connected in a series string, the weakest cell will bring down the other cells' power level.

Good quality solar panels will not degrade much from year to year, typically less than 1 percent .

To capture the maximum amount of solar radiation throughout the year, mount a fixed solar panel to optimize the sun's energy. For the northern hemisphere, face the panel true south. For the southern hemisphere, face the panel true north. If you are using a compass to orientate the panels, compensate for the difference between true north and magnetic north. Magnetic declination varies across the globe.

A solar panel's average tilt from horizontal is at an angle equal to the latitude of the site location. For optimum performance, adjust the tilt by plus 15 degrees in the winter or minus 15 degrees in the summer. For a fixed panel with a consistent power requirement throughout the year, adjust the tilt angle to optimize for the winter months: latitude plus 15 degrees. Although in the summer months the angle may not be the most efficient, there are more hours of solar energy available.

For sites with snow in the winter months, the increased angle helps to shed snow. A solar panel covered in snow produces little or no power.

### 5.5.3 Recommended Solar Configurations

These solar panel and battery combinations assume direct sunlight for two to three hours a day. Solar insolation maps provide approximate sun energy for various locations. The depth of battery discharge is assumed to be 50 percent.

Solar panel and battery combinations for a DXM100 system				
Solar Panel	Battery Capacity <sup>8</sup>	Days of Autonomy	DXM mA	DXM Controller
5 watt	10 Ahr	10 days	25 mA	DXM Slave Controller - ISM radio and I/O base board
20 watt	14 Ahr	10 days	30 mA	DXM Controller with ISM radio
20 watt	20 Ahr	10 days	35 mA	DXM Controller with ISM radio and Cellular Modem

<sup>8</sup> Battery capacity (amp hour) is standard amp rating taken for 20 hours. Battery capacity should be monitored for reliable system power and may need to be increased for cold weather locations.

### 5.5.4 Monitoring Solar Operation

The DXM solar controller provides Modbus registers that allow the user to monitor the state of the solar panel input voltage, the battery voltage, the charging current, and the temperature in °C. The DXM100 can be configured to monitor the health of the charging system as well as send an alert message when the battery is too low.

The charts show a typical charging cycle, with each vertical grid representing about eight hours. The chart shows three days of charging.

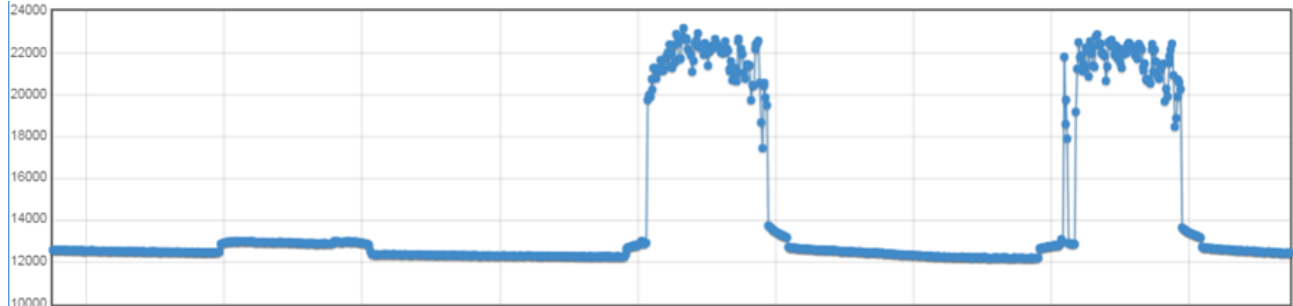


Figure 3. Solar Panel Voltage (mV) -- Cloudy First Day

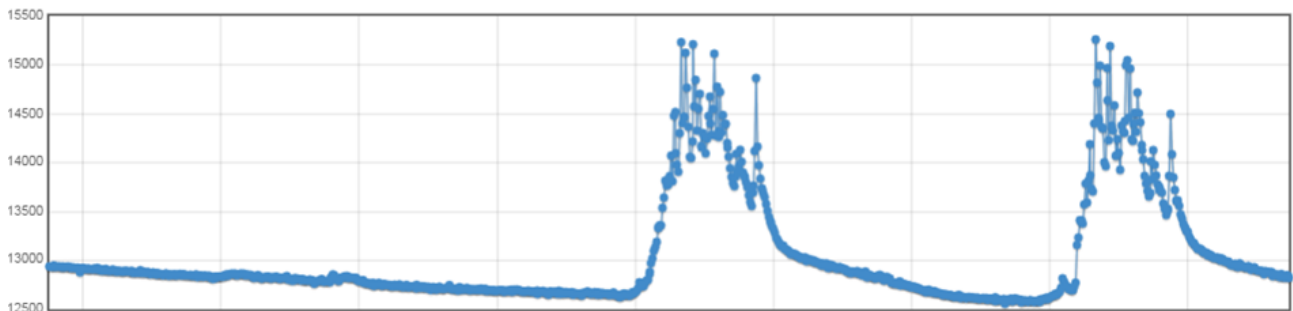
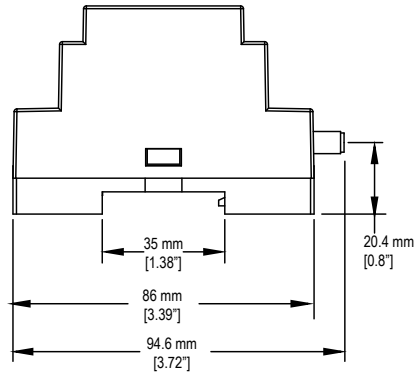
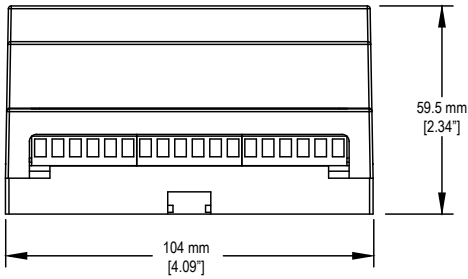
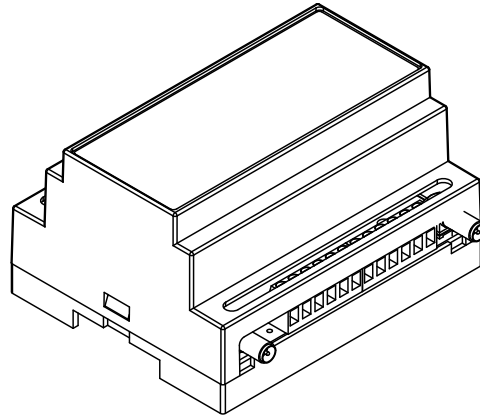
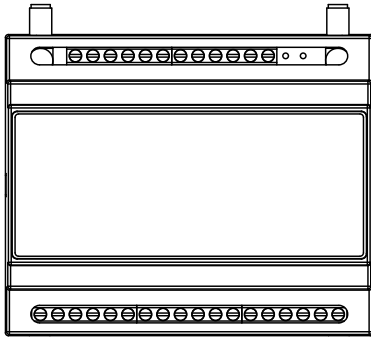


Figure 4. Battery Voltage (mV) - Cloudy First Day

## 6 DXM100 and DXM1000 Dimensions

All measurements are listed in millimeters, unless noted otherwise.



## 7 Accessories

For a complete list of all the accessories for the Sure Cross wireless product line, please download the Accessories List (p/n [b\\_3147091](#)).

### Cordsets

MQDC1-506—5-pin M12/Euro-style, straight, single ended, 6 ft  
 MQDC1-530—5-pin M12/Euro-style, straight, single ended, 30 ft  
 MQDC1-506RA—5-pin M12/Euro-style, right-angle, single ended, 6 ft  
 MQDC1-530RA—5-pin M12/Euro-style, right-angle, single ended, 30 ft

### Static and Surge Suppressor

BWC-LFNBMN-DC—Surge Suppressor, bulkhead, N-Type, dc Blocking, N-Type Female, N-Type Male

### Short-Range Omni Antennas

BWA-2O2-D—Antenna, Dome, 2.4 GHz, 2 dBi, RP-SMA Box Mount  
 BWA-9O2-D—Antenna, Dome, 900 MHz, 2 dBi, RP-SMA Box Mount  
 BWA-9O2-RA—Antenna, Rubber Fixed Right Angle, 900 MHz, 2 dBi, RP-SMA Male Connector

### Medium-Range Omni Antennas

BWA-9O5-C—Antenna, Rubber Swivel, 900 MHz 5 dBi, RP-SMA Male Connector  
 BWA-2O5-C—Antenna, Rubber Swivel, 2.4 GHz 5 dBi, RP-SMA Male Connector

### Enclosures and DIN Rail Kits

[BWA-AH864](#)—Enclosure, Polycarbonate, with Opaque Cover, 8 × 6 × 4  
[BWA-AH1084](#)—Enclosure, Polycarbonate, with Opaque Cover, 10 × 8 × 4  
[BWA-AH12106](#)—Enclosure, Polycarbonate, with Opaque Cover, 12 × 10 × 6  
 BWA-AH8DR—DIN Rail Kit, 8", 2 trilobular/self-threading screws  
 BWA-AH10DR—DIN Rail Kit, 10", 2 trilobular/self-threading screws  
 BWA-AH12DR—DIN Rail Kit, 12", 2 trilobular/self-threading screws

### Misc Accessories

BWA-CG.5-3X5.6-10—Cable Gland Pack: 1/2-inch NPT, Cordgrip for 3 holes of 2.8 to 5.6 mm diam, 10 pack  
 BWA-HW-052— Cable Gland and Vent Plug Pack: includes 1/2-inch NPT gland, 1/2-inch NPT multi-cable gland, and 1/2-inch NPT vent plug, one each

### Antenna Cables

BWC-1MRSMN05—LMR200 RP-SMA to N-Type Male, 0.5 m  
 BWC-2MRSFRS6—LMR200, RP-SMA Male to RP-SMA Female Bulkhead, 6 m  
 BWC-4MNFN6—LMR400 N-Type Male to N-Type Female, 6 m

### Long-Range Omni Antennas

BWA-9O8-AS—Antenna, Fiberglass, 3/4 Wave, 900 MHz, 8 dBi, N-Type Female Connector  
 BWA-2O8-A—Antenna, Fiberglass, 2.4 GHz, 8 dBi, N-Type Female Connector

### Long-Range Yagi Antennas

BWA-9Y10-A—Antenna, 900 MHz, 10 dBd, N-Type Female Connector

### Cellular Antenna

BWA-CELLA-002—Cellular multiband, 2 dBi, RP-SMA male connection, 6.3 inch blade style. Datasheet: [b\\_4475176](#)

### Power Supplies

[PSD-24-4](#)—DC Power Supply, Desktop style, 3.9 A, 24 V dc, Class 2, 4-pin M12/Euro-style quick disconnect (QD)  
[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  
[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  
[BWA-SOLAR PANEL 20W](#)—Solar Panel, 12 V, 20 W, Multicrystalline, 573 × 357 × 30, "L" style mounting bracket included (does not include controller)

## 8 Product Support and Maintenance

### 8.1 Restoring Factory Default Settings for the I/O Base Board

To reset the I/O base board to factory defaults, write to two Modbus registers in the base board. The default slave ID for the base board is 11.

To reset the DXM I/O base board parameters back to factory defaults:

1. Write a 1 to Modbus register 4152
2. Write a 10 to Modbus register 4151

To reboot (cycle power) the DXM I/O base board:

1. Write a 0 to Modbus register 4152
2. Write a 10 to Modbus register 4151

Restoring Factory Defaults for the I/O Base Board		
Register	Values	Description
4151	0-255	Reset/restore trigger. This timer is based in 100 millisecond units. Once written, the timer starts to count down to zero. After the timer expires, the restore factory defaults are applied if register 4152 = 1. If register 4152 is zero, the I/O board is reset. Default value: 0 1 = 100 milliseconds, 10 = 1 second.
4152	0-1	0 = Reboots (cycles power) to the I/O base board 1 = Restores factory defaults for I/O parameters

### 8.2 DXM100 Documentation

- DXM Wireless Controller Sell Sheet, p/n [194063](#)
- DXM100-B1 Wireless Controller Datasheet, p/n [186724](#)
- DXM100-B2 Wireless Controller Datasheet, p/n [195232](#)
- DXM100-Bx Wireless Controller Instruction Manual, p/n [190037](#)
- DXM100-S1 Modbus Slave Datasheet, p/n [195454](#)
- DXM100-S2 Modbus Slave Datasheet, p/n [195231](#)
- DXM100-Sx Modbus Slave Instruction Manual, p/n [188231](#)
- DXM ScriptBasic Instruction Manual, p/n [191745](#)
- DXM Controller API Protocol, p/n [186221](#)
- DXM Controller Configuration Quick Start, p/n [191247](#)
- SolutionsKit-AG1 Quick Start Guide, p/n [212028](#)
- DXM Configuration Software v4 (p/n [b\\_4496867](#))
- DXM Configuration Software v4 Instruction Manual, p/n [209933](#)
- DXM EDS [Configuration file](#) for Allen-Bradley PLCs
- EIP Configuration File for DXM 1xx-BxR1 and R3 models, p/n [194730](#)
- Banner CDS Web Service Quick Start Guide, p/n [201126](#)
- Banner CDS Web Service Instruction Manual, p/n [178337](#)
- Activating a Cellular Modem, p/n [b\\_4419353](#)
- Additional technical notes and videos

For more information about the DXM100 family of products, including technical notes, configuration examples, and ScriptBasic programs, please visit [www.bannerengineering.com](http://www.bannerengineering.com).

### 8.3 DXM100 Support Policy

The DXM Wireless Controllers are industrial wireless controllers that facilitate Industrial Internet of Things (IIoT) applications. As a communications gateway, it interfaces local serial ports, local I/O ports, and local ISM radio devices to the Internet using either a cellular connection or a wired Ethernet network connection. In a continuing effort to provide the best operation for the DXM100, stay connected with Banner Engineering Corp to hear about the latest updates through the Banner website. Create a login today to stay informed of all Banner product releases.

### 8.3.1 Firmware Updates

The DXM100 has been designed to be a robust and secure IOT device. To provide the most reliable and secure device possible, periodic firmware updates are released to enhance and expand the capabilities of the DXM100. Firmware updates and description details are found on the Banner website. Customers with critical update requirements will get access to pre-released firmware from the factory.

### 8.3.2 Website Information

The Banner website is the main method of disseminating DXM100 information to customers. The data found on the website include:

- DXM instruction manuals
- Configuration manuals
- Firmware downloads
- Firmware release notes
- Errata data, any known issues with a release of firmware
- Possible work-around solutions for known issues
- DXM Solutions Guides

### 8.3.3 Feature Requests

Our customer is our most valuable resource to improve our DXM100. If you have suggestions for improvements to the DXM100 or configuration tools, please contact Banner Engineering Corp.

### 8.3.4 Potential DXM Issues

Potential issues with the DXM100 are collected from Banner's support engineers to provide solutions. Users can get help from the website documentation or by calling Banner Engineering for support help. Solutions are as simple as configuration adjustments, work-around configuration solutions, or potential new firmware updates.

### 8.3.5 DXM Security

The DXM100 was designed to collect local wireless sensor data, local sensor data, provide simple control, and send the data to the cloud.

The DXM100 does not run a Linux or Windows based operating system but an embedded real-time operating system (RTOS) environment. As a proprietary operating system, the security aspects are easier to manage and minimize.

Security updates are released through the Banner Engineering Corp website ([www.bannerengineering.com](http://www.bannerengineering.com)) and New Product Release Announcements (NPRA).

## 8.4 Contact Us

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Banner Engineering Corp. headquarters is located at:

9714 Tenth Avenue North  
 Minneapolis, MN 55441, USA  
 Phone: + 1 888 373 6767

For worldwide locations and local representatives, visit [www.bannerengineering.com](http://www.bannerengineering.com).

## 8.5 Warnings

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

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

## 8.6 Banner Engineering Corp. Limited Warranty

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

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

This Warranty is exclusive and limited to repair or, at the discretion of Banner Engineering Corp., replacement. **IN NO EVENT SHALL BANNER ENGINEERING CORP. BE LIABLE TO BUYER OR ANY OTHER PERSON OR ENTITY FOR ANY EXTRA COSTS, EXPENSES, LOSSES, LOSS OF PROFITS, OR ANY INCIDENTAL, CONSEQUENTIAL OR SPECIAL DAMAGES RESULTING FROM ANY PRODUCT DEFECT OR FROM THE USE OR INABILITY TO USE THE PRODUCT, WHETHER ARISING IN CONTRACT OR WARRANTY, STATUTE, TORT, STRICT LIABILITY, NEGLIGENCE, OR OTHERWISE.**

Banner Engineering Corp. reserves the right to change, modify or improve the design of the product without assuming any obligations or liabilities relating to any product previously manufactured by Banner Engineering Corp. Any misuse, abuse, or improper application or installation of this product or use of the product for personal protection applications when the product is identified as not intended for such purposes will void the product warranty. Any modifications to this product without prior express approval by Banner Engineering Corp will void the product warranties. All specifications published in this document are subject to change; Banner reserves the right to modify product specifications or update documentation at any time. Specifications and product information in English supersede that which is provided in any other language. For the most recent version of any documentation, refer to: [www.bannerengineering.com](http://www.bannerengineering.com).

For patent information, see [www.bannerengineering.com/patents](http://www.bannerengineering.com/patents).

## 8.7 Glossary of Wireless Terminology

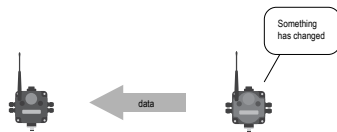
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This definitions list contains a library of common definitions and glossary terms specific to the Wireless products.

- active threshold** An active threshold is a trigger point or reporting threshold for an analog input.
- a/d converter** An analog to digital converter converts varying sinusoidal signals from instruments into binary code for a computer.
- address mode** The Sure Cross® wireless devices may use one of two types of addressing modes: rotary dial addressing or extended addressing. In **rotary dial** address mode, the left rotary dial establishes the network ID (NID) and the right rotary dial sets the device address. **Extended** address mode uses a security code to "bind" Nodes to a specific Gateway. Bound Nodes can only send and receive information from the Gateway they are bound to.
- antenna** Antennas transmit radio signals by converting radio frequency electrical currents into electromagnetic waves. Antennas receive the signals by converting the electromagnetic waves back into radio frequency electrical currents.
- attenuation** Attenuation is the radio signal loss occurring as signals travel through the medium. Radio signal attenuation may also be referred to as free space loss. The higher the frequency, the faster the signal strength decreases. For example, 2.4 GHz signals attenuate faster than 900 MHz signals.
- baseline filter (M-GAGE)** Under normal conditions, the ambient magnetic field fluctuates. When the magnetic field readings drift below a threshold setting, the baseline or drift filter uses an algorithm to slowly match the radio device's baseline to the ambient magnetic field.
- binding (DX80 star networks)** Binding Nodes to a Gateway ensures the Nodes only exchange data with the Gateway they are bound to. After a Gateway enters binding mode, the Gateway automatically generates and transmits a unique extended addressing (XADR), or binding, code to all Nodes within range that are also in binding mode. The extended addressing (binding) code defines the network, and all radios within a network must use the same code.
- After binding your Nodes to the Gateway, make note of the binding code displayed under the **\*DVCFG > XADR** menu on the Gateway's LCD. Knowing the binding code prevents having to re-bind all Nodes if the Gateway is ever replaced.
- binding (MultiHop networks)** Binding MultiHop radios ensures all MultiHop radios within a network communicate only with other radios within the same network. The MultiHop radio master automatically generates a unique binding code when the radio master enters binding mode. This code is then transmitted to all radios within range that are also in binding mode. After a repeater/slave is bound, the repeater/slave radio accepts data only from the master to which it is bound. The binding code defines the network, and all radios within a network must use the same binding code.
- After binding your MultiHop radios to the master radio, make note of the binding code displayed under the **\*DVCFG > -BIND** menu on the LCD. Knowing the binding code prevents having to re-bind all radios if the master is ever replaced.



- binding (serial data radio networks)** Binding the serial data radios ensures all radios within a network communicate only with the other radios within the same network. The serial data radio master automatically generates a unique binding code when the radio master enters binding mode. This code is transmitted to all radios within range that are also in binding mode. After a repeater/slave is bound, the repeater/slave radio accepts data only from the master to which it is bound. The binding code defines the network, and all radios within a network must use the same binding code.
- bit packing i/o** Bit packing uses a single register, or range of contiguous registers, to represent I/O values. This allows you to read or write multiple I/O values with a single Modbus message.
- booster (boost voltage)** A booster is an electronic circuit that increases a battery-level voltage input (3.6V) to a sensor operating voltage output (5 to 20 V).
- CE** The CE mark on a product or machine establishes its compliance with all relevant European Union (EU) Directives and the associated safety standards.
- change of state** Change of state reporting is a report initiated by the Node when a change to the sensor's input state is detected. If the input does not change, nothing is reported to the Gateway.



- channel** A channel may be either a path for communications or a range of radio frequencies used by a transceiver during communication.
- collision** A collision is a situation in which two or more transmissions are competing to communicate on a system that can only handle one transmission at a time. This may also be referred to as a data collision.
- collocated networks** To prevent interference between collocated wireless networks, assign each wireless network a different Network ID. The Network ID is a unique identifier assigned to each wireless network using the rotary dials on the Gateway.
- contention architecture** Contention architecture is a wireless communication architecture that allows all network devices access to the communications channel at the same time. This may lead to transmission collisions.
- counter - event** The event counter counts the total number of times an input signal changes to the high/ON/1 state. The counter increments on the falling edge of an input signal when the signal level crosses the threshold. Event counters can be used to measure the total operational cycles of a spinning shaft or the total number of items traveling down a conveyor.
- counter - frequency** The frequency counter calculates the frequency of the input signal, in Hz. Frequency counters can be used to measure flow rates, such as measuring the flow rate of items on a conveyor or the speed at which a windmill spins.
- cyclic reporting** Cyclic reporting is when the Gateway polls the Node at user-defined intervals.



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



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



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



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

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

**decibel**

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

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

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

**deep sleep mode**

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

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

**default output conditions/triggers**

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

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

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

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

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

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

**default output value**

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

**delta**

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

**determinism**

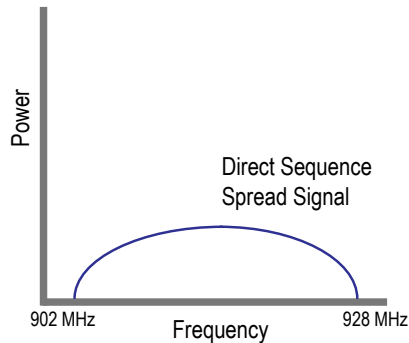
A deterministic system defines how network endpoints behave during the loss of communications. The network identifies when the communications link is lost and sets relevant outputs to user-defined conditions. Once the radio signal is re-established, the network returns to normal operation.

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

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



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



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

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

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

**EtherNet/IP™** EtherNet/IP is Allen-Bradley’s DeviceNet running over Ethernet hardware.

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

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

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

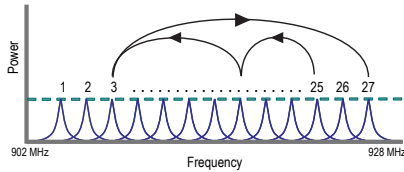
**free space loss (FSL)** The radio signal loss occurring as the signal radiates through free space. Free Space Loss =  $20 \text{ Log } (4(3.1416)d/\lambda)$  where d is in meters. Remembering that  $\lambda f = c = 300 \times 10^6 \text{ m/s}$ , the equations reduce down to:

$$\text{For the 900 MHz radio band: FSL} = 31.5 + 20 \text{ Log } d \text{ (where d is in meters).}$$

For the 2.4 GHz radio band:  $FSL = 40 + 20 \text{ Log } d$  (where  $d$  is in meters.)

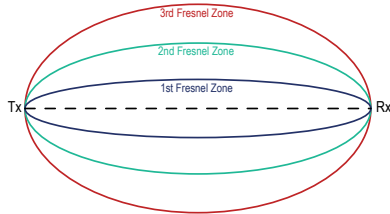
**Frequency Hopping Spread Spectrum (FHSS)**

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



**Fresnel zone**

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



**gain**

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

**gateway**

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

**Gateway**

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

**GatewayPro**

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

**ground loop**

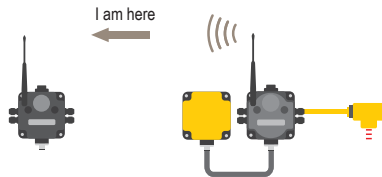
Ground loops are grounds within a system that are not at the same potential. Ground loops can damage electrical systems.

**ground plane**

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

**heartbeat mode**

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



**hibernation/ storage mode**

While in **storage mode**, the radio does not operate. All Sure Cross® radios powered from an integrated battery ship from the factory in storage mode to conserve the battery. To wake the device, press and hold button 1 for 5 seconds. To put any FlexPower® or integrated battery Sure Cross radio into storage mode, press and hold button 1 for 5 seconds. The radio is in storage mode when the LEDs stop

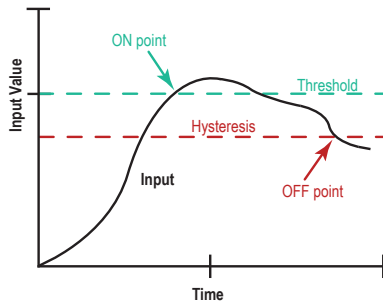
blinking, but in some models, the LCD remains on for an additional minute after the radio enters storage mode. After a device has entered storage mode, you must wait 1 minute before waking it.

For the Wireless Q45 and Q120 Sensors: While in **storage mode**, the DXM100's radio does not operate. The DXM100 ships from the factory in storage mode to conserve the battery. To wake the device, press and hold the binding button (inside the housing on the radio board) for five seconds. To put any DXM100 into storage mode, press and hold the binding button for five seconds. The DXM100 is in storage mode when the LEDs stop blinking.

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

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

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



**Industrial, Scientific, and Medical Band (ISM)**

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

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

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



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

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

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

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

<b>local and non-local registers</b>	Local registers are registers specific to the device in question. When discussing a Gateway, the Gateway's local registers include the registers specific to the Gateway in addition to all the Nodes' registers that are stored in the Gateway. Non-local, or remote, registers refer to registers on other Modbus slave devices, such as other MultiHop slave radios or third-party Modbus devices.
<b>master/slave relationship</b>	The master/slave relationships is the model for a communication protocol between devices or processes in which one device initiates commands (master) and other devices respond (slave). The Sure Cross network is a master/slave network with the Gateway acting as the master device to the Nodes, which are the slave devices. A PC can also be a master device to a wireless sensor network. See <i>star networks</i> .
<b>maximum bad count</b>	The maximum bad count refers to a user-established maximum count of consecutive failed polling attempts before the Gateway considers the radio (RF) link to have failed.
<b>maximum misses</b>	The maximum misses is the number of consecutive polling messages the Node fails to respond to. For more information, see Polling Rate and Maximum Misses.
<b>median filter</b>	When the median filter is turned on, three samples are taken for each analog sensor reading. The high and low values are discarded and the middle value is used as the analog value. Set to zero (0) to turn off the median filter. Set to one (1) to turn on the median filter.
<b>Modbus</b>	Modbus is a master-slave communications protocol typically used for industrial applications.
<b>Modbus/TCP</b>	Modbus/TCP is an open standard protocol very similar to Modbus RTU except that it uses standard Internet communication protocols.
<b>MultiHop</b>	<p>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.</p> <p>The master radio controls the overall timing of the network and is always the parent device for other MultiHop radios. The host system connects to this master radio. Repeater radios extend the range of the wireless network and slave radios are the end point of the wireless network.</p> <p>For more information, refer to the Sure Cross MultiHop Radios Instruction Manual (p/n <a href="#">151317</a>).</p>
<b>multipath fade</b>	Obstructions in the radio path reflect or scatter the transmitted signal, causing multiple copies of a signal to reach the receiver through different paths. Multipath fade is the signal degradation caused by these obstructions.
<b>network ID</b>	The Network ID (NID) is a unique identifier you assign to each wireless network to minimize the chances of two collocated networks interfering with each other. Assigning different NIDs to different networks improves collocation performance in dense installations.
<b>node</b>	A node is any communications point within a network.
<b>Node</b>	Nodes are remote I/O slave devices within Banner's wireless sensor networks. Sensors and other devices connect to the Node's inputs or outputs, allowing the Node to collect sensor data and wirelessly transmit it to the Gateway. Every Sure Cross device is a transceiver, meaning it can transmit and receive data.
<b>noise</b>	Noise is any unwanted electromagnetic disturbances from within the RF equipment, especially the receiver. Noise is more of a concern when signal levels are low.
<b>omni-directional antenna</b>	Omni-directional antennas transmit and receive radio signals equally in all directions.
<b>out of sync/link loss (loss of radio signal)</b>	The Sure Cross wireless devices use a deterministic link time-out method to address RF link interruption or failure. When a radio link fails, all pertinent wired outputs are sent to the selected default value/state until the link is recovered, ensuring that disruptions in the communications link result in predictable system behavior. Following a time-out, all outputs linked to the Node in question are set to 0, 1, or hold the last stable state depending on the value selected.
<b>path loss</b>	Path loss describes attenuation as a function of the wavelength of the operating frequency and the distance between the transmitter and receiver.
<b>path loss (or link loss) calculations</b>	Link loss calculations determine the capabilities of a radio system by calculating the total gain or loss for a system. If the total gain/loss is within a specific range, the radio signal will be received by the radio. <b>Total Gain = Effective output + Free space loss + Total received power</b> . Because the transmitter and

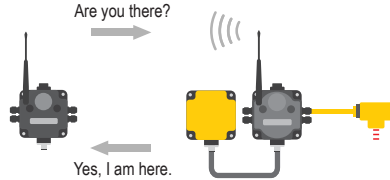
receiver gains are positive numbers and the free space loss is a larger negative number, the total gain of a system should be negative. A link loss calculation may also be called a link budget calculation.

**peer to peer network**

Peer-to-peer is a model for a communication protocol in which any device in the network can send or receive data. Any device can act as a Master to initiate communication.

**polling interval/rate**

The Gateway communicates with, or polls, each Node to determine if the radio link is active. The polling rate defines how often the Gateway communicates with each Node. Polling is always initiated by the Gateway and only verifies radio signal communications.



**polling interval/rate and maximum misses**

The Gateway communicates with, or polls, each Node to determine if the radio link is active. The polling rate, or interval, defines how often the Gateway communicates with each Node. Polling is always initiated by the Gateway and only verifies radio signal communications. Nodes that fail to respond are counted against the 'Maximum Misses' for that Node. If the 'Maximum Misses' is exceeded for any Node, the Gateway generates an RF timeout error in the Modbus I/O register 8 of the appropriate Node. The 'Maximum Misses' is defined as the number of consecutive polling messages that the Node fails to respond to.

**radiation pattern**

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

**re-link count**

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

**remote antenna**

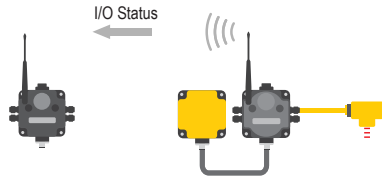
A remote antenna installation is any antenna not mounted directly to the Sure Cross wireless device, especially when coaxial cable is used. Always properly install and ground surge suppressors in remote antenna systems.

**repeater radio**

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

**report interval/rate**

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



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

**rotary dial address mode**

See: *address mode*

**Received Signal Strength Indicator (RSSI)**

An RSSI is the measurement of the strength of received signals in a wireless environment. See *Site Survey*.

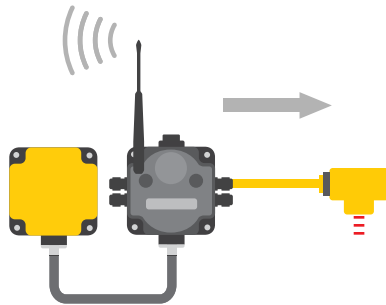
**resistance temperature detector (RTD)**

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

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



- sample high/  
sample low  
(analog I/O)** For analog inputs, the sample high parameter defines the number of consecutive samples the input signal must be above the threshold before a signal is considered active. Sample low defines the number of consecutive samples the input signal must be below the threshold minus hysteresis before a signal is considered deactivated. The sample high and sample low parameters are used to avoid unwanted input transitions.
- sample high/  
sample low  
(discrete I/O)** For discrete inputs, the sample high parameter defines the number of consecutive samples the input signal must be high before a signal is considered active. Sample low defines the number of consecutive samples the input signal must be low before a signal is considered low. The sample high and sample low parameters are used to create a filter to avoid unwanted input transitions. The default value is 0, which disables this feature. The value range is 1 through 255.
- sample interval/  
rate** The sample interval, or rate, defines how often the Sure Cross device samples the input. For battery-powered applications, setting a slower rate extends the battery life.



- sample on demand** Sample on demand allows a host system to send a Modbus command to any register and require the inputs to immediately sample the sensor and report readings back to the host system. Sampling on demand can be used between the normal periodic reporting.  
To use the Sample on Demand feature requires using a host-controlled system capable of sending Modbus commands to the master radio.
- signal-to-noise ratio (SNR)** The signal-to-noise ratio is the ratio of the signal to any background noise or noise generated by the medium. In radio terms, it is a ratio of the transmitted radio signal to the noise generated by any electromagnetic equipment, in particular the radio receiver. The weaker the radio signal, the more of an influence noise has on radio performance. Like gain, the signal-to-noise ratio is measured in decibels.  
The equations for calculating SNR are:  

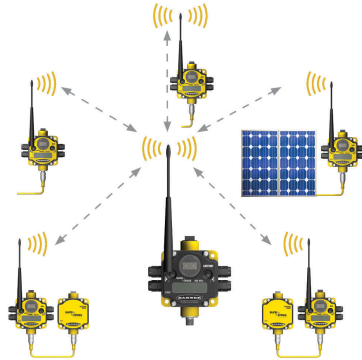
$$\text{SNR} = 20 \times \log (V_s/V_n)$$
 where  $V_s$  is the signal voltage and  $V_n$  is the noise voltage;  

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

$$\text{SNR} = 10 \times \log (P_s/P_n)$$
 where  $P_s$  is the signal power and  $P_n$  is the noise power.
- single-point ground** All grounds within a system are made to a single ground to avoid creating ground loops.
- site survey** Conducting a site survey, also known as a radio signal strength indication (RSSI), analyzes the radio communications link between the Gateway (or master radio) and any Node (or slave radio) within the network by analyzing the radio signal strength of received data packets and reporting the number of missed packets that required a retry.
- slave ID** The slave ID is an identifying number used for devices within a Modbus system. When using more than one Modbus slave, assign each slave a unique ID number.  
By default, Gateways are set to Modbus Slave ID 1.
- sleep mode** During normal operation, the Sure Cross radio devices enter **sleep mode** after 15 minutes of operation. The radio continues to function, but the LCD goes blank. To wake the device, press any button.
- slow scan mode** (All internal battery models) In slow scan mode, the radio wakes up every 15 minutes to search for its parent radio. If a parent or master radio is not found, the radio goes back to sleep for another 15 minutes.



- SMA connector** An SMA connector (SubMiniature version A) is a 50 ohm impedance connector used for coaxial RF connections and developed in the 1960s. An SMA connector is typically used between the radio and the antenna.
- spread spectrum** Spread spectrum is a technique in which the transmitter sends (or spreads) a signal over a wide range of frequencies. The receiver then concentrates the frequencies to recover the information. The Sure Cross radio devices use a version of spread spectrum technology called Frequency Hop Spread Spectrum.
- star networks** A star topology network is a point to multipoint network that places the network master radio in a center or hub position. Slave radios only transmit messages to the master radio, not to each other. These network layouts can be very flexible and typically operate relatively quickly. Slave radios acknowledge receipt of messages transmitted from the master radio.

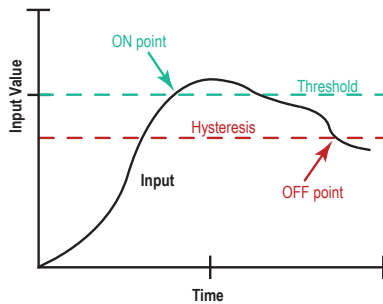


For more information on Banner's star network products, refer to the Sure Cross Performance DX80 Wireless I/O Network Instruction Manual (p/n [132607](#))

- switch power** Efficient power management technology enables some *FlexPower* devices to include an internal power output supply, called switch power (SP), that briefly steps up to power sensors (ideally, 4 to 20 mA loop-powered sensors). The warmup time denotes how long the sensor must be powered before a reliable reading can be taken. After the warmup time has passed, the input reads the sensor, then the switched power shuts off to prolong battery life.
- system operating margin (fade margin)** The system operating margin, or fade margin, is the difference between the received signal level (in dBm) and the receiver sensitivity (also in dBm) required for reliable reception. It is recommended that the receiver sensitivity be more than 10 dBm less than the received signal level. For example, if the signal is about -65 dB after traveling through the air and the radio receiver is rated for -85 dB, the operating margin is 20 dB — an excellent margin.
- tau filter** Set to zero (0) to turn off the tau filter. Set to 1 (weakest filter) through 6 (strongest filter) to turn on the tau filter. (In the DX80 products, the Low Pass Filter is a combination of the median filter and the tau filter.)
- TCP/IP** TCP/IP stands for Transfer Control Protocol / Internet Protocol and describe several layers in the OSI model that control the transfer and addressing of information.
- time-division multiple access (TDMA)** TDMA is a wireless network communication architecture that provides a given slot of time for each device on the network, providing a guaranteed opportunity for each device to transmit to the wireless network master device.
- thermistor** A thermistor is a temperature-sensitive resistor that changes resistance based on temperature fluctuation.
- thermocouple** A thermocouple is a temperature measuring device consisting of two dissimilar metals joined together so that the difference in voltage can be measured. Voltage changes in proportion to temperature, therefore the voltage difference indicates a temperature difference.
- The different “types” of thermocouples use different metal pairs for accuracy over different temperature ranges. Thermocouples are inexpensive, relatively interchangeable, have standard connectors, and have a wide temperature range of operation. They can be susceptible to noise, with the wire length affecting accuracy. Thermocouples are best suited for applications with large temperature ranges, not for measuring small temperature changes over small ranges.

**threshold and hysteresis**

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



In the example shown, the input is considered on at 15 mA. To consider the input off at 13 mA, set the hysteresis to 2 mA. The input will be considered off when the value is 2 mA less than the threshold. Setting threshold and hysteresis points prevents inputs from oscillating between 'on' and 'off' when the input remains close to the threshold point.

**timeout interval**

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

**topology**

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

**transceiver**

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

**wireless sensor network (WSN)**

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

**Yagi**

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

