# DXM150-Sx Wireless Modbus Slave

## Instruction Manual

Original Instructions
195455 Rev. B
13 July 2018


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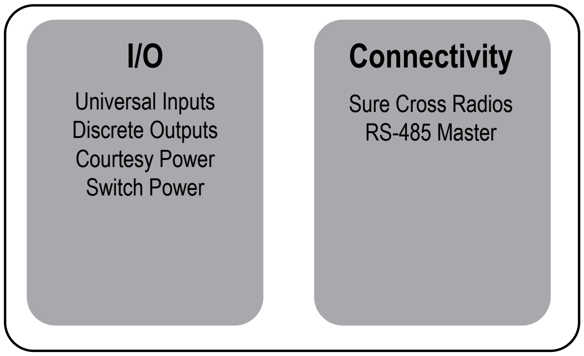
195455

# Contents

# 1 DXM150-Sx Overview

## 1.1 DXM150-Sx Wireless Modbus Slave 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 Master

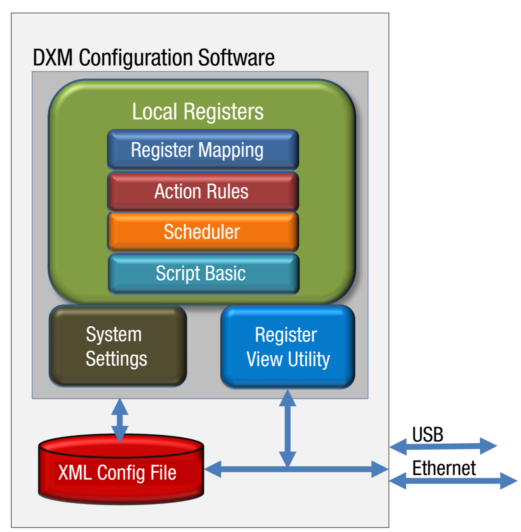
**Wireless Connectivity**
Sure Cross MultiHop 900 MHz, or MultiHop 2.4 GHz

## 1.2 DXM Configuration Tool Overview

The DXM Configuration Tool configures the DXM Modbus Slave by creating an XML file that is transferred to the DXM Modbus Slave using a USB or Ethernet connection. The DXM Modbus Slave 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 DXM Modbus Slave operation. The wireless network devices are a separate configurable system. Use the DX80 User Configuration Tool (UCT) to configure the internal DX80 wireless Gateway and the attached wireless Nodes. Use the MultiHop Configuration Tool (MCT) if the internal radio is a MultiHop device.

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

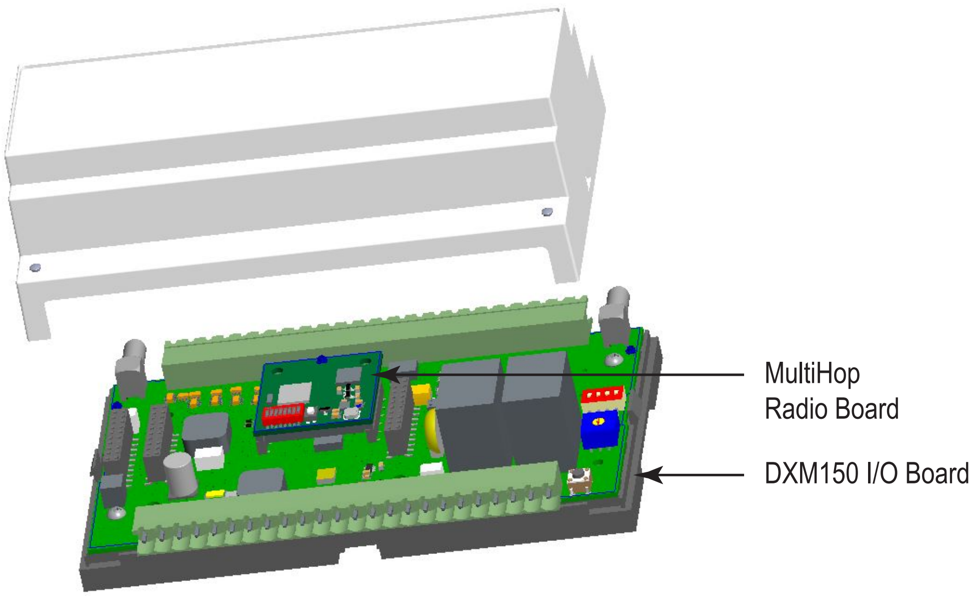


# 2 DXM150-Sx Hardware Overview

## 2.1 DXM Hardware Configuration Overview

The DXM Modbus Slave can have multiple configurations. The DXM Modbus Slave 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 DXM Modbus Slave, follow proper ESD grounding procedures. Refer to the ESD warning in the appendix.




The DXM Modbus Slave 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 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 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 radio or a 2.4 GHz radio.

# 3 ISM Radio

## 3.1 ISM Radio Board (Modbus Slave ID 1)

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

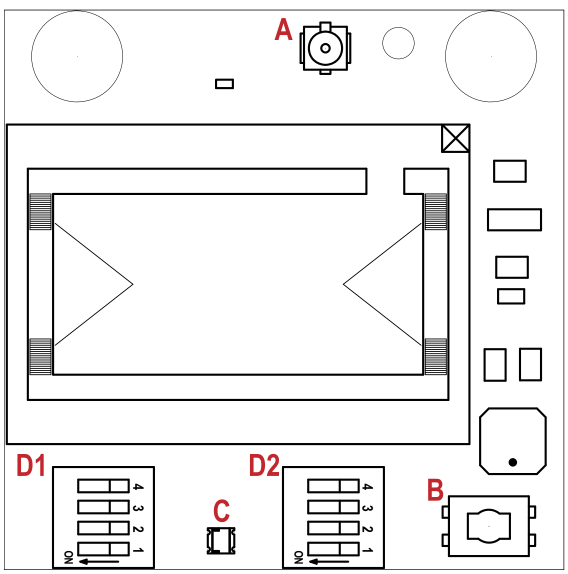
The DX80 MultiHop architecture creates a tree network with a Master radio and one or more Repeater/Slave devices. The MultiHop architecture is suited for networks requiring repeater devices to provide extended range or obstacle avoidance. MultiHop ISM radio devices are defined with R2, R4, and R5 in the model number.

- DXMxxx-xxR2 - MultiHop 900 MHz
- DXMxxx-xxR4 - MultiHop 2.4 GHz
- DXMxxx-xxR5 - MultiHop 900 MHz, 100 mW
- DXMxxx-xxR9 - MultiHop 900 MHz, (Australia)

The DX80 Performance architecture is a star-based architecture with one Gateway radio and 1 to 47 Node devices. The Nodes communicate with the Gateway in a time slot method that is very predictable. DX80 Performance Gateway ISM radio devices are defined with R1, R3, and R8 in the model number.

- DXMxxx-xxR1 - DX80 Performance 900MHz
- DXMxxx-xxR3 - DX80 Performance 2.4GHz
- DXMxxx-xxR8 - DX80 Performance 900MHz (Australia)

The settings outlined below are specific for the DXM Modbus Slave. Not all selections are possible with the DXM Modbus Slave.




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

#### 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.

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

| | D1 Switches | | | | D2 Switches | | | |
|---|---|---|---|---|---|---|---|---|
| Device Settings | 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 | | | | |
| Transmit power<br>900 MHz radios: 1.00 Watt (30 dBm)<br>2.4 GHz radios: 0.065 Watts (18 dBm) and 60 ms frame | | | | | OFF* | | | |
| Transmit power<br>900 MHz radios: 0.25 Watts (24 dBm)<br>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

### 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.

### 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.

### Disable Serial

If the local serial connection is not needed, disable it to reduce the power consumption of a data radio powered from the solar assembly or from batteries. All radio communications remain operational.

### 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.

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

## 3.2 Binding the ISM Radio of a DXM150-Sx Wireless Modbus Slave

A DXM150-Sx Wireless 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 DXM150-Sx Wireless Modbus Slave (as either a repeater or slave radio) to its master radio, follow the 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 Tool to display and configure a MultiHop radio network. With the DXM150-Sx Wireless 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.

# 4 I/O Base Board for the DXM150-S1 Model

## 4.1 Board Connections

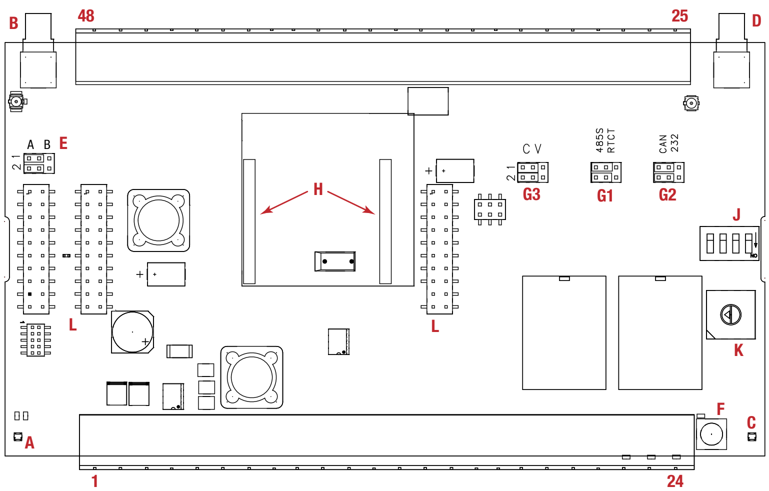



*Figure 1. Board Connections*

| | | | | | |
|---|---|---|---|---|---|
| 1 | NC | 17 | Input 2B | 33 | Analog Output 1 (0 to 10 V) |
| 2 | 12 to 30 V dc or solar power in (+) | 18 | Ground | 34 | Ground |
| 3 | Ground | 19 | Output 1 Normally Open | 35 | PWR Out - Jumper |
| 4 | Battery in (< 15 V dc) (must be a sealed lead acid battery) | 20 | Output 1 Common | 36 | Ground |
| 5 | Ground | 21 | Output 1 Normally Closed | 37 | Universal Input 8 |
| 6 | Primary RS-485 – | 22 | Output 3 Normally Open | 38 | Universal Input 7 |
| 7 | Primary RS-485 + | 23 | Output 3 Common | 39 | Universal Input 6 |
| 8 | Ground | 24 | Output 3 Normally Closed | 40 | Universal Input 5 |
| 9 | Not used | 25 | NMOS Output 5 | 41 | Ground |
| 10 | Not used | 26 | No connection | 42 | Universal Input 4 |
| 11 | Not used | 27 | NMOS Output 6 | 43 | Universal Input 3 |
| 12 | Not used | 28 | NMOS Output 7 | 44 | Ground |
| 13 | Ground | 29 | No connection | 45 | PWR Out - Jumper |
| 14 | Input 1A | 30 | NMOS Output 8 | 46 | Universal Input 2 |
| 15 | Input 1B | 31 | Ground | 47 | Universal Input 1 |
| 16 | Input 2A | 32 | Analog Output 2 (0 to 10 V) | 48 | Ground |

| | | | | | |
|---|---|---|---|---|---|
| A | Base Board LED | E | PWR Out Jumpers | G3 | Analog Output Characteristics Jumpers (Jumper 1 sets analog out 1, jumper 2 sets analog out 2) |
| B | Not Used | F | Radio Binding Button | H | ISM Radio Connection |
| C | Radio LED | G1 | Not Used | J | Modbus Slave ID DIP Switches |
| D | Radio Module Antenna | G2 | Not Used | K | Rotary Dials |
| | | | | L | SAM4 Processor Board Connection |

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

The DXM150-Sx Wireless Modbus Slave I/O board DIP switches are set from the factory to Modbus Slave ID 11. For more information, refer to *Setting the Modbus Slave ID on the I/O Base Board*.

### 4.1.2 I/O Board Jumpers

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 | Courtesy power output | Jumper 2 is the power jumper for pin 45. Jumper 1 is the power jumper for pin 35.<br>• The pin 45 jumper selects 2.7 V when in the "a" position and 12 V battery in the "b" position.<br>• The pin 35 jumper selects 4.2 V when in the "a" position and device power on pin 2 in the "b" position. |
| G1 | RS-485 Modbus Slave or RS-232 Flow Control | Defines the operation of pins 11 and 12. Set the jumpers to use pins 11 and 12 as a secondary Modbus RS-485 slave port or flow control pins for the RS-232 port. Both jumpers must be set to the same operation, RS-485 Modbus Slave or Flow control.<br>The default setting is RS-485. |
| G2 | Generic RS-232 Serial Port or CAN Serial Port | Defines the operation of pins 9 and 10. Set the jumpers to use pins 9 and 10 as a CAN serial port or a generic RS-232 serial port. Both jumpers must be set to the same operation, CAN or RS232.<br>The default setting is CAN serial port. |
| G3 | Analog output characteristics for AO2 (pin 32) and AO1 (pin 33) | Defines current (0–20 mA) or voltage (0–10 V) for analog output 1 and 2.<br>By default, current (0–20 mA) is selected using jumpers 1 and 2 and registers 4008 and 4028 contain a value of 2.<br>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.<br>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. |

## 4.2 Applying Power to the DXM150-Sx Wireless Modbus Slave

Apply power to the DXM150-Sx Wireless 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, 13, 18, 31, 34, 36, 41, 44, 48 | Main logic ground for the DXM150-Sx Wireless 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. |
| Pin 35, Pin 45 | These outputs are controlled by hardware jumpers.<br>Jumper 2 is the power jumper for pin 45. Jumper 1 is the power jumper for pin 35. Refer to the wiring board for more information.<br>• The pin 45 jumper selects 2.7 V when in the "a" position and 12 V battery in the "b" position.<br>• The pin 35 jumper selects 4.2 V when in the "a" position and device power on pin 2 in the "b" position. |

### 4.2.1 Supplying Power from a Solar Panel

To power the DXM150-Sx Wireless 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 algorithm 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 algorithm.

To change the charging algorithm from the menu system:

1. From the DXM Modbus Slave LCD menu, navigate to **System Config** > **I/O Board** > **Charger**.
2. Select **Solar** for solar panel configurations.

To change the charging algorithm 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 algorithm.

| Modbus Slave ID | Modbus Register | Description |
|---|---|---|
| 11 * | 6071 | Battery backup charging algorithm.<br>0 = Battery is recharged from a solar panel<br>1 = Battery is recharged from 12 to 30 V dc (default) |

The following power operating characteristics are stored in Modbus registers.

**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 algorithm 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**
This register stores the on-board 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.

| Modbus Slave ID | Modbus Register | Description |
|---|---|---|
| 11 * | 6081 | Battery voltage (mV) |
| | 6082 | Battery charging current (mA) |
| | 6083 | Incoming supply voltage (mV) (solar or power supply) |
| | 6084 | On-board thermistor temperature (ºC) |

* The Slave ID for the base board is set at the factory. This may be changed using the base board DIP switch settings.

## 4.2.2 Connecting a Battery to the DXM Modbus Slave

When attaching a battery to the DXM Modbus Slave 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.
- When using a solar panel, connect the solar panel output to pin 2 and connect the ground to pin 3. Connect the 12 V dc SLA battery to pin 4 (+) and pin 5 (-). To change the charging algorithm, refer to *Supplying Power from a Solar Panel* on page 10.

The battery charging algorithm defaults to a battery backup configuration. To charge the battery from a solar panel, change the battery charging algorithm.

1. From the DXM Modbus Slave LCD menu navigate to **Setting Config** > **I/O Board** > **Charger**.
2. Select **Solar** for solar panel configurations or **DC** for battery backup configurations.

| Modbus Slave ID | Modbus Register | Description |
|---|---|---|
| 11 * | 6071 | Battery backup charging algorithm.<br>0 = Battery is recharged from a solar panel<br>1 = Battery is recharged from 12 to 30 V dc (default) |

* The Modbus Slave ID for the base board is set at the factory and may be changed using the base board DIP switch settings.

## 4.3 Working with Solar Power

A reliable solar system requires careful planning and monitoring to size the components correctly. The recommendations provided are for the DXM Modbus Slave 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.

### 4.3.1 Setting the DXM Modbus Slave for Solar Power

By default, the DXM Modbus Slave is set from the factory to charge a backup battery from a line power source. Use the LCD menu on the front of the DXM Modbus Slave to change the charging algorithm to solar power.

Go to **System Config** > **I/O Board** > **Charger**. Use the up/down arrows to select **Solar**.

For DXM devices without an LCD, adjust the I/O board Modbus register 6071. Set the register to 0 to select battery charging from a solar panel, and set to 1 to select battery charging from incoming 12 to 30 V dc supply.

Here are a few DXM configuration tips to help minimize the power consumption (may not apply to all models).
- If Ethernet is not being used, save up to 25% of the consumed power by disabling Ethernet. Set DIP switch 1 to the ON position on the processor board then reboot.
- Instead of powering external devices all the time, take advantage of the switched power mechanisms to turn off devices when possible.
- Minimize the number of cellular transactions and the amount of data pushed across the cellular modem.

### 4.3.2 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 lead acid battery. The characteristics of a solar system require the battery to be of a certain type. There are basically 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 AGM (absorbed glass mat).

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**

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 DXM Modbus Slave: 5 Watt and 20 Watt. Both panels are designed to work with the DXM Modbus Slave 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 .

**Solar Panel Mounting**

To capture the maximum amount of solar radiation throughout the year, mount a fixed solar panel to optimize the sun's energy throughout the year. 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.

## 4.3.3 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 **DXM Modbus Slave** system | | | | |
|---|---|---|---|---|
| Solar Panel | Battery Capacity[1] | 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 |

1 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.

| Solar panel and battery combinations for a **DXM Modbus Slave** system | | | | |
|---|---|---|---|---|
| Solar Panel | Battery Capacity[1] | Days of Autonomy | DXM mA | DXM Controller |
| 20 watt | 20 Ahr | 10 days | 35 mA | DXM Controller with ISM radio and Cellular Modem |

### 4.3.4 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 DXM Modbus Slave 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.

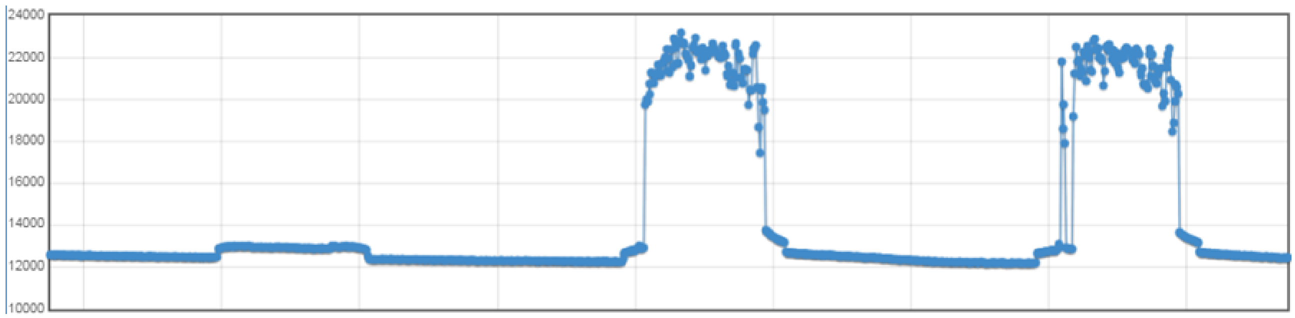



*Figure 2. Solar Panel Voltage (mV) -- Cloudy First Day*

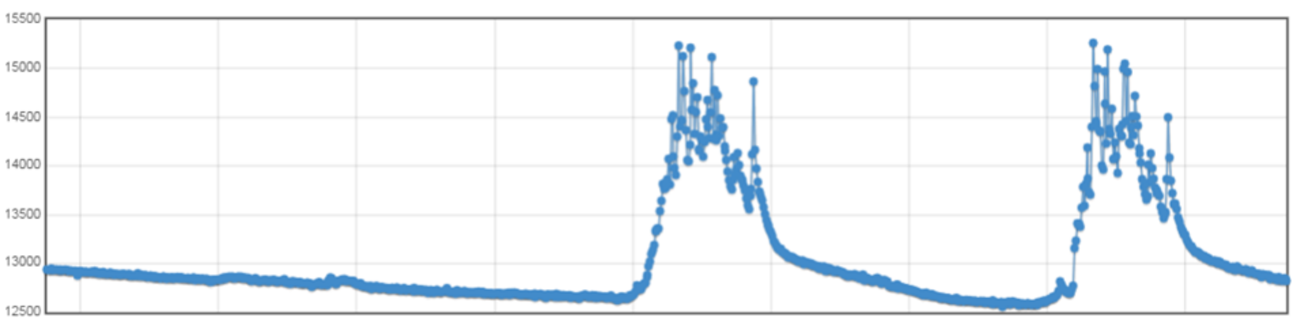



*Figure 3. Battery Voltage (mV) - Cloudy First Day*

## 4.4 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 – | Running Modbus protocol at 19.2k baud, use this bus to connect to other Modbus Slave devices. The DXM150-Sx Wireless Modbus Slave is a Modbus Master device on this RS-485 port.<br>Modbus Register 6101 = Baud Rate<br>0 = 19.2k<br>1 = 9600<br>2 = 38400<br>Modbus Register 6103 = Parity<br>0 = no parity<br>1 = odd?<br>2 = even? |
| Pin 7 | Primary RS-485 + | |

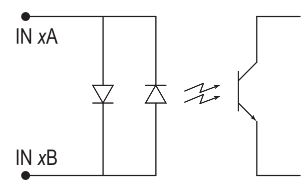
[1] Battery capacity (amp hour) is standard amp rating taken for 20 hours. Battery capacity should be monitored for reliable system power and may need to be increased for cold weather locations.

| Pin | Parameter | Description |
|---|---|---|
| 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 + | |

## 4.5 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 DXM150-Sx Wireless Modbus Slave.

### 4.5.1 Isolated Discrete Inputs

| Pin | Input | Description | |
|---|---|---|---|
| Pin 14 | Input 1A | Optically isolated AC input type, 0 to 12 to 30 V dc<br>Input to output isolation of 2.5 kV |  |
| Pin 15 | Input 1B | | |
| Pin 16 | Input 2A | | |
| Pin 17 | Input 2B | | |

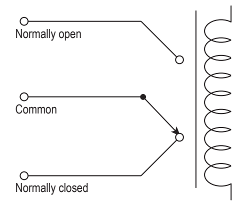
**Synchronous Counters**. An isolated input can be programmed to count the input signal transitions. When an input is enabled as a counter, the counter value is stored into two 16-bit Modbus registers for a total count of 32-bits (unsigned). To program an input to capture the edge transition counts, follow *Example: Configure Input 1 as a Synchronous Counter* on page 18.

The counters are synchronous because the inputs are sampled at a 10 ms clock rate. The input logic does not detect rising or falling edges, it 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.

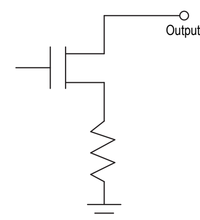
Universal inputs can also be configured as a synchronous counter. See the Modbus register map for universal inputs and all the register definitions. The procedure for creating a synchronous counter is the same as a isolated input with the addition of changing the input type to PNP or NPN.

| Discrete Inputs | Modbus Registers for Counter Parameters | Register Definitions |
|---|---|---|
| Input 1 | 3013 | Enable Rising |
| | 3014 | Enable Falling |
| | 3015 | Counter High |
| | 3016 | Counter Low |
| Input 2 | 3033 | Enable Rising |
| | 3034 | Enable Falling |
| | 3035 | Counter High |
| | 3036 | Counter Low |

### 4.5.2 Relay Outputs

| Pin | Output | Description | Wiring |
|---|---|---|---|
| Pin 19 | Output 1: Normally Open | SPDT (Form C) relay, 250 V ac, 16 A |  |
| Pin 20 | Output 1: Common | | |
| Pin 21 | Output 1: Normally Closed | | |
| Pin 22 | Output 3: Normally Open | | |
| Pin 23 | Output 3: Common | | |
| Pin 24 | Output 3: Normally Closed | | |

### 4.5.3 NMOS Outputs

| Pin | Output | Description | Wiring |
|---|---|---|---|
| Pin 25 | NMOS Discrete Outputs | Less than 1 A maximum current at 30 V dc<br>ON-State Saturation: Less than 0.7 V at 20 mA<br>ON Condition: Less than 0.7 V<br>OFF Condition: Open |  |
| Pin 27 | | | |
| Pin 28 | | | |
| Pin 30 | | | |

### 4.5.4 Analog Outputs (DAC)

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

| Pin | Output | Description |
|---|---|---|
| Pin 33 | Analog Output 1 | 0 to 20 mA or 0 to 10 V dc output (I/O board jumper selectable)<br>Accuracy: 0.1% of full scale +0.01% per °C<br>Resolution: 12-bit |
| Pin 32 | Analog Output 2 | |

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

| Parameter Registers for Analog Outputs (4xxxx) | | |
|---|---|---|
| OUT 1 | OUT 2 | Parameters |
| 4001 | 4021 | Maximum Analog Value |
| 4002 | 4022 | Minimum Analog Value |
| 4003 | 4023 | Enable Register Full Scale |
| 4004 | 4024 | Hold Last State Enable |
| 4005 | 4025 | Default Output State |
| 4008 | 4028 | Analog Output Type |

**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.

## 4.5.5 Universal Inputs

The universal inputs can be programmed to accept different types of inputs: discrete NPN/PNP, 0 to 20 mA analog, 0 to 10 V analog, 10k thermistor, potentiometer sense, bridge, and NPN raw fast. Use the DXM Configuration Tool 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. See the Modbus register section 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 Registers* for the universal input register definitions.

| Pin | Univ. Input | Description |
|---|---|---|
| Pin 47 | Universal Input 1 | 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.<br>0 = NPN<br>1 = PNP<br>2 = 0 to 20 mA<br>3 = 0 to 10 V dc<br>4 = 10k Thermistor<br>5 = Potentiometer Sense (DXM150 only)<br>6 = Not used<br>7 = Bridge<br>8 = NPN Raw Fast (default) |
| Pin 46 | Universal Input 2 | |
| Pin 43 | Universal Input 3 | |
| Pin 42 | Universal Input 4 | |
| Pin 40 | Universal Input 5 | |
| Pin 39 | Universal Input 6 | |
| Pin 38 | Universal Input 7 | |
| Pin 37 | Universal Input 8 | |

**Thermistor Input**. A thermistor input must use a 10k 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 to the Modbus registers defined in *I/O Base Board*.

**Potentiometer Sense (DXM150 only)**. A potentiometer input is created from two inputs: a voltage source (pin 45) that supplies a voltage to the potentiometer and an input sense (Potentiometer Sense) to read the resistance. Follow *Example: Change Universal Input 8 to Read a Potentiometer Input* on page 18 to configure the DXM150 Controller for a potentiometer input.

**Potentiometer Input (DXM100 only)**. 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 technical 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.

## Example: Configure Input 1 as a Synchronous Counter

1. Connect the DXM Modbus Slave to the PC.
2. Launch the DXM Configuration Tool software.
3. Connect to the DXM Modbus Slave by selecting the **Device** > **Connection Settings** menu option. You may connect using either USB or Ethernet.
4. Select a COMM port from the drop-down list and click **Connect**.
5. Click on the **Register View** tab on the left part of the page.
6. Change the **Source Register** selection to **I/O Board Registers**.
7. In the **Write Registers** area, write Modbus register 4908 to 1 to enable counting on the rising edge of the input signal.
8. 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. Connect the DXM Modbus Slave to the PC.
2. Launch the DXM Configuration Tool software.
3. Connect to the DXM Modbus Slave by selecting the **Device** > **Connection Settings** menu option. You may connect using either USB or Ethernet.
4. Select a COMM port from the drop-down list and click **Connect**.
5. Click on the **Register View** tab on the left part of the page.
6. Change the **Source Register** selection to **I/O Board Registers**.
7. Write a 3 to Modbus register 3326 on Modbus Slave ID 11 (I/O board).
8. Cycle power to the device.
9. 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. Connect the DXM Modbus Slave to the PC.
2. Launch the DXM Configuration Tool software.
3. Connect to the DXM Modbus Slave by selecting the **Device** > **Connection Settings** menu option. You may connect using either USB or Ethernet.
4. Select a COMM port from the drop-down list and click **Connect**.
5. Click on the **Register View** tab on the left part of the page.
6. Change the **Source Register** selection to **I/O Board Registers**.
7. 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.
8. Write a 3 to Modbus register 4008 on Modbus Slave ID 11 (I/O board).
9. Cycle power to the device.
10. Using the **Register View** tab, read register 4008 to verify it is set to 3.

## Example: Change Universal Input 8 to Read a Potentiometer Input

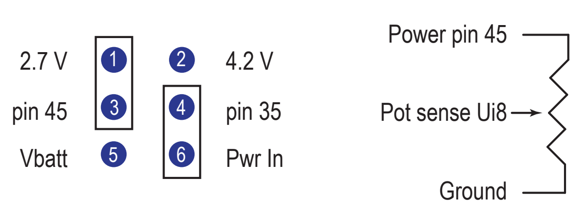



*Figure 4. Default jumper position*

1. Launch the DXM Configuration Tool tool.
2. Click on the **Register View** tab on the left part of the page.
3. In the upper right part of the window select **Modbus Registers using Modbus Slave ID** radio button and enter Modbus Slave ID 11.

4. To set universal input 8 as the sense, write Modbus register 3446 with 5 (Potentiometer Sense).
5. Verify the jumpers are still set to their default position. One jumper should be on pins 1 and 3 to get a 2.7 V source voltage out pin 45. The default position of the other jumper is on pins 4 and 6.
6. Connect one potentiometer side to power output (pin 45), connect the tap point of the pot to universal input 8 (pin 37), and connect the other end of the pot to ground (pin 36).

## 4.5.6 Modbus Registers

The DXM MultiHop Modbus Slave device can have two Modbus Slave IDs: one for the MultiHop ISM radio (default 1) and one for the I/O base (default to 11). All Modbus registers are defined as 16-bit Modbus Holding Registers. When connecting additional Modbus slave devices, only use Modbus slave IDs 2 through 198.

### Modbus Registers for the I/O Board

The I/O board slave ID is 11.

| Base Board Input Connection | |
|---|---|
| Modbus Register | Description |
| 1 | Optically isolated input 1 |
| 2 | Optically isolated input 2 |
| 3 | Universal input 1 |
| 4 | Universal input 2 |
| 5 | Universal input 3 |
| 6 | Universal input 4 |
| 7 | Universal input 5 |
| 8 | Universal input 6 |
| 9 | Universal input 7 |
| 10 | Universal input 8 |

| Base Board Output Connection | |
|---|---|
| Modbus Register | Description |
| 501 | Relay 1 |
| 502 | Not used |
| 503 | Relay 2 |
| 504 | Not used |
| 505 | NMOS Output 5 |
| 506 | NMOS Output 6 |
| 507 | NMOS Output 7 |
| 508 | NMOS Output 8 |
| 509 | DAC Output 1 |
| 510 | DAC Output 2 |

### Configuration Registers for the I/O Board

| Register | Isolated Input A |
|---|---|
| 3013 | Enable rising edge counter |
| 3014 | Enable falling edge counter |
| 3015 | High register for counter |
| 3016 | Low register for counter |

| Register | Isolated Input A |
|---|---|
| 3033 | Enable rising edge counter |
| 3034 | Enable falling edge counter |
| 3035 | High register for counter |
| 3036 | Low register for counter |

| Universal Input Parameter Modbus Registers | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Universal Inputs | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Enable Full Scale | 3303 | 3323 | 3343 | 3363 | 3383 | 3403 | 3423 | 3443 |
| Temperature °C/°F | 3304 | 3324 | 3344 | 3364 | 3384 | 3404 | 3424 | 3444 |
| Input Type | 3306 | 3326 | 3346 | 3366 | 3386 | 3406 | 3426 | 3446 |
| Threshold | 3308 | 3328 | 3348 | 3368 | 3388 | 3408 | 3428 | 3448 |
| Hysteresis | 3309 | 3329 | 3349 | 3369 | 3389 | 3409 | 3429 | 3449 |
| Enable Rising | 4908 | 4928 | 4948 | 4968 | 4988 | 5008 | 5028 | 5048 |

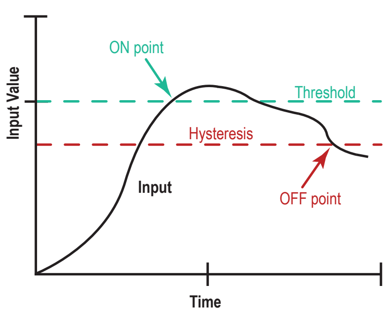
| Universal Input Parameter Modbus Registers | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Universal Inputs | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Enable Falling | 4909 | 4929 | 4949 | 4969 | 4989 | 5009 | 5029 | 5049 |
| High Register for Counter | 4910 | 4930 | 4950 | 4970 | 4990 | 5010 | 5030 | 5050 |
| Low Register for Counter | 4911 | 4931 | 4951 | 4971 | 4991 | 5011 | 5031 | 5051 |

**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 µA (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.

| 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.

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

Only DXM150-Sx and SxR2 Modbus Slave models require that the Modbus Slave ID to be adjusted on the I/O base board. The DXM150-Sx Wireless Modbus Slave devices use DIP switch J and rotary dial K to set the Modbus slave ID. The device can use a Modbus register 6804 in the I/O board to access the full range of Modbus Slave IDs.

On the DXM150-Sx Wireless Modbus Slave models, use rotary dial K to select the lower digit of the Modbus Slave ID.

### 4.6.1 DXM150-Sx Wireless Modbus Slave Models

DIP Switch location J defines the course group of Modbus Slave IDs. DIP Switch 4 must be set to ON for DXM1*xx*-Sx and DXM1*xx*-SxR2 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 (S1 model only) [2] | | | | ON |
| I2C Processor Communication | | | | OFF |

Rotary dial location K and DIP Switch location J set the Modbus Slave IDs.

| DIP Switches J | | Location K Rotary Dials — Position 0 through 9 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| OFF | OFF | x [3] | 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 |

#### DXM150-Sx Wireless Modbus Slave Example

To set the DXM150-Sx Wireless Modbus Slave to a Modbus Slave ID of 25, set the following:

Location J DIP switches set to: 1= ON, 2=OFF
Rotary dial set to 5

The DIP switch sets the upper digit of the slave ID to 2 while the rotary dial sets the lower digit to 5.

### 4.6.2 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 DXM150-Sx Wireless Modbus Slave model, rotary dial K should be in the zero position to use the Modbus register slave ID.

### 4.6.3 I/O Board Jumpers

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

[2] Must be in the ON position for the -S1 model)
[3] Uses value in Modbus register 6804.

| Jumper | Function | Positions |
| --- | --- | --- |
| E | Courtesy power output | Jumper 2 is the power jumper for pin 45. Jumper 1 is the power jumper for pin 35.<br>• The pin 45 jumper selects 2.7 V when in the "a" position and 12 V battery in the "b" position.<br>• The pin 35 jumper selects 4.2 V when in the "a" position and device power on pin 2 in the "b" position. |
| G1 | Not Used | Not Used |
| G2 | Not Used | Not Used |
| G3 | Analog output characteristics for AO2 (pin 32) and AO1 (pin 33) | Defines current (0–20 mA) or voltage (0–10 V) for analog output 1 and 2.<br>By default, current (0–20 mA) is selected using jumpers 1 and 2 and registers 4008 and 4028 contain a value of 2.<br>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 to 3.<br>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 to 3. |

# 5 I/O Base Board for the DXM150-S2 Models

## 5.1 Board Connections

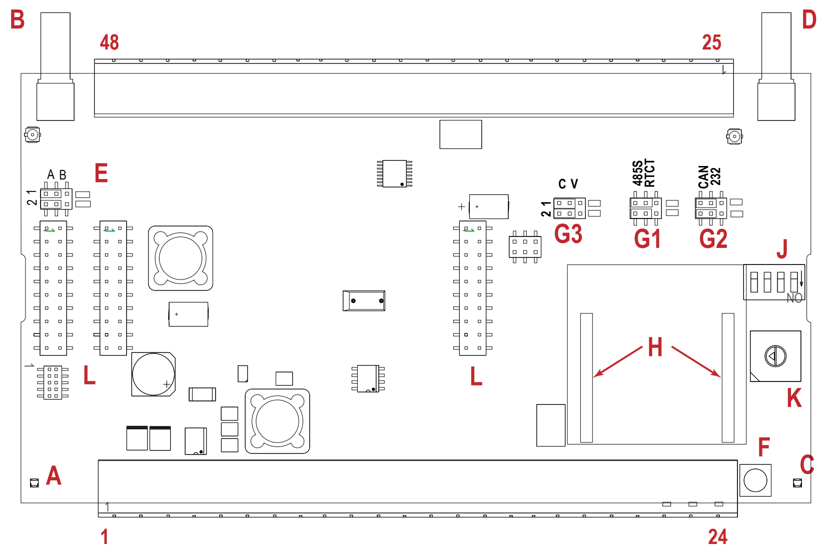



*Figure 5. Board Connections*

********* THIS IS THE TABLE FOR THE DXM150-B2. PLEASE MARK THIS UP FOR THE DXM150-S2. *********

| | | | | | |
|---|---|---|---|---|---|
| 1 | NC | 17 | Input 2B | 33 | Analog Output 1 (0–20 mA or 0–10 V) |
| 2 | 12 to 30 V dc or solar power in (+) | 18 | Ground | 34 | Ground |
| 3 | Ground | 19 | Output 1 PNP/NPN | 35 | PWR Out - Jumper |
| 4 | Battery in (< 15 V dc) (must be a sealed lead acid battery) | 20 | Output 2 PNP/NPN | 36 | Ground |
| 5 | Ground | 21 | Output 3 PNP/NPN | 37 | Universal Input 8 |
| 6 | Primary RS-485 – | 22 | Output 4 PNP/NPN | 38 | Universal Input 7 |
| 7 | Primary RS-485 + | 23 | PWR Out OR | 39 | Universal Input 6 |
| 8 | Ground | 24 | Ground | 40 | Universal Input 5 |
| 9 | RS-232 Tx / CAN | 25 | Ground | 41 | Ground |
| 10 | RS-232 Rx / CAN | 26 | PWR OUT OR | 42 | Universal Input 4 |
| 11 | Secondary RS-485 – or RS-232 RXRDY | 27 | Output 8 PNP/NPN | 43 | Universal Input 3 |
| 12 | Secondary RS-485 + or RS-232 TXRDY | 28 | Output 7 PNP/NPN | 44 | Ground |
| 13 | Ground | 29 | Output 6 PNP/NPN | 45 | PWR Out - Jumper |
| 14 | Input 1A | 30 | Output 5 PNP/NPN | 46 | Universal Input 2 |
| 15 | Input 1B | 31 | Ground | 47 | Universal Input 1 |
| 16 | Input 2A | 32 | Analog Output 2 (0–20 mA or 0–10 V) | 48 | Ground |

| | | | | | |
|---|---|---|---|---|---|
| A | Base Board LED | E | PWR Out Jumpers | G3 | Analog Output Characteristics Jumpers (Jumper 1 sets analog out 1, jumper 2 sets analog out 2) |

| | | | | | |
|---|---|---|---|---|---|
| B | Cellular Antenna | F | Radio Binding Button | H | ISM Radio Connection |
| C | Radio LED | G1 | RS-485 Jumpers | J | Modbus Slave ID DIP Switches |
| D | Radio Module Antenna | G2 | RS-232 Jumpers | K | Rotary Dials |
| | | | | L | SAM4 Processor Board Connection |

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

The DXM150-Sx Wireless Modbus Slave I/O board DIP switches are set from the factory to Modbus Slave ID 11. For more information, refer to *Setting the Modbus Slave ID on the I/O Base Board*.

### 5.1.2 I/O Board Jumpers

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 | Courtesy power output | Jumper 2 is the power jumper for pin 45. Jumper 1 is the power jumper for pin 35.<br>• The pin 45 jumper selects 2.7 V when in the "a" position and 12 V battery in the "b" position.<br>• The pin 35 jumper selects 4.2 V when in the "a" position and device power on pin 2 in the "b" position. |
| G1 | RS-485 Modbus Slave or RS-232 Flow Control | Defines the operation of pins 11 and 12. Set the jumpers to use pins 11 and 12 as a secondary Modbus RS-485 slave port or flow control pins for the RS-232 port. Both jumpers must be set to the same operation, RS-485 Modbus Slave or Flow control.<br>The default setting is RS-485. |
| G2 | Generic RS-232 Serial Port or CAN Serial Port | Defines the operation of pins 9 and 10. Set the jumpers to use pins 9 and 10 as a CAN serial port or a generic RS-232 serial port. Both jumpers must be set to the same operation, CAN or RS232.<br>The default setting is CAN serial port. |
| G3 | Analog output characteristics for AO2 (pin 32) and AO1 (pin 33) | Defines current (0–20 mA) or voltage (0–10 V) for analog output 1 and 2.<br>By default, current (0–20 mA) is selected using jumpers 1 and 2 and registers 4008 and 4028 contain a value of 2.<br>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.<br>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. |

## 5.2 Applying Power

Apply power to the DXM Modbus Slave using either 12 to 30 V dc or a 12 V dc solar panel and 12 V sealed lead acid battery.

If the incoming voltage drops below 11.2 V dc, the cellular modem does not turn on and will not turn on until the voltage is above 11.8 V dc. A text file (CmVMon.txt) on the internal micro SD card saves the periodic sampling of the incoming voltage. If cellular operation stops because of voltage, it is logged in this file.

| Pin | Description |
|---|---|
| Pin 1 | No connection |
| Pin 2 | 12 to 30 V dc input (+) or solar panel connection (+) |
| Pins 3, 5, 8, 13, 18, 24, 25, 31, 34, 36, 41, 44, 48 | Main logic ground for the DXM 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. |

| Pin | Description |
|---|---|
| Pin 35, Pin 45 | These outputs are controlled by hardware jumpers.<br>Jumper 2 is the power jumper for pin 45. Jumper 1 is the power jumper for pin 35. Refer to the wiring board for more information.<br>• The pin 45 jumper selects 2.7 V when in the "a" position and 12 V battery in the "b" position.<br>• The pin 35 jumper selects 4.2 V when in the "a" position and device power on pin 2 in the "b" position. |
| Pin 23, Pin 26 | Courtesy power output from either the input power from pin 2 or the battery power from pin 4. |

### 5.2.1 Supplying Power from a Solar Panel

To power the DXM150-Sx Wireless 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 algorithm 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 algorithm.

To change the charging algorithm from the menu system:

1. From the DXM Modbus Slave LCD menu, navigate to **System Config** > **I/O Board** > **Charger**.
2. Select **Solar** for solar panel configurations.

To change the charging algorithm 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 algorithm.

| Modbus Slave ID | Modbus Register | Description |
|---|---|---|
| 11 * | 6071 | Battery backup charging algorithm.<br>0 = Battery is recharged from a solar panel<br>1 = Battery is recharged from 12 to 30 V dc (default) |

The following power operating characteristics are stored in Modbus registers.

**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 algorithm 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**
: This register stores the on-board 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.

| Modbus Slave ID | Modbus Register | Description |
|---|---|---|
| 11 * | 6081 | Battery voltage (mV) |
| | 6082 | Battery charging current (mA) |
| | 6083 | Incoming supply voltage (mV) (solar or power supply) |
| | 6084 | On-board thermistor temperature (ºC) |

* The Slave ID for the base board is set at the factory. This may be changed using the base board DIP switch settings.

### 5.2.2 Connecting a Battery to the DXM Modbus Slave

When attaching a battery to the DXM Modbus Slave 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.
- When using a solar panel, connect the solar panel output to pin 2 and connect the ground to pin 3. Connect the 12 V dc SLA battery to pin 4 (+) and pin 5 (-). To change the charging algorithm, refer to *Supplying Power from a Solar Panel* on page 10.

The battery charging algorithm defaults to a battery backup configuration. To charge the battery from a solar panel, change the battery charging algorithm.

1. From the DXM Modbus Slave LCD menu navigate to **Setting Config** > **I/O Board** > **Charger**.
2. Select **Solar** for solar panel configurations or **DC** for battery backup configurations.

| Modbus Slave ID | Modbus Register | Description |
| --- | --- | --- |
| 11 * | 6071 | Battery backup charging algorithm.<br>0 = Battery is recharged from a solar panel<br>1 = Battery is recharged from 12 to 30 V dc (default) |

* The Modbus Slave ID for the base board is set at the factory and may be changed using the base board DIP switch settings.

## 5.3 Working with Solar Power

A reliable solar system requires careful planning and monitoring to size the components correctly. The recommendations provided are for the DXM Modbus Slave 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.

### 5.3.1 Setting the DXM Modbus Slave for Solar Power

By default, the DXM Modbus Slave is set from the factory to charge a backup battery from a line power source. Use the LCD menu on the front of the DXM Modbus Slave to change the charging algorithm to solar power.

Go to **System Config** > **I/O Board** > **Charger**. Use the up/down arrows to select **Solar**.

For DXM devices without an LCD, adjust the I/O board Modbus register 6071. Set the register to 0 to select battery charging from a solar panel, and set to 1 to select battery charging from incoming 12 to 30 V dc supply.

Here are a few DXM configuration tips to help minimize the power consumption (may not apply to all models).

- If Ethernet is not being used, save up to 25% of the consumed power by disabling Ethernet. Set DIP switch 1 to the ON position on the processor board then reboot.
- Instead of powering external devices all the time, take advantage of the switched power mechanisms to turn off devices when possible.
- Minimize the number of cellular transactions and the amount of data pushed across the cellular modem.

### 5.3.2 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 lead acid battery. The characteristics of a solar system require the battery to be of a certain type. There are basically 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 AGM (absorbed glass mat).

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**

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 DXM Modbus Slave: 5 Watt and 20 Watt. Both panels are designed to work with the DXM Modbus Slave 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 .

**Solar Panel Mounting**

To capture the maximum amount of solar radiation throughout the year, mount a fixed solar panel to optimize the sun's energy throughout the year. 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.

## 5.3.3 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 **DXM Modbus Slave** system | | | | |
|---|---|---|---|---|
| Solar Panel | Battery Capacity[4] | 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 |

### 5.3.4 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 DXM Modbus Slave 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.

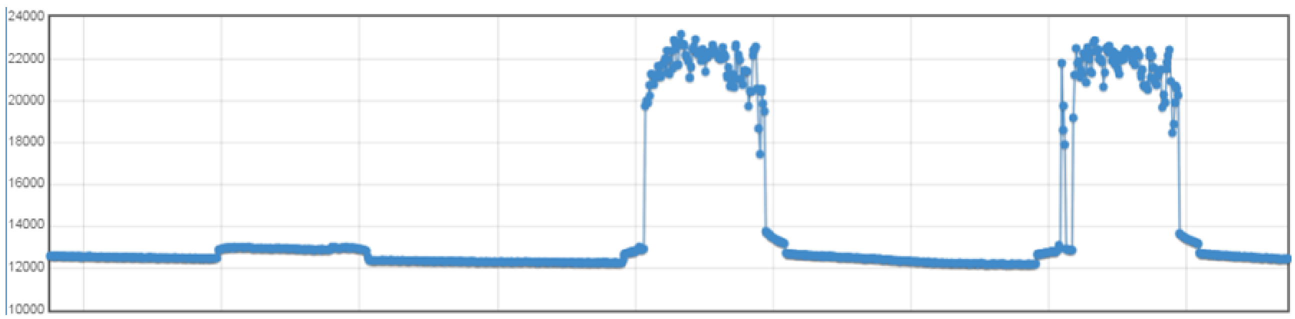



*Figure 6. Solar Panel Voltage (mV) -- Cloudy First Day*

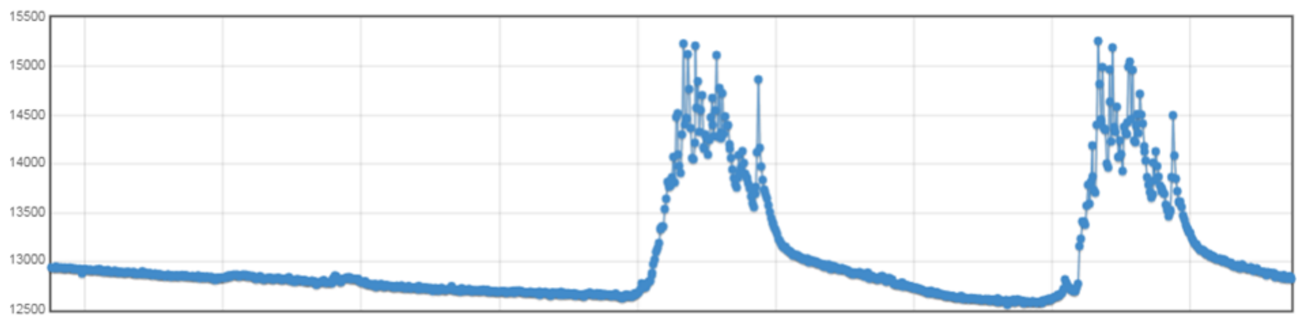



*Figure 7. Battery Voltage (mV) - Cloudy First Day*

## 5.4 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 – | Running Modbus protocol at 19.2k baud, use this bus to connect to other Modbus Slave devices. The DXM150-Sx Wireless Modbus Slave is a Modbus Master device on this RS-485 port.<br>Modbus Register 6101 = Baud Rate<br>0 = 19.2k<br>1 = 9600<br>2 = 38400<br>Modbus Register 6103 = Parity<br>0 = no parity<br>1 = odd?<br>2 = even? |
| Pin 7 | Primary RS-485 + | |

[4] 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.

| Pin | Parameter | Description |
| --- | --- | --- |
| 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 + | |

## 5.5 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 DXM150-Sx Wireless Modbus Slave.

### 5.5.1 Universal Inputs

The universal inputs can be programmed to accept different types of inputs: discrete NPN/PNP, 0 to 20 mA analog, 0 to 10 V analog, 10k thermistor, potentiometer sense, bridge, and NPN raw fast. Use the DXM Configuration Tool 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. See the Modbus register section 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 Registers* for the universal input register definitions.

| Pin | Univ. Input | Description |
| --- | --- | --- |
| Pin 47 | Universal Input 1 | 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.<br>0 = NPN<br>1 = PNP<br>2 = 0 to 20 mA<br>3 = 0 to 10 V dc<br>4 = 10k Thermistor<br>5 = Potentiometer Sense (DXM150 only)<br>6 = Not used<br>7 = Bridge<br>8 = NPN Raw Fast (default) |
| Pin 46 | Universal Input 2 | |
| Pin 43 | Universal Input 3 | |
| Pin 42 | Universal Input 4 | |
| Pin 40 | Universal Input 5 | |
| Pin 39 | Universal Input 6 | |
| Pin 38 | Universal Input 7 | |
| Pin 37 | Universal Input 8 | |

**Thermistor Input**. A thermistor input must use a 10k 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 to the Modbus registers defined in *I/O Base Board*.

**Potentiometer Sense (DXM150 only)**. A potentiometer input is created from two inputs: a voltage source (pin 45) that supplies a voltage to the potentiometer and an input sense (Potentiometer Sense) to read the resistance. Follow *Example: Change Universal Input 8 to Read a Potentiometer Input* on page 18 to configure the DXM150 Controller for a potentiometer input.

**Potentiometer Input (DXM100 only)**. 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 technical 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.

## Example: Configure Input 1 as a Synchronous Counter

1. Connect the DXM Modbus Slave to the PC.
2. Launch the DXM Configuration Tool software.
3. Connect to the DXM Modbus Slave by selecting the **Device** > **Connection Settings** menu option. You may connect using either USB or Ethernet.
4. Select a COMM port from the drop-down list and click **Connect**.
5. Click on the **Register View** tab on the left part of the page.
6. Change the **Source Register** selection to **I/O Board Registers**.
7. In the **Write Registers** area, write Modbus register 4908 to 1 to enable counting on the rising edge of the input signal.
8. 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. Connect the DXM Modbus Slave to the PC.
2. Launch the DXM Configuration Tool software.
3. Connect to the DXM Modbus Slave by selecting the **Device** > **Connection Settings** menu option. You may connect using either USB or Ethernet.
4. Select a COMM port from the drop-down list and click **Connect**.
5. Click on the **Register View** tab on the left part of the page.
6. Change the **Source Register** selection to **I/O Board Registers**.
7. Write a 3 to Modbus register 3326 on Modbus Slave ID 11 (I/O board).
8. Cycle power to the device.
9. 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. Connect the DXM Modbus Slave to the PC.
2. Launch the DXM Configuration Tool software.
3. Connect to the DXM Modbus Slave by selecting the **Device** > **Connection Settings** menu option. You may connect using either USB or Ethernet.
4. Select a COMM port from the drop-down list and click **Connect**.
5. Click on the **Register View** tab on the left part of the page.
6. Change the **Source Register** selection to **I/O Board Registers**.
7. 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.
8. Write a 3 to Modbus register 4008 on Modbus Slave ID 11 (I/O board).
9. Cycle power to the device.
10. Using the **Register View** tab, read register 4008 to verify it is set to 3.

## Example: Change Universal Input 8 to Read a Potentiometer Input

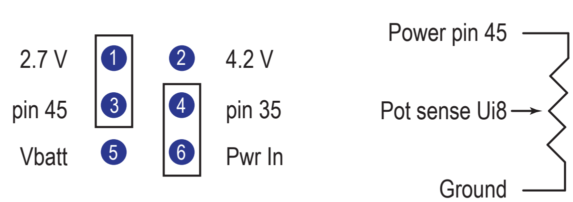
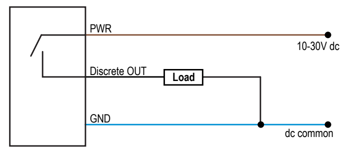
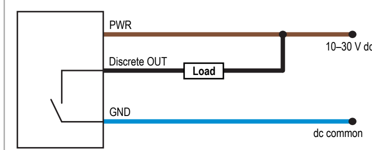



*Figure 8. Default jumper position*

1. Launch the DXM Configuration Tool tool.
2. Click on the **Register View** tab on the left part of the page.
3. In the upper right part of the window select **Modbus Registers using Modbus Slave ID** radio button and enter Modbus Slave ID 11.
4. To set universal input 8 as the sense, write Modbus register 3446 with 5 (Potentiometer Sense).
5. Verify the jumpers are still set to their default position. One jumper should be on pins 1 and 3 to get a 2.7 V source voltage out pin 45. The default position of the other jumper is on pins 4 and 6.

6. Connect one potentiometer side to power output (pin 45), connect the tap point of the pot to universal input 8 (pin 37), and connect the other end of the pot to ground (pin 36).

### 5.5.2 PNP and NPN Outputs

| Pin | Output | Modbus Register | Description | PNP OUT Wiring | NPN OUT Wiring |
|---|---|---|---|---|---|
| 19 | 1 | 501 | PNP/NPN Output 1 |  |  |
| 20 | 2 | 502 | PNP/NPN Output 2 | | |
| 21 | 3 | 503 | PNP/NPN Output 3 | | |
| 22 | 4 | 504 | PNP/NPN Output 4 | | |
| 30 | 5 | 505 | PNP/NPN Output 5 | | |
| 29 | 6 | 506 | PNP/NPN Output 6 | | |
| 28 | 7 | 507 | PNP/NPN Output 7 | | |
| 27 | 8 | 508 | PNP/NPN Output 8 | | |

### 5.5.3 Analog Outputs (DAC)

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

| Pin | Output | Description |
|---|---|---|
| Pin 33 | Analog Output 1 | 0 to 20 mA or 0 to 10 V dc output (I/O board jumper selectable) |
| Pin 32 | Analog Output 2 | Accuracy: 0.1% of full scale +0.01% per °C<br>Resolution: 12-bit |

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

| Parameter Registers for Analog Outputs (4xxxx) | | |
|---|---|---|
| OUT 1 | OUT 2 | Parameters |
| 4001 | 4021 | Maximum Analog Value |
| 4002 | 4022 | Minimum Analog Value |
| 4003 | 4023 | Enable Register Full Scale |
| 4004 | 4024 | Hold Last State Enable |
| 4005 | 4025 | Default Output State |
| 4008 | 4028 | Analog Output Type |

**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.

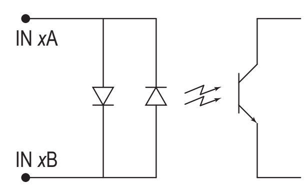
**Enable Register Full Scale**. Set to 1 to enable a linear range from 0 to 65535 for specified input range. For a 4 to 20 mA output, a value of 0 represents 4 mA and 65535 represents 20 mA. Set this parameter to 0 to store readings in unit-specific data. For example, the register data representing a 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.

## 5.5.4 Isolated Discrete Inputs

| Pin | Input | Description | |
|---|---|---|---|
| Pin 14 | Input 1A | Optically isolated AC input type, 0 to 12 to 30 V dc<br>Input to output isolation of 2.5 kV |  |
| Pin 15 | Input 1B | | |
| Pin 16 | Input 2A | | |
| Pin 17 | Input 2B | | |

**Synchronous Counters**. An isolated input can be programmed to count the input signal transitions. When an input is enabled as a counter, the counter 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 page 18.

The counters are synchronous because the inputs are sampled at a 10 ms clock rate. The input logic does not detect rising or falling edges, it 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.

Universal inputs can also be configured as a synchronous counter. See the Modbus register map for universal inputs and all the register definitions. The procedure for creating a synchronous counter is the same as a isolated input with the addition of changing the input type to PNP or NPN.

| Discrete Inputs | Modbus Registers for Counter Parameters | Register Definitions |
|---|---|---|
| Input 1 | 3013 | Enable Rising |
| | 3014 | Enable Falling |
| | 3015 | Counter High |
| | 3016 | Counter Low |
| Input 2 | 3033 | Enable Rising |
| | 3034 | Enable Falling |
| | 3035 | Counter High |
| | 3036 | Counter Low |

## 5.5.5 Modbus Registers

The DXM MultiHop Modbus Slave device can have two Modbus Slave IDs: one for the MultiHop ISM radio (default 1) and one for the I/O base (default to 11). All Modbus registers are defined as 16-bit Modbus Holding Registers. When connecting additional Modbus slave devices, only use Modbus slave IDs 2 through 198.

## Modbus Registers for the I/O Board

The I/O board is Slave ID 11.

| Base Board Input Connection | |
|---|---|
| Modbus Register | Description |
| 1 | Optically isolated input 1 |
| 2 | Optically isolated input 2 |
| 3 | Universal input 1 |
| 4 | Universal input 2 |
| 5 | Universal input 3 |
| 6 | Universal input 4 |
| 7 | Universal input 5 |
| 8 | Universal input 6 |
| 9 | Universal input 7 |
| 10 | Universal input 8 |

| Base Board Output Connection | |
|---|---|
| Modbus Register | Description |
| 501 | PNP/NPN Output 1 |
| 502 | PNP/NPN Output 2 |
| 503 | PNP/NPN Output 3 |
| 504 | PNP/NPN Output 4 |
| 505 | PNP/NPN Output 5 |
| 506 | PNP/NPN Output 6 |
| 507 | PNP/NPN Output 7 |
| 508 | PNP/NPN Output 8 |
| 509 | DAC Output 1 |
| 510 | DAC Output 2 |

## Configuration Registers for the I/O Board

The DXM Configuration Tool creates a graphical view of the I/O board parameters. This allows for easy and quick configuration of the I/O board parameters. Modbus configuration registers are identified below.

| Register | Isolated Input A |
|---|---|
| 3013 | Enable rising edge counter |
| 3014 | Enable falling edge counter |
| 3015 | High register for counter |
| 3016 | Low register for counter |

| Register | Isolated Input A |
|---|---|
| 3033 | Enable rising edge counter |
| 3034 | Enable falling edge counter |
| 3035 | High register for counter |
| 3036 | Low register for counter |

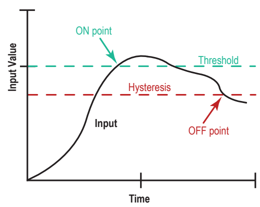
| Universal Input Parameter Modbus Registers | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Universal Inputs | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Enable Full Scale | 3303 | 3323 | 3343 | 3363 | 3383 | 3403 | 3423 | 3443 |
| Temperature °C/°F | 3304 | 3324 | 3344 | 3364 | 3384 | 3404 | 3424 | 3444 |
| Input Type | 3306 | 3326 | 3346 | 3366 | 3386 | 3406 | 3426 | 3446 |
| Threshold | 3308 | 3328 | 3348 | 3368 | 3388 | 3408 | 3428 | 3448 |
| Hysteresis | 3309 | 3329 | 3349 | 3369 | 3389 | 3409 | 3429 | 3449 |
| Enable Rising | 4908 | 4928 | 4948 | 4968 | 4988 | 5008 | 5028 | 5048 |
| Enable Falling | 4909 | 4929 | 4949 | 4969 | 4989 | 5009 | 5029 | 5049 |
| High Register for Counter | 4910 | 4930 | 4950 | 4970 | 4990 | 5010 | 5030 | 5050 |
| Low Register for Counter | 4911 | 4931 | 4951 | 4971 | 4991 | 5011 | 5031 | 5051 |

**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 µA (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.

| 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.

| Register | Description | Values | Register | Description |
|---|---|---|---|---|
| 3704 | Enable Discrete Output 1 | 0 = NPN; 1 = PNP | 3705 | Invert Output |
| 3724 | Enable Discrete Output 2 | 0 = NPN; 1 = PNP | 3725 | Invert Output |
| 3744 | Enable Discrete Output 3 | 0 = NPN; 1 = PNP | 3745 | Invert Output |
| 3764 | Enable Discrete Output 4 | 0 = NPN; 1 = PNP | 3765 | Invert Output |
| 3784 | Enable Discrete Output 5 | 0 = NPN; 1 = PNP | 3785 | Invert Output |
| 3804 | Enable Discrete Output 6 | 0 = NPN; 1 = PNP | 3805 | Invert Output |
| 3824 | Enable Discrete Output 7 | 0 = NPN; 1 = PNP | 3825 | Invert Output |
| 3844 | Enable Discrete Output 8 | 0 = NPN; 1 = PNP | 3845 | Invert Output |

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

Only DXM150-Sx and SxR2 Modbus Slave models require that the Modbus Slave ID to be adjusted on the I/O base board. The DXM150-Sx Wireless Modbus Slave devices use DIP switch J and rotary dial K to set the Modbus slave ID. The device can use a Modbus register 6804 in the I/O board to access the full range of Modbus Slave IDs.

On the DXM150-Sx Wireless Modbus Slave models, use rotary dial K to select the lower digit of the Modbus Slave ID.

### 5.6.1 DXM150-Sx Wireless Modbus Slave Models

DIP Switch location J defines the course group of Modbus Slave IDs. DIP Switch 4 must be set to ON for DXM1*xx*-Sx and DXM1*xx*-SxR2 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 (S1 model only) [5] | | | | ON |
| I2C Processor Communication | | | | OFF |

Rotary dial location K and DIP Switch location J set the Modbus Slave IDs.

| DIP Switches J | | Location K Rotary Dials — Position 0 through 9 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| OFF | OFF | x [6] | 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 |

#### DXM150-Sx Wireless Modbus Slave Example

To set the DXM150-Sx Wireless Modbus Slave to a Modbus Slave ID of 25, set the following:

Location J DIP switches set to: 1= ON, 2=OFF
Rotary dial set to 5

The DIP switch sets the upper digit of the slave ID to 2 while the rotary dial sets the lower digit to 5.

### 5.6.2 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 DXM150-Sx Wireless Modbus Slave model, rotary dial K should be in the zero position to use the Modbus register slave ID.

## 5.7 Restoring Factory Default Settings

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

To reset the DXM I/O board parameters:

1. Write a 1 to Modbus register 4152

[5] Must be in the ON position for the -S1 model)
[6] Uses value in Modbus register 6804.

2. Write a 10 to Modbus register 4151

To reset only the I/O board:

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

| Modbus 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.<br>Default value: 0<br>1 = 100 milliseconds, 10 = 1 second. |
| 4152 | 0–1 | 1 = Restores factory defaults for I/O parameters.<br>Default value: 0 |

# 6 Restoring Factory Default Settings

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

To reset the DXM I/O board parameters:

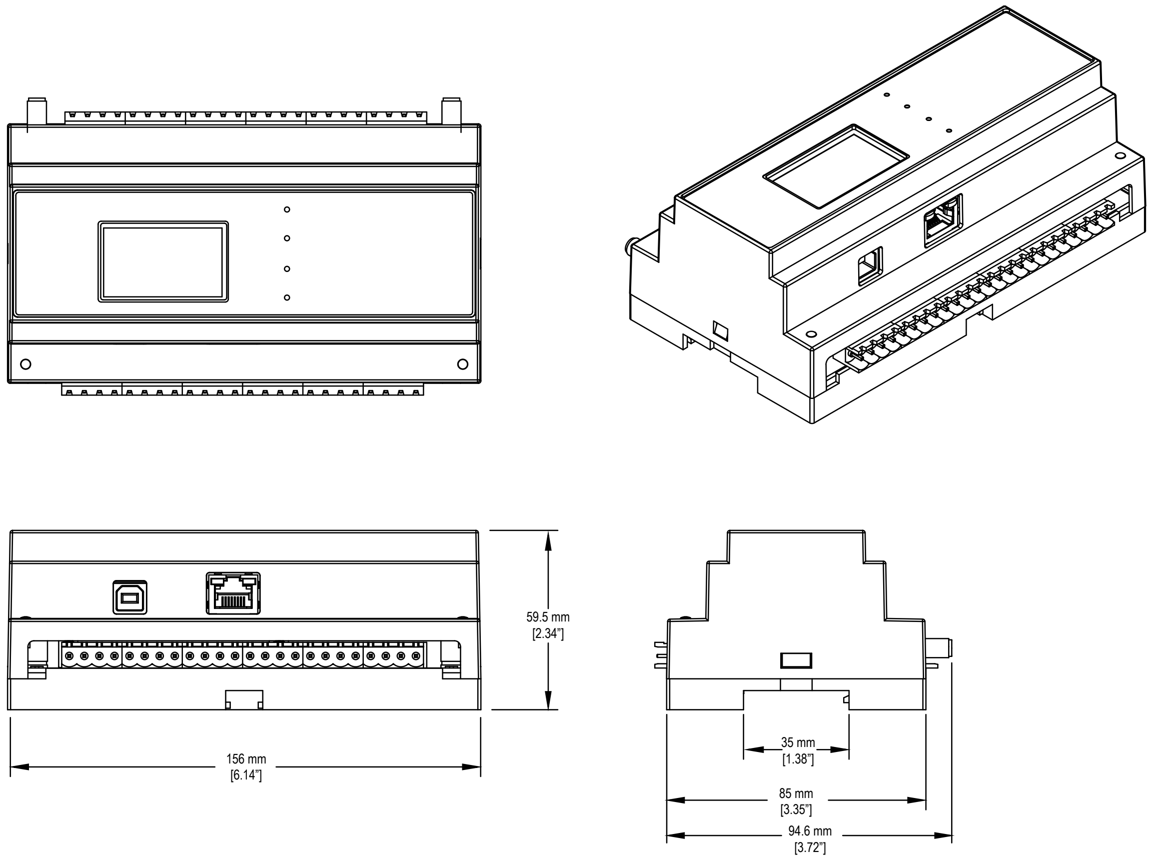
1. Write a 1 to Modbus register 4152
2. Write a 10 to Modbus register 4151

To reset only the I/O board:

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

| Modbus 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.<br>Default value: 0<br>1 = 100 milliseconds, 10 = 1 second. |
| 4152 | 0–1 | 1 = Restores factory defaults for I/O parameters.<br>Default value: 0 |

# 7 DXM150 Dimensions




All measurements are listed in millimeters [inches], unless noted otherwise.

# 8 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, qty 10
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, qty 1 each

### Antenna Cables

BWC-1MRSMN05—LMR100 RP-SMA to N-Type Male, 0.5 m
BWC-2MRSFRS6—LMR200, RP-SMA Male to RP-SMA Female, 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

### 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)

# 9 Additional Information

## 9.1 DXM150 Documentation List

For more information about the DXM Modbus Slave family of products, please see additional documentation and videos on the Banner website: *www.bannerengineering.com/wireless*.

- DXM Wireless Controller Sell Sheet, p/n *194063*
- DXM150-B1 Wireless Controller Datasheet, p/n *178136*
- DXM150-B2 Wireless Controller Datasheet, p/n *195952*
- DXM150-Bx Wireless Controller Instruction Manual, p/n *190038*
- DXM150-S1 Modbus Slave Datasheet, p/n *160171*
- DXM150-S2 Modbus Slave Datasheet, p/n *200634*
- DXM150-Sx Modbus Slave Instruction Manual, p/n *195455*
- DXM ScriptBasic Instruction Manual, p/n *191745*
- DXM Controller Configuration Quick Start, p/n *191247*
- DXM Configuration Tool software (p/n *b_4447978*)
- DXM Configuration Tool Instruction Manual, p/n *158447*
- DXM EDS *Configuration file* for Allen-Bradley PLCs
- EIP Configuration File for DXM 1xx-BxR1 and R3 models (p/n *194730*)
- Activating a Cellular Modem (p/n *b_4419353*)
- Additional technical notes and videos

Technical notes, configuration examples, and ScriptBasic program examples are available at *http://www.bannerengineering.com*.

## 9.2 DXM Modbus Slave 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 DXM Modbus Slave, 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.

### 9.2.1 Firmware Updates

The DXM Modbus Slave 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 DXM Modbus Slave. 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.

### 9.2.2 Website Information

The Banner website is the main method of disseminating DXM Modbus Slave 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

### 9.2.3 Feature Requests

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

### 9.2.4 Potential DXM Issues

Potential issues with the DXM Modbus Slave 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.

### 9.2.5 DXM Security

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

TheDXM Modbus Slave does not run a Linux or Windows based operating system but an embedded RTOS environment. As a proprietary operating system, the security aspects are easier to manage and minimize.

Security updates are released through the Banner website and New Product Release Announcements (NPRA).

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# 10 Warnings

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

**Exporting Sure Cross® Radios.** It is our intent to fully comply with all national and regional regulations regarding radio frequency emissions. **Customers who want to re-export this product to a country other than that to which it was sold must ensure the device is approved in the destination country.** A list of approved countries appears in the *Radio Certifications* section of the product manual. 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. Consult with Banner Engineering Corp. if the destination country is not on this list.

## 10.1 Banner Engineering Corp. Limited Warranty

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

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