Sure Cross® User Configuration Tool (UCT)

Instruction Manual

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Contents

1 Sure Cross® User Configuration Tool

The User Configuration Tool (UCT) offers an easy way to link I/O points in your wireless network, view I/O register values, and set system communication parameters when a host system is not part of the wireless network. The software runs on any computer with the Windows Vista, Windows 7, Windows 8, or Windows 10 operating system.
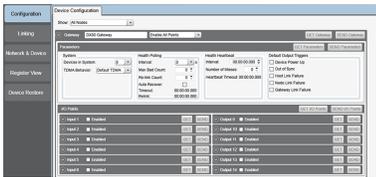
Use a USB to RS-485 adapter cable to connect a standalone DX80 Gateway to the computer. For DXM Controllers with an internal DX80 radio, connect a computer to the DXM Controller using a USB or Ethernet connection. Download the most recent revisions of the UCT software from Banner Engineering's website: *www.bannerengineering.com/wireless*.

The USB to RS-485 adapter cable is not required for the DXM Controller. For standalone DX80 Gateway devices use:

- USB to RS-485 adapter cable model BWA-UCT-900 for 1 Watt radios
- USB to RS-485 adapter cable model BWA-HW-006 for all other radios

1.1 Installation

The User Configuration Tool uses a USB to RS-485 adapter cable to connect a standalone Sure Cross Gateway to a PC. The DXM Controller connects directly to a PC using a USB or Ethernet cable.

Before connecting a USB device, first download and run the User Configuration Tool program from Banner Engineering Corp's website (*www.bannerengineering.com/wireless*). If the USB device is connected while the software is installing, the driver installation may not finish properly.

To connect a Sure Cross wireless Gateway to a computer:

1. Complete the software installation first. The program installs the User Configuration Tool and the driver for the Banner USB/485 converter.
2. Connect the USB end of the Banner USB/485 converter to a USB port on the computer. The computer should recognize the Banner USB/485 device.
3. Connect a Banner wireless Gateway to the Euro-style connect end of the Banner USB/485 converter. The Gateway device powers up.[1] When using a third-party USB/485 converter, manually wire the communication and power connections. Refer to Banner's Gateway datasheet for the wiring pinout configurations.
4. Launch the User Configuration Tool.
5. Select the correct COMM port for the USB to RS-485 converter.

The DXM Controller ships from the factory with a USB cable to directly connect to a PC. An Ethernet connection is also an option for configuration. Refer to the DXM Controller Instruction Manual (p/n *190037*) for more information about defining an IP address for an Ethernet connection.

1.2 Menu Bar

The **File** and **Device** menus select the basic file operations and communication configuration for the DX80 Gateway.

Access the **File** and **Device** menus from the menu bar.

1.2.1 File Menu

Exit—Closes the COMM port and exits the program. Any data that is not saved is lost.

Load—Loads a specific XML configuration file into the tool for editing. This XML configuration file is unique to the User Configuration Tool and is not compatible with other configuration tool XML files.

New—Loads blank configuration settings into the tool.

Save—Saves the current settings in the configuration tool under the current XML file name. The program switches to Save As if there is no XML file name assigned.

Save As—Saves the current settings in the configuration tool to a new file name specified by the user.

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[1] The Gateway will not remain powered up until the computer recognizes and configures the USB port. After plugging the USB/485 converter into the computer's USB port, wait about 10 seconds for the Gateway to be powered (LED 1 solid green).

1.2.2 Device Menu

Traffic Watcher—Views all serial data traffic between the host and the master radio. The Traffic Watcher logs file loads, error messages, and data transfers.

Connection Settings—Sets the COMM port to communicate with the master radio. There are four possible connection with the User Configuration Tool.

> Serial—Direct connection to the master radio using a RS485 to USB converter cable.
> Serial DXM—Connecting to a DXM internal ISM radio using USB
> TCP DXM—Connecting to a DXM internal ISM radio using Ethernet; select the VPN checkbox only when your DXM is connected to the Internet via a cell modem

1.3 Connection Settings

The DX80 User Configuration Tool or the MultiHop Configuration Tool connects directly to a standalone Gateway or Master device by using the USB to RS-485 adapter cable. When using a DXM Controller, you may connect to the internal radio or any MultiHop radio attached to the DXM Controller, through the DXM Controller.

After the software launches, go to **Device** > **Connection Settings** to choose one of the four communication modes: **Serial**, **Modbus over TCP**, **Serial DXM**, or **TCP DXM**.
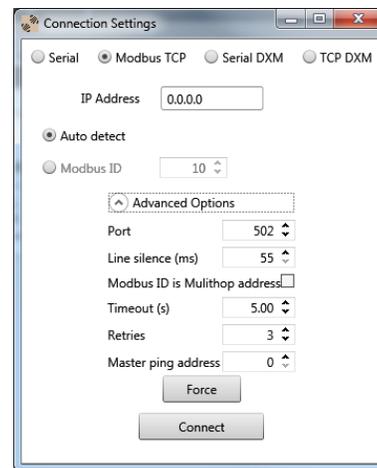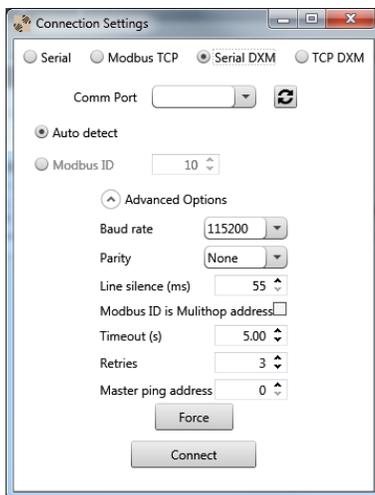
1.3.1 Basic Connection Settings

Comm Port / IP Address—Select the COMM port of the PC or, when using Ethernet, the IP address of the device. Click the refresh button to refresh the COMM ports on the PC.

Connect/Click to Cancel—Click to verify a radio is present by reading back the RF firmware. After a connection is in progress, this button changes to **Click to Cancel**.

Modbus ID—Modbus address ID of the radio.

Modbus TCP—Use when connecting to a standard DX80 Gateway or MultiHop master radio using an Ethernet connection. The IP address must be known to communicate with the device.

Serial—Use when directly connecting to a standard DX80 Gateway or MultiHop radio using the USB to RS-485 adapter cable.

Serial DXM—Use when configuring an internal radio of the DXM Controller using the USB connection on the DXM Controller.

TCP DXM—Use when configuring the internal radio of the DXM Controller using the Ethernet port. The standard DXM TCP port is 8844.

1.3.2 Advanced Connection Settings

Baud Rate (Serial only)—Defines the baud rate for the serial connection of the USB to RS-485 converter or DXM USB connection. Default of 19200 for the USB to RS-485 converter or 115k for the DXM USB connection.

Force—Click to have the software use the selected parameters and force a connection to a device without validating the device is present.

Line Silence—Specifies the wait time between two consecutive Modbus messages created by the DXM Controller. Too short of a wait time may cause external Modbus devices to miss or create errors on Modbus traffic. A typical setting should be 50 to 100 ms.

Master Ping—For most applications, leave the Master Ping set to 0. To communicate directly with a DXM baseboard, set the value to 2. Using Master Ping allows you to have multiple master radios on a single network. For more information about this advanced setting, contact Banner Engineering Corp and ask to speak to a Wireless applications engineer.

Parity (Serial only)—The default parity setting is None. Optional settings are Even or Odd.

Port (Ethernet only)—Defines the Ethernet port used when communicating via Modbus/TCP or to the DXM Controller. The default is 502.

Retries—The number of times the software resends Modbus messages before it errors out. The minimum number of retries is three.

Timeout—The time allowed for a Modbus message to complete. The default time out is 0.5 seconds for a serial connection and 5 second for a TCP connection. This may need to be extended for battery-powered devices or networks with communications paths that include multiple repeater devices.

2 Device Configuration

Use the **Device Configuration** screen to configure the Gateway and each Node's input and output parameters. Click on the arrow to the left of the device type to expand the settings for that device.

Devices are listed as a single line that can be expanded to view device level parameters and individual I/O points. Use the drop-down list in the upper left to select how the devices are shown: All Nodes, Nodes with Configuration Data, or Nodes Currently in the System.
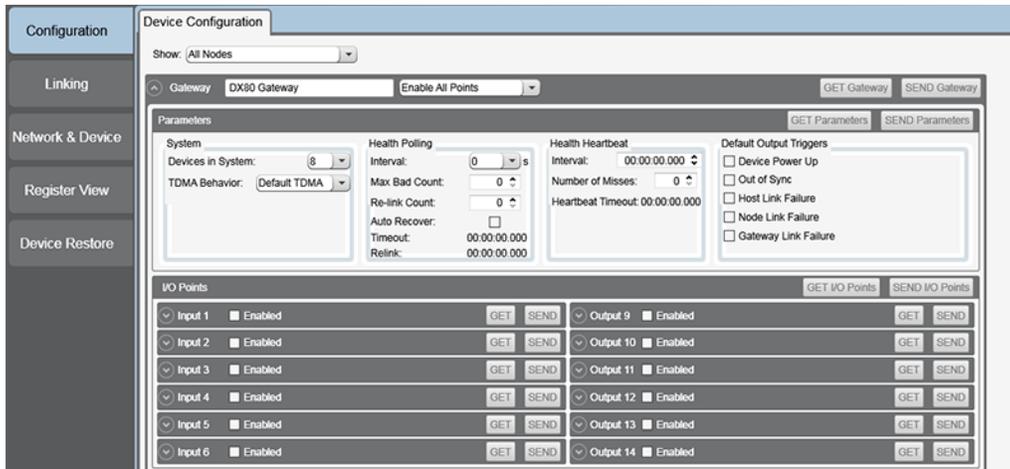
2.1 Gateway or Node Parameters

Get all the parameter data for a device by clicking on **GET Gateway** or **GET Node**. This may take a few minutes. Click the down arrow next to the device name to expand the screen.

Click **GET Parameters** or **SEND Parameters** to read or write the device-level parameters (first section under the Gateway line).

Expand individual lines of an I/O point by clicking on the down arrow next to the input or output name. Read or write I/O point data individually using **GET** or **SEND**. Read or write I/O data all at once using **GET I/O Points** or **SEND I/O Points**.
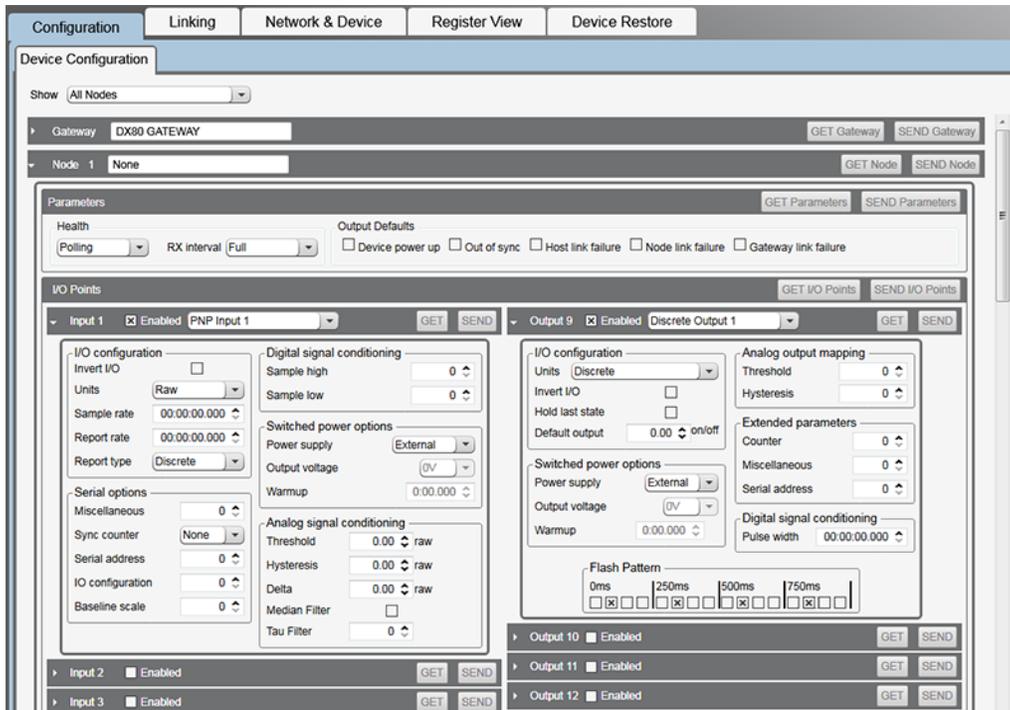
2.1.1 Gateway Device-Level Parameters

The following are the Gateway-specific device-level parameters.

Default Output Conditions/Triggers

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

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

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

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

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

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

Health Heartbeat

Heartbeat mode is typically used for battery-powered devices. This allows for optimal battery performance but will not be a fast deterministic indicator of network health. Typically Heartbeat parameters are setup to detect a network failure in 1-5 minutes. In heartbeat mode, the Nodes send "heartbeat" messages to the Gateway at specific intervals to indicate the radio link is active. The heartbeat is always initiated by the Node and is used only to verify radio communications.

Interval—The interval the Node sends the heartbeat messages to the Gateway.

Number of Misses—If the Node fails to get its heartbeat message to the Gateway, it immediately retries for the Number of Misses times. The length of time these retries take depends on the maximum number of Nodes in the system. The length of time in which the Gateway listens for a specific Heartbeat message is defined by the Node's Heartbeat Interval + the time to complete the Number of Misses + 1 second buffer. The time to complete the selected Number of Misses depends on the number of Nodes in system.

Health Polling

Polling is the default method to verify device communications status within the network. Banner wireless systems use polling to monitor the status of the RF communications link. If the RF link fails, the system can take precautions to set outputs to defined states. Choose system polling parameters carefully: higher polling intervals create more RF traffic. With multiple wireless systems within range, more RF traffic results in a higher percentage of missed communications.

Auto Recover—A device that is out of sync will automatically rejoin the network when the Auto Recover is enabled. Otherwise, it will require a manual reset of the error condition before the Node is allowed back into the wireless network. Default setting: enabled.

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

Maximum Bad Count—The maximum bad count refers to a user-established maximum count of consecutive failed polling attempts before the Gateway considers the radio (RF) link to have failed.

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

System

Device In System—Use the drop-down list to select the total number of wireless devices in your wireless network, including the Gateway. The more devices in the network, the slower the overall network performance is.

    8 Devices = Nodes communicate every 62.5 milliseconds
    16 Devices = Nodes communicate every 128 milliseconds
    32 Devices = Nodes communicate every 250 milliseconds
    48 Devices = Nodes communicate every 500 milliseconds

TDMA Behavior—Select the TDMA behavior from the following choices:

Default TDMA— Standard communications with Node devices.

Fast Sync—Allows DX80 Nodes to synchronize to the Gateway much faster, which causes more RF traffic from the Gateway and uses more operating current. We do not recommend using this setting in multiple network environments.

Power Save Gateway— Used for applications that require minimizing the power consumption of the Gateway (battery or solar powered). This setting causes higher latency in the communications between the Gateway and Node.

2.1.2 Node Device-Level Parameters

There are two parameters that determine the **Health** of a DX80 star architecture wireless network: polling and heartbeat. Both parameters are defined on the Gateway.

- **Polling**—Polling is the default health method for 10 to 30 V dc powered devices. A polling setting of less than one second requires the RX interval to be set to Full.
- **Heartbeat**—Heartbeat is more efficient for battery-powered devices and is the default setting for battery-powered devices.

The **RX interval** is a Node parameter that defines how often a Node will listen for Gateway communications.

- Full—For 10 to 30 V dc power devices, set the RX interval to FULL to have the Node communicate with the Gateway at the maximum rate. Any Polling or Heartbeat health settings will operate.
- 1 second—For battery-powered devices, set the RX interval to 1 second. This optimizes the battery life for battery-powered devices, but slows down the communication rate with the Gateway. Only Polling health settings greater than 1 second are allowed.
- 2 seconds to 4 seconds—Some battery-powered devices are set higher than a 1 second receive interval to optimize battery life. Set the DX80 Q45 and M-GAGE device receive intervals to 2 seconds, and set the 900 MHz M-GAGE to 4 seconds. Devices set to 2 or 4 second RX intervals should use the Heartbeat health method.

For the **Output Defaults** definitions, see *Gateway Device-Level Parameters* on page 7.

2.2 Input Parameters

To view or change the input parameters, click on the arrow next to the **Input** number and select **Enabled**.

For each input, the following input types are available. Verify with your device datasheet which inputs are configurable and which inputs are set by the factory.

- Accelerometer in
- Accelerometer configuration
- Analog
- Asychronous counter
- Battery voltage
- Bridge
- Constant value
- HART
- Interrupt

- J-type thermocouple
- K-type thermocouple
- Modbus holding registers
- Multiple NPN
- Multiple PNP
- NPN (sinking) or PNP (sourcing) discrete
- Photoelectric
- R-type thermocouple
- Relay

- SDI-12
- Stack light
- Thermistor
- Touch sensor
- Ultrasonic
- 100-ohm RTD
- 10-ohm RTD
- Other thermocouple types

2.2.1 Analog Signal Conditioning

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

Median Filter—When the median filter is turned on, three samples are taken for each analog sensor reading. The high and low values are discarded and the middle value is used as the analog value. Set to zero (0) to turn off the median filter. Set to one (1) to turn on the median filter.

Tau Filter—Set to zero (0) to turn off the tau filter. Set to 1 (weakest filter) through 6 (strongest filter) to turn on the tau filter. (In the DX80 products, the Low Pass Filter is a combination of the median filter and the tau filter.)

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

2.2.2 Digital Signal Conditioning

Sample High/Low (Analog)—For analog inputs, the sample high parameter defines the number of consecutive samples the input signal must be above the threshold before a signal is considered active. Sample low defines the number of consecutive samples the input signal must be below the threshold minus hysteresis before a signal is considered deactivated. The sample high and sample low parameters are used to avoid unwanted input transitions.

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

2.2.3 I/O Configuration

Report Rate—The report rate defines how often the Node communicates the I/O status to the Gateway. For *Flex*Power® applications, setting the report rate to a slower rate extends the battery life. The units are hours:minutes:seconds.

Report Type—The report type defines the data format for the reporting message. A report type of discrete indicates this is a single bit of data. A report type of analog defines the reporting message to be 16-bits of data. A report type of double is 32-bits of data. Enter the time in minutes:seconds (MM:SS.sss).

Sample Rate—The sample interval, or rate, defines how often the Sure Cross device samples the input. For battery-powered applications, setting a slower rate extends the battery life. The units are hours:minutes:seconds.

Units—Select the units of your input from the drop-down list.

2.2.4 Serial Options

I/O Config—The I/O Config parameter is a configuration parameter for smart sensor devices. This parameter also defines I/O information for the Extended Logic I/O type. (Parameter number 0x14).

Serial Address—The serial address parameter defines the remote serial device address to read. This parameter also defines configuration information for the Extended Logic I/O type. (Parameter number 0x19).

Sync Counter—Select between none, 16-bit, or 32-bit counters.

2.2.5 Switched Power Options

Efficient power management technology enables some *Flex*Power devices to include an internal power output supply, called switch power (SP), that briefly steps up to power sensors (ideally, 4 to 20 mA loop-powered sensors). The warmup time denotes how long the sensor must be powered before a reliable reading can be taken. After the warmup time has passed, the input reads the sensor, then the switched power shuts off to prolong battery life.

Power Supply—Select how the sensor connected to this input is powered: external power supply or switch power 1 through 4. Only devices with switched power outputs can power a sensor. Refer to the device datasheet to see which, if any, switched power outputs are available.

Output Voltage—Select the voltage of your switched power output from the drop-down list.

Warmup—Select the warmup time of your sensor. Units are shown in minutes:seconds. The maximum value is 2:07.5 (two minutes, 7.5 seconds). The minimum time is 0.001 seconds.

2.3 Output Parameters

For each output, the following output types are available. Verify with your device datasheet which outputs are configurable and which outputs are set by the factory.

- Analog
- Clear asynchronous counter
- Clear synchronous counter
- Discrete
- Enable RTS

- Force sample and report
- H-bridge
- M-GAGE baseline
- M-GAGE configure
- NMOS

- Relay
- Serial write
- Set thresholds with offsets
- Stack light
- Switch

2.3.1 Analog Output Mapping

The default view shows the **Threshold** and **Hysteresis** parameters. These parameters are used in certain configuration modes of the output. When Linking is defined, these parameters change names to Start and End parameters.

The Start and End parameters define the beginning and ending window when mapping an analog input range to an analog output range. The output range is always defined as the output capability: 4–20 mA, 0–20 mA, or 0–10 V. The Start and End parameters define the input range.

For example, a temperature input on a Node is linked to the 4–20 mA analog output on a Gateway. If we want to link a temperature range of 32 to 90 degrees to 4–20mA, the Start parameter is set to 32 degrees and the End parameter is set to 90 degrees. The parameters will be grayed out until an input to output linking is defined.

2.3.2 Digital Signal Conditioning

Pulse Width—The number of 62.5 ms intervals a digital output is active (1) before returning to zero. Zero disables the pulse width feature and any value on an output point remains indefinitely. Maximum pulse width is about 16 seconds. Value range: 0 (disable, default) through 255. (Parameter number 0x0A).

2.3.3 Flash Pattern

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

2.3.4 I/O Configuration

Default Output—If a default output is selected, this is the value placed in this register when radio communications are lost between the Gateway and this Node.

Hold Last State—If this checkbox is selected, this register retains the last sampled state when radio communications are lost between the Gateway and this Node.

2.3.5 Miscellaneous

Counter—Select between none, 16-bit, or 32-bit counters.

IO Config— The I/O Config parameter is a configuration parameter for smart sensor devices. This parameter also defines I/O information for the Extended Logic I/O type. (Parameter number 0x14).

Serial Address— The serial address parameter defines the remote serial device address to read. This parameter also defines configuration information for the Extended Logic I/O type. (Parameter number 0x19).

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Power Supply—Select how the sensor connected to this input is powered: external power supply or switch power 1 through 4. Only devices with switched power outputs can power a sensor. Refer to the device datasheet to see which, if any, switched power outputs are available.

Output Voltage—Select the voltage of your switched power output.

Warmup—Select the warm up time of your sensor.

3 Linking Configuration

Use the **Linking Configuration** screen to map one Sure Cross device's inputs to another Sure Cross device's outputs, as long as both devices are part of the wireless network.

The DX80 Gateway is capable of internally mapping any input register to any output register. Do not use the internal linking capability if an external host system will be reading and writing Modbus data registers in the Gateway. The **Linking Configuration** screen lists each device on a line. Click on the arrow to expand that device's parameters. Inputs are on the left, outputs are on the right.
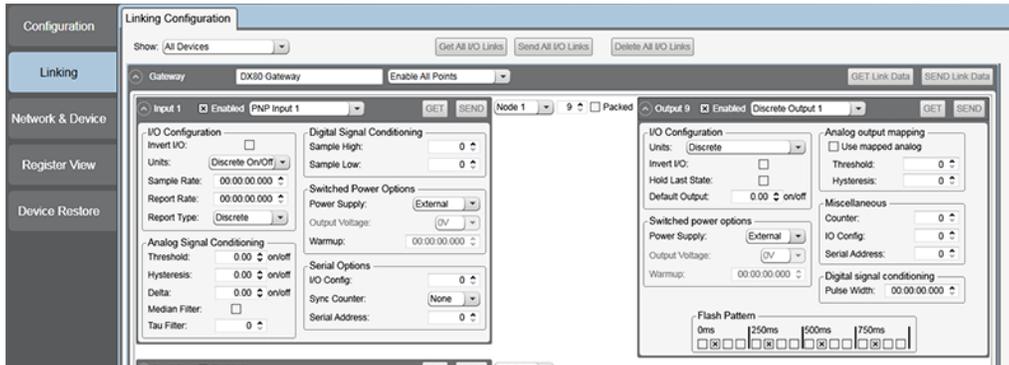
Click **Get All I/O Links** to retrieve any existing links in the entire wireless network. After the linking is defined, click **Send All I/O Links** to write all linking data. To erase all linking data, click **Delete All I/O Links**.

For simple register linking, you are not required to define the detailed parameters of an input or output (using **GET** or **SEND** on the I/O). If required, I/O can be configured using the **Configuration** screen.

For complex linking from an input scale to a different output scale, define **Analog Output Mapping** parameters to set the start and end of the output scale.

To map your I/O:

1. Select the Gateway or Node and click on the arrow to the left of its name. A list of that device's inputs and outputs is shown.
2. To map each input to an output, change the **Not Linked** entry on the drop-down menu to the appropriate device for the output.
3. Select the output register.
4. Define each input-to-output linking for this device.
5. Click **SEND Link Data**.

The source device may be the Gateway or any of the Nodes physically present in the network. Device I/O points 1 through 8 are inputs on most DX80 wireless models. Device I/O points 9 through 14 are outputs on all DX80 wireless models. Refer to the device's datasheet for exact input and output configurations. The source type field displays the input structure for that given input. Sample input structures include discrete, 0–20 mA, 4–20 mA, 0–10V dc, degrees C, degrees F, and raw.

4 Network and Device Information

Use the **Network & Device Information** screen to view factory information about your wireless network devices and to view the Site Survey results.

Factory information about a device includes the model number, production date, serial number, and various firmware and EEPROM versions.
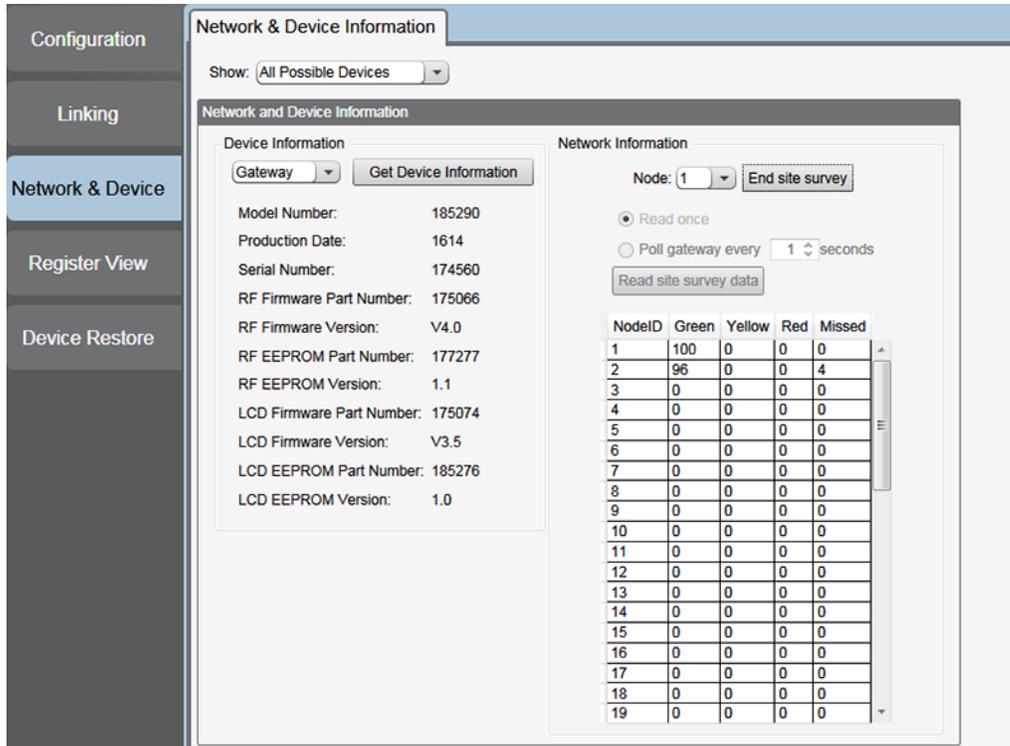
To view all the device's factory information:

1. From the **Device Information** drop-down list, select a device.
2. Click **Get Device Information**. The program retrieves all version and manufacturing data from the device and displays it on the screen.

To conduct a Site Survey analysis:

1. Select the Node number from the drop-down menu.
2. Click **START Site Survey**.
3. To view the results from within the User Configuration Tool, click on **Read Site Survey**.

Leaving this screen before the Site Survey has completed running ends the Site Survey. While the Site Survey is running, the Node currently being surveyed displays.

4.1 Interpreting the Site Survey Results

Site Survey results are listed as a percentage of data packets received and indicate the signal strength of the received signal.

	Result	Description
	Green	Packets received at a strong signal strength. A strong signal strength is greater than −90 dBm at the receiver.
	Yellow	Packets received at a good signal strength. A good signal is between −90 and −100 dBm at the receiver.

	Result	Description
	Red	Packets received at a weak signal strength. A weak signal is less than −100 dBm at the receiver.
	Missed	Packets not received on the first transmission and requiring a retry.

Judging if the reliability of a network's signal meets the needs of the application is not just a matter of green, yellow, and red packets received. In normal operating mode, when data packets are not received, the transmitter re-sends the packet until all data is received.

For slow monitoring applications such as a tank farm, where data is required in terms of seconds or minutes, receiving most of the data in the 'red' range, indicating a weak but reliable signal, transmits enough data for accurate monitoring. Nodes positioned near the outside range of the radio signal may have 90% of the data packets received in the red zone, again indicating a weak, but reliable signal.

We recommend keeping the missed packets average to less than 25%. When the network misses more than 25% of the data packets, the signal is usually too unreliable or obstacles may be interfering with the signal. When Site Survey reports the missed packets are 25% or higher, improve the radio system performance by:

- **Mounting the network's antennas higher** to clear obstacles in the area and improve the line of sight between Sure Cross® devices
- **Using higher gain antennas** to focus the energy of the radio signal in a specific direction and extend the signal's range
- **Adding data radios to the network** to extend the range of a radio network. For more information on data radios, please refer to Banner's white paper on range extension on *www.bannerengineering.com/wireless*.

5 Register View

The **Register View** screen creates a Modbus master utility to read or write any Modbus register within the DX80 Gateway. Use the **Register View** screen to read or write specified device I/O values.
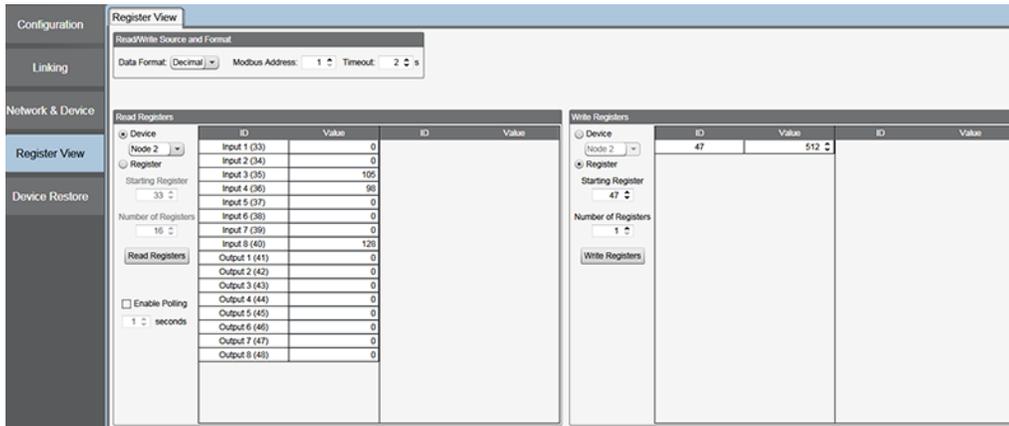
Read/Write Source and Format—From the drop-down list, select the which data format to view the register values in: decimal or hex. Enter the Modbus address of the wireless network's Gateway.

Read Registers—To read selected registers:

1. Select a device from which to read registers value.
2. Click **Read Registers**. The register values are displayed for the selected device.

Select **Enable Polling** and enter a time in seconds to enable constant polling from the Gateway. The **Read Registers** button changes to **Begin Polling**. Click **Begin Polling** to start polling at the defined rate.

Write Registers—To write to specific registers:

1. Select a device to write to from the drop-down list.
2. Enter a value into the value column for the specific register you want to write to.
3. Click **Write Registers**.

Click **Click to Cancel** to end the read or write process.

6 Device Restore

Use the **Device Restore** screen to change the baud rate, parity, or slave ID settings on the DX80 Gateway. Changes to these parameters require the same changes be reflected in the User Configuration Tool software to remain in communication with the DX80 Gateway.
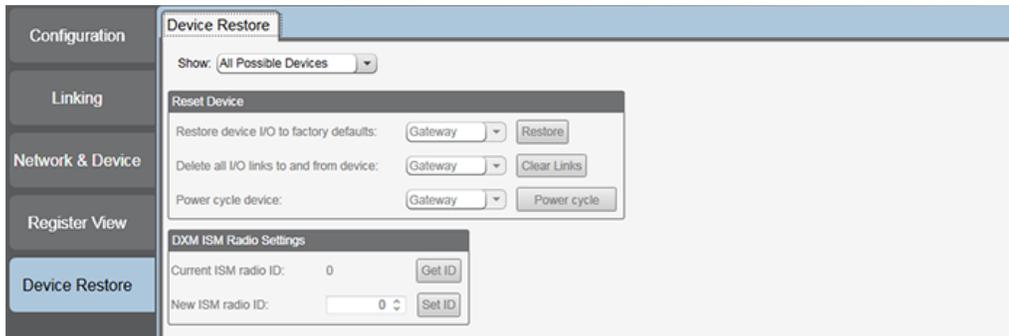
Reset Device—To restore the factory default settings to a selected device, select the device from the drop-down list. Click **Restore**.

To clear the I/O links from a device, select the device from the drop-down list. Click **Clear Links**. This erases any I/O links to or from the selected device.

To reboot, or cycle power, to a device, select the device from the drop-down list. Click **Power Cycle**. Cycle power to a device after you have changed any of the settings of that device.

Serial Port Settings—The Gateway's factory default baud rate is 19.2k, 1 stop bit, no parity. If you set the device's baud rate to something other than 19.2k, match the computer's baud rate to that speed to use the UCT.

If you do not know what baud rate or parity your Gateway is set to, refer to the Gateway's LCD display, under the Device Config (DVCFG) menu. Click **SET** to send any new settings to the Gateway.

By default, Gateways are set to use Modbus Slave ID 1. To set your Gateway's Modbus Slave ID to another number, enter a number in the Modbus Address field and click **SET**.

7 Example Configuration -- Analog Inputs

To configure Analog IN 1 for a specific sample rate, report rate, and switch power output voltage, follow these steps.

For this specific configuration example, we will be using a DX80N9X2S-P1 Sure Cross® Performance Node. Configuring other Node models is the same, except that the input point associated with Analog IN 1 may be different.

To use the UCT to configure your Node, first set the Node's DIP switch to be Host Configured. This overrides all other DIP switch settings and relies on the host system or UCT to configure the device. Consult your Node's datasheet to determine which DIP switch selected between Host Configured (ignores DIP switches) and DIP switch configuration.

Determine which analog input you are configuring. For this example, we are configuring Analog IN 1 of a -P1 Node. This is input 3.

1. Select the P1 Node from the list and click the arrow to the left of the Node name to open those device parameters.
2. Click the arrow next to Input 3 to open the parameters for that input.
3. Enable Input 3.
4. From the drop-down, select Analog Input 1.

7 Configure the Switched Power Options

To configure the switch power, you must set the power supply, switch power voltage, and warm-up parameters. These parameters must be assigned to the same I/O point as the analog input you are configuring, in this example this is I/O point 3 (Analog IN 1).

After configuring each parameter, click the **Send** button associated with this input to send the configuration changes to the Gateway's configuration file.

1. Set the power supply parameter. In this example, we are associating SP1 with Analog IN 1 (I/O point 3 on the -P1 Performance Node).
2. Set the switch power voltage parameter. In the example, we are setting the switch power voltage to 15 V and the switch power voltage is associated with I/O point 3 (Analog IN 1 for the -P1 Performance Node).
3. Set the warm-up parameter. In this example, we are setting the switch power warm-up time to one (1) 62.5 millisecond interval, or 62.5 milliseconds.
4. Click **Send** to send this setting to the Gateway's configuration file.

7 Configure the Sample and Report Rates

1. From the Units drop-down list, select the units for your analog input.
2. Set the sample rate of input 3 (Analog IN 1) to 30 minutes.
3. Set the report rate of input 3 (Analog IN 1) to 30 minutes.
4. Click **Send** to send this setting to the Gateway's configuration file.
5. From the Report Type drop-down list, select the report type.

8 Advanced Topics

8.1 Parameter Definitions and Numbers

The following parameters can be changed using the User Configuration Tool or by sending register commands from your host system.

Counter Enable. An enable byte that turns any input point into a synchronous counter. Set to 0 to turn off (default). Set to 1 to enable the 16-bit counter (report type must be set to analog). Set to 2 to enable the 32-bit counter (report type must be set to double). (Parameter number 0x18). The counter value is stored in the Modbus registers. For a 32-bit counter type, Modbus registers N and N+1 are used.

Default Value (bits 15:0). Defines the default state for each output on all devices. This parameter only applies to outputs. A value of 65535, or 0xFFFF, sets the default value to the last known state. (Parameter number 0x11). There are five conditions that cause the output points to be set:

- Bit 1. Power-up. If enabled, output points are set to the default state when the device powers up. When disabled, outputs are set to 0 when the device powers up.
- Bit 2. Node Out-of-Sync. If enabled, the output points are set to the default state when a Node determines it is out of sync with the Gateway (7 to 10 sec). When disabled, no action takes place for the output points when an out-of-sync condition is detected.
- Bit 3. Host Link Failure. A Modbus user-defined timeout period expired. If enabled, a host link failure forces all device outputs to the user-defined default state. Each device can be enabled/disabled for this feature.
- Bit 4. Gateway Link Failure. The Gateway has detected a problem with a Node in the system. If enabled, any Node outputs linked to the failing device are set to the default state when a Gateway link failure is detected. Each device can be enabled or disabled to use this feature.
- Bit 5. Node Link Failure. The Node detected a problem communicating with the Gateway. If enabled, the Node sets all outputs to the user-defined default state when a Node link failure is detected. Each device can be enabled or disabled to used this feature.

Delta (bits 15:0). Defines the amount of change required between two successive analog input sample points to trigger a report condition. To disable (default), set to 0. (Parameter number 0x0F).

Duty Cycle (Outputs only) (bits 15:0). This parameter defines the proportion of time the output is active. Using the 16-bit field, each "on" bit represents 1/16 seconds. For example, 0000 0000 0000 1111 (0x000F) sets the duty cycle to 1/4 seconds; 0000 0000 0000 0011 (0x0003) sets the duty cycle to 1/8 seconds. (Parameter number 0x04).

Enable Flag (bit 0). Enables (1) or disables (0, default) the I/O point. (Parameter number 0x01).

Hysteresis (bits 15:0). Works with the active threshold parameter to define when to disable event reporting of an analog input. The hysteresis parameter defines how much below the active threshold the analog input is required to be before the analog input is considered to be off. Value range: 0 (disable, default) through 65535 (two-byte value). (Parameter number 0x09).

I/O Config. The I/O Config parameter is a configuration parameter for smart sensor devices. This parameter also defines I/O information for the Extended Logic I/O type. (Parameter number 0x14).

I/O Type (bits 7:0). Defines the operations required to operate this I/O point. Every enabled I/O point must have a defined I/O type. (Parameter number 0x02). This parameter is hardware specific and is not typically changed from the factory settings. (See input and output type tables after this section.)

Invert Flag (bit 0). Complements the polarity of the sensed I/O point. A value of 1 becomes 0. An analog value is not changed, but an analog value with a threshold and hysteresis is complemented. Value range: 0 (inactive) to 1 (active). (Parameter number 0x10).

Low Pass Filter. This parameter defines the operation digital filters for standard analog inputs. Setting parameter bit 7 enables a median filter. Parameter bits [2:0] define the output filtering magnitude. (Parameter number 0x12).

Power Supply # (bits 7:0). Turns on a local power supply to supply power to an external device. A parameter value of 0 indicates no power supply. A parameter value of 1, 2, 3, or 4 enables that particular internal supply connection. (Parameter number 0x0D).

Value range: 0 (external power supply, default), 1 (selects SP1), 2 (selects SP2), 3 (selects SP3), and 4 (selects SP4).

Three parameters define a power supply connection: power supply selection, voltage, and warm-up time. The voltage parameter defines the supply voltage. The warm-up parameter defines the time the power supply is on before evaluating the input point.

Pulse Width (Outputs Only; bits 7:0). The number of 62.5 ms intervals a digital output is active (1) before returning to zero. Zero disables the pulse width feature and any value on an output point remains indefinitely. Maximum pulse width is about 16 seconds. Value range: 0 (disable, default) through 255. (Parameter number 0x0A).

Report Rate (bits 15:0) . The report rate defines the rate that the I/O status is reported back to the Gateway. The value represents the number of 62.5 ms increments. Report rates can be from 0 to 4095 seconds. A non-zero report rate guarantees a report on a periodic basis AND at change of state. When set to zero, there will only be a report at change of state. Value range: 0 through 65535. (Parameter number 0x04).

Report Type (bits 1:0). Defines the internal data structure and reporting definition for an I/O point. If a discrete point changes state, all I/O points are reported to the Gateway in discrete values. An analog input can be treated as a digital value using the Threshold and Hysteresis parameters. (Parameter number 0x0E).

- Discrete/bit report type = 0. Use for discrete values.
- Analog report type = 1 (default). Use for all analog values (two bytes).
- Double report type = 2. Use for 32-bit counter values (four bytes).

Samples High (bits 7:0). The number of samples an I/O point must be detected high (1) before it is a change of state. This parameter can be applied to a discrete input or a analog input using the threshold parameter. Value range: 0 (disable, default) through 255. (Parameter number 0x06).

Samples Low (bits 7:0). The number of samples an I/O point must be detected low (0) before it is a change of state. This parameter can be applied to a discrete input or a analog input using the threshold parameter. Value range: 0 (disable, default) through 255. (Parameter number 0x07).

Sample Rate (bits 15:0). The rate at which the I/O point is sampled. The value represents the number of 62.5 ms increments. The sample rate/interval can be from 1 (0.0625 seconds, default) to 65535 (4095 seconds). Set to 0 to Sample on Demand. (Parameter number 0x03).

Sample on Demand allows a host system to send a Modbus command to any register and require the Node's inputs to immediately sample the sensor and report readings back to the host system. Sampling on demand can be used between the normal periodic reporting.

Serial Address. The serial address parameter defines the remote serial device address to read. This parameter also defines configuration information for the Extended Logic I/O type. (Parameter number 0x19).

Switch Power Voltage (bits 7:0). Used for I/O points supplying power to external devices. Use the lowest operating voltage of the external device when supplying power from a battery-powered DX80. Value range: 0 (default) through 255. (Parameter number 0x0B).

Output Voltage	Parameter (dec)	Parameter (hex)
5 V	204	CC
7 V	125	7D
10 V	69	45
15 V	32	20
20 V	12	0C
24 V	03	03

Threshold (bits 15:0). The trigger point or threshold for an analog input. When an analog input is greater than or equal to the threshold value, a ON or 1 event is reported (if not inverted). If the analog input does not reach the active threshold value, no change of state is reported. If the threshold parameter is 0, there is no threshold and the analog input will report based on the delta rate. Value range: 0 (disable, default) through 65535 (two-byte value). (Parameter number 0x08).

Units (bits 7:0). The parameter defines the range and/or type of value associated with the I/O point. The devices use this parameter to correctly interpret the I/O point data. (Parameter number 0x0C). (See units tables after this section.)

Warm-up Time (bits 7:0). Values 01 through 127 set the number of 62.5 millisecond increments. Values 129 through 255 set the number of 250 microsecond increments, with 129 representing 250 microseconds, 130 representing two 250 microsecond increments (500 microseconds, and 255 representing 127 250 microsecond increments (or 31 milliseconds). When the device supplies power to external sensors, this parameter defines how long power is applied before the input point is examined for changes. When running multiple I/O point using switched power, only use values 0–127 (62.5 ms to 7.9 seconds). Value range: 00 (off, default) through 255. (Parameter number 0x05).

Internal Output Mapping. Reserved. Do not use. (Parameter number 0x1A).

Miscellaneous. Reserved. (Parameter number 0x17).

8.1 M-GAGE Parameters

M-GAGE Baseline Threshold/Filter. Under normal conditions, the ambient magnetic field fluctuates. When the magnetic field readings drift below a threshold setting, the baseline or drift filter uses an algorithm to slowly match the radio device's baseline to the ambient magnetic field.

The baseline threshold/filter parameter sets a baseline threshold and filter activation time on M-GAGE devices. When M-GAGE input readings are below the selected baseline threshold setting, the filter algorithm slowly lowers the magnetic baseline reading to zero to remove small changes in the magnetic field over time. Setting options include the following values: (Parameter number 0x13).

Filter Threshold 30, 2 hour	Two hours after the M-GAGE reading of the ambient magnetic field (baseline) has dropped below 30, the algorithm begins to slowly lower the magnetic baseline reading to zero.
Filter Threshold 30, 8 hour	Eight hours after the M-GAGE reading of the ambient magnetic field (baseline) has dropped below 30, the algorithm begins to slowly lower the magnetic baseline reading to zero.

M-GAGE Baseline Filter (unrestricted). An M-GAGE only parameter, the baseline filter parameter sets the coefficient value of the baseline filter algorithm. (Parameter number 0x15).

M-GAGE Low Pass Filter. The filters T0 through T6 are parameter settings that define the degree of input digital signal filtering for analog inputs. T0 is the least amount of filtering. T6 is the highest filter setting and has the least amount of fluctuation between readings. (Parameter number 0x12).

M-GAGE Report Rate (Inputs) . The report rate defines how often the Node communicates the I/O status to the Gateway. For *Flex*Power® applications, setting the report rate to a slower rate extends the battery life. (Parameter number 0x04).

M-GAGE Sample High and M-GAGE Sample Low. For analog inputs, the sample high parameter defines the number of consecutive samples the input signal must be above the threshold before a signal is considered active. Sample low defines the number of consecutive samples the input signal must be below the threshold minus hysteresis before a signal is considered deactivated. The sample high and sample low parameters are used to avoid unwanted input transitions.

This parameter can be applied to a discrete input or a analog input using the threshold parameter. (Sample high parameter number 0x06, Sample low parameter number: 0x07).

M-GAGE Sample Rate. The sample interval, or rate, defines how often the Sure Cross device samples the input. For battery-powered applications, setting a slower rate extends the battery life. (Parameter number 0x03).

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

The M-GAGE Node's threshold and hysteresis ranges are 0 to 65,535. The factory default threshold setting is 100 and default hysteresis is 30 (the sensor detects an OFF condition at threshold minus hysteresis, or 100 - 30 = 70). With the default settings, once the magnetic field reading is above 100, an ON or "1" is stored in the lowest significant bit (LSB) in the Modbus register. When the M-GAGE reading drops below the OFF point (threshold minus hysteresis), the LSB of the Modbus register is set to "0." To determine your threshold, take M-GAGE readings of the test objects at the distance they are likely to be from the sensor. For example, if a car reads 100, a bicycle 15, and a truck reads 200, setting the threshold to 150 will detect only trucks of a specific size. Magnetic field fluctuations vary based on the amount of ferrous metal present and the distance from the sensor.

If the threshold parameter is 0, there is no threshold and the analog input will report based on the delta rate. Value range: 0 (disable, default) through 65535 (two-byte value). (Threshold parameter number 0x08; Hysteresis parameter number 0x09).

8.1.1 I/O Types (Parameter 0x02)

The following inputs and output types are set using **Device Config** > **Device Parameters** screen of the User Configuration Tool. You may also configure the I/O by sending Modbus commands from your host system.

General Input Types

Type #		Description	Type #		Description	Type #		Description
Hex	Dec		Hex	Dec		Hex	Dec	
0x30	48	Analog IN 1	0x01	1	NPN IN 1	0x19	25	Multiple Discrete NPN
0x31	49	Analog IN 2	0x03	3	NPN IN 2	0x1A	26	Multiple Discrete PNP
0x32	50	Analog IN 3	0x05	5	NPN IN 3	0x3B	59	SDI 12 COMMs
0x33	51	Analog IN 4	0x07	7	NPN IN 4	0xB1	177	Serial Read
			0x1B	27	NPN IN 5	0xB2	178	Serial Write
0x0D	13	Async Counter 1	0x1D	29	NPN IN 6	0x37	55	Battery voltage
0x0E	14	Async Counter 2	0x1F	31	NPN IN 7	0xF0	240	Constant

Type # Hex	Dec	Description	Type # Hex	Dec	Description	Type # Hex	Dec	Description
0x0F	15	Async Counter 3	0x21	33	NPN IN 8	0xB3	179	Force sample/report
0x10	16	Async Counter 4	0x02	2	PNP IN 1	0xB4	180	Set threshold with offset
			0x04	4	PNP IN 2	0xA3	163	Frequency read
0x4B	75	Bridge IN 1	0x06	6	PNP IN 3	0xA0	160	M-GAGE
0x4C	76	Bridge IN 2	0x08	8	PNP IN 4	0xA1	161	M-GAGE baseline
			0x1C	28	PNP IN 5	0xA7	167	M-GAGE configure
0x09	9	Pulse Input 1	0x1E	30	PNP IN 6	0xA4	164	M-GAGE X-Axis
0x0A	10	Pulse Input 2	0x20	32	PNP IN 7	0xA5	165	M-GAGE Y-Axis
			0x22	34	PNP IN 8	0xA6	166	M-GAGE Z-Axis
0xB0	176	Clear async counter				0xB5	181	Extended Input Logic
0xAF	175	Clear sync counter				0xA2	162	Enable RTS

Temperature Input Types

Type # Hex	Dec	Description	Type # Hex	Dec	Description	Type # Hex	Dec	Description
0x47	71	10 Ohm RTD (3-wire) IN 1	0xC5	197	Thermocouple E1	0xD1	209	Thermocouple N1
0x48	72	10 Ohm RTD (3-wire) IN 2	0xC6	198	Thermocouple E2	0xD2	210	Thermocouple N2
0x49	73	10 Ohm RTD (3-wire) IN 3	0xC7	199	Thermocouple E3	0xD3	211	Thermocouple N3
0x4A	74	10 Ohm RTD (3-wire) IN 4	0x53	83	Thermocouple E4	0x57	87	Thermocouple N4
0x40	64	100 Ohm RTD (3-wire) IN 1	0xC8	200	Thermocouple G1	0xD4	212	Thermocouple P1
0x41	65	100 Ohm RTD (3-wire) IN 2	0xC9	201	Thermocouple G2	0xD5	213	Thermocouple P2
0x42	66	100 Ohm RTD (3-wire) IN 3	0xCA	202	Thermocouple G3	0xD6	214	Thermocouple P3
0x43	67	100 Ohm RTD (3-wire) IN 4	0x54	84	Thermocouple G4	0x58	88	Thermocouple P4
0x3C	60	Thermistor IN 1	0x34	52	Thermocouple J1	0x44	68	Thermocouple R1
0x3D	61	Thermistor IN 2	0x35	53	Thermocouple J2	0x45	69	Thermocouple R2
0x3E	62	Thermistor IN 3	0x36	54	Thermocouple J3	0x46	70	Thermocouple R3
0x3F	63	Thermistor IN 4	0x4D	77	Thermocouple J4	0x47	71	Thermocouple R4
0x5C	92	Thermistor IN 5	0x38	56	Thermocouple K1	0xD7	215	Thermocouple S1
0xBC	188	Thermocouple B1	0x39	57	Thermocouple K2	0xD8	216	Thermocouple S2
0xBD	189	Thermocouple B2	0x3A	58	Thermocouple K3	0xD9	217	Thermocouple S3
0xBE	190	Thermocouple B3	0x4E	78	Thermocouple K4	0x59	89	Thermocouple S4
0x50	80	Thermocouple B4	0xCB	203	Thermocouple L1	0xDA	218	Thermocouple T1
0xBF	191	Thermocouple C1	0xCC	204	Thermocouple L2	0xDB	219	Thermocouple T2
0xC0	192	Thermocouple C2	0xCD	205	Thermocouple L3	0xDC	220	Thermocouple T3
0xC1	193	Thermocouple C3	0x55	85	Thermocouple L4	0x5A	90	Thermocouple T4
0x51	81	Thermocouple C4	0xCE	206	Thermocouple M1	0xDD	221	Thermocouple U1
0xC2	194	Thermocouple D1	0xCF	207	Thermocouple M3	0xDE	222	Thermocouple U2
0xC3	195	Thermocouple D2	0xD0	208	Thermocouple M3	0xDF	223	Thermocouple U3

Type #		Description	Type #		Description	Type #		Description
Hex	Dec		Hex	Dec		Hex	Dec	
0xC4	196	Thermocouple D3	0x56	86	Thermocouple M4	0x5B	91	Thermocouple U4

Output Types

Type #		Description	Type #		Description	Type #		Description
Hex	Dec		Hex	Dec		Hex	Dec	
0x80	128	Analog OUT 1	0x60	96	Discrete OUT 1	0x64	100	Discrete OUT NMOS 1
0x81	129	Analog OUT 2	0x61	97	Discrete OUT 2	0x65	101	Discrete OUT NMOS 2
0x82	130	Analog OUT 3	0x62	98	Discrete OUT 3	0x6C	108	Discrete OUT NMOS 3
0x83	131	Analog OUT 4	0x63	99	Discrete OUT 4	0x6D	109	Discrete OUT NMOS 4
			0x67	103	Discrete OUT 5			
0x6B	107	Switch Power Output	0x68	104	Discrete OUT 6	0x66	102	Multiple Discrete OUT
			0x69	105	Discrete OUT 7			
			0x6A	106	Discrete OUT 8			

8.2 Defining the Units

The units parameter defines the range and/or type of data value associated with an input or output.

Selecting **Units** from within any configuration tool changes the units definition of several parameters, including threshold, hysteresis, and delta. For example, if the units are 0 to 20 mA, the threshold, hysteresis, and delta values are entered as milliampere values. Selecting Temp °C changes the threshold, hysteresis, and delta units to degrees Celsius.

Signed values range from −32768 to +32767 and allow for the measurement of negative values. Signed values are typically used for measuring temperatures. Signed values are stored as two's complement values.

Unsigned values range from 0 to 65535 and are used to measure values that do not go below zero, such as 4 to 20 mA, distance, or a counter.

8.2.1 Input Units

Units	Description	Definition
0	Raw	Displays the raw A/D conversion data with data ranges from 0 to 65535. This units type is typically used only for factory calibration. LCD: Raw A/D hex value
1	4 to 20 mA	Analog unit. Modbus register contents are scaled such that 0 represents 4 mA and 65535 represents 20 mA. LCD: 4.00mA–20.00mA
2	0 to 20 mA	Default analog input unit. Modbus register contents are scaled such that 0 represents 0 mA and 65535 represents 20 mA. LCD: 0.00mA–20.00mA
3	Discrete (ON/OFF)	Default discrete input unit. LCD: ON/OFF
4	0 to 10 V (Volts)	Analog input using 0 to 10 V instead of current. Modbus register contents are scaled such that 0 represents 0V and 65535 represents 10V. LCD: 0.00V–10.00V
6	Temp °C	Celsius, high resolution. Analog input for temperature devices such as thermocouples, RTD, and thermistors. In high resolution mode, temperature = (Modbus register value) ÷ 20. LCD: 0000.0C

Units	Description	Definition
7	Temp °F	Fahrenheit, high resolution. Analog input for temperature devices such as thermocouples, RTD, and thermistors. In high resolution mode, temperature = (Modbus register value) ÷ 20. LCD: 0000.0F
8	Temp °C (Low Res)	Celsuis, low resolution. To measure a greater temperature range, use the low resolution unit. In low resolution mode, temperature = (Modbus register value) ÷ 2. LCD: 0000.0C
9	Temp °F (Low Res)	Fahrenheit, low resolution. To measure a greater temperature range, use the low resolution unit. In low resolution mode, temperature = (Modbus register value) ÷ 2. LCD: 0000.0F
10	Asynchronous Counter, 32-bit	The 32-bit counter value records counts up to 4.29 billion. LCD: 0000 0000
11	Asynchronous Counter, 16-bit	The 16-bit counter value records counts up to 65535. LCD: 0000

8.2.2 Output Units

Units	Description	Definition
0	Raw	Displays the raw A/D conversion data with data ranges from 0 to 65535. This units type is typically used only for factory calibration. LCD: Raw A/D hex value
1	4 to 20 mA	Analog unit. Modbus register contents are scaled such that 0 represents 4 mA and 65535 represents 20 mA. LCD: 4.00mA–20.00mA
2	0 to 20 mA	Default analog input unit. Modbus register contents are scaled such that 0 represents 0 mA and 65535 represents 20 mA. LCD: 0.00mA–20.00mA
3	Discrete (ON/OFF)	Default discrete unit. LCD: ON/OFF
4	0 to 10 V (Volts)	Analog unit using 0 to 10 V instead of current. Modbus register contents are scaled such that 0 represents 0 V and 65535 represents 10 V. LCD: 0.00V–10.00V
5	Signed Analog, 0 to 10 V	For a signed value, such as temperature, that is to be converted to a voltage out value. Use null to set the start point and span to define the range. The null value is the starting temperature to be associated with 0 V. The span is the entire temperature range that is to be associated with 0 to 10 V. LCD: 0.00V–10.00V
6	Signed Analog, 0 to 20 mA	For a signed value, such as temperature, that is to be converted to a mA out value. Use null to set the start point and span to define the range. The null value is the starting temperature to be associated with 0 mA. The span is the entire temperature range that is to be associated with 0 to 20 mA. LCD: 0.00mA–20.00mA
7	Unsigned Analog, 0 to 20 mA	For unsigned values, such as a counter, that is to be converted to a mA out value. Use the null to set the start point and span to define the range. The null value is the distance to be associated with 0 mA. The span is the entire distance range that is to be associated with 0 to 20 mA. LCD: 0.00mA–20.00mA
8	Signed Analog, 4 to 20 mA (A)	In older models, this units type is for degree Celsius conversions only. Use null to set the start point and span to define the range. The null value is the starting temperature to be associated with 4 mA. The span is the entire temperature range that is to be associated with 4 to 20 mA. For newer firmware models, type codes 8 and 9 are treated the same. LCD: 4.00mA–20.00mA
9	Signed Analog, 4 to 20 mA (B)	In older models, this units type is for degree Fahrenheit conversions only. Use null to set the start point and span to define the range. The null value is the starting temperature to be associated with 4 mA. The span is the entire temperature range that is to be associated with 4 to 20 mA. For newer firmware models, type codes 8 and 9 are treated the same. LCD: 4.00mA–20.00mA

Units	Description	Definition
10	Unsigned Analog, 0 to 10 V	For an unsigned value, such as 0 to 20 mA, that is to be converted to a voltage out value. Use the null to set the start point and span to define the range. The null value is the distance to be associated with 0V. The span is the entire distance range that is to be associated with 0 to 10 V. LCD: 0.00V–10.00V
11	Counter, 16-bit	The 16-bit counter value records counts up to 65535. LCD: 0000
12	Unsigned Analog, 4 to 20 mA	For an unsigned value, such as 0 to 10 V, that is to be converted to a mA out value. Use the null to set the start point and span to define the range. The null value is the distance to be associated with 4 mA. The span is the entire distance range that is to be associated with 4 to 20 mA. LCD: 4.00mA–20.00mA

8.2.3 Interpreting Register Values in the Banner Wireless System

The units conversion table defines the type and range of values for each type of I/O.

The wireless devices have many different units of measure for inputs including: milliamp (mA), voltage (V), temperature (°C or °F), humidity (RH), or a raw 16-bit or 32-bit value. Outputs can be either current (4 to 20 mA, 0 to 20 mA) or voltage (0 to 10 V dc). All values stored in Modbus registers are unsigned numbers, except for temperature readings. The temperature readings are stored as signed numbers (two's complement).

The following table defines the range of values and descriptions for input units.

Input Type	I/O Range		Holding Register Representation		Data Conversion	Description
	Min.	Max.	Min.	Max.		
Discrete	0	1	0	1	-	-
0 to 20 mA	0.0 mA	20.0 mA	0	65535	(20 mA ÷ 65535) × Reg Value = mA	Linear mapping of unsigned register value to current
4 to 20 mA	4.0 mA	20.0 mA	0	65535	((16 mA ÷ 65535) × Reg Value) + 4 = mA	Linear mapping of unsigned register value to current
0 to 10 V dc	0.0 V dc	10.0 V dc	0	65535	(10 V ÷ 65535) × Reg Value = V	Linear mapping of unsigned register value to voltage
Temp C/F (high resolution)	−1638.3	+1638.4	0	65535	(Converted Reg Value) ÷ 20 = Temp	Signed Values
Counter	0	65535	0	65535	-	-
16-bit T30UF	0 mm	65535 mm	0	65535	None; stored as millimeter value	Unsigned
Humidity	0% RH	100% RH	0	10000	(Reg Value) ÷ 100 = Relative Humidity (RH)	Unsigned

Temperature Measurements:
- In high resolution mode, the temperature = (Modbus register value) ÷ 20. For high resolution temperature input, 0 in the register is interpreted as 0° and 65535 in the register (0xFFFF) is interpreted as −1 ÷ 20 = −0.05°.
- In low resolution mode, the temperature is (Modbus register value) ÷ 2. For low resolution temperature input, 0 in the register is interpreted as 0° and 65535 in the register (0xFFFF) is interpreted as −1 ÷ 2 = −0.5°. The I/O range values are −16383 through 16384.

When using a 4 to 20 mA sensor with a 0 to 20 mA input, the sensor uses the 4 to 20 mA section of the total range. Using a 4 to 20 mA with a 0 to 20 mA input allows you to determine when you have an error condition with the sensor. A normal input reading between 4 and 20 mA indicates a functioning sensor whereas a value below 4 mA indicates an error condition, such as a broken wire or loose connection. Some Sure Cross devices allow you to configure the analog inputs and outputs to use either 0 to 20 mA or 4 to 20 mA.

8.2.4 Signed Numbers

Temperature values are stored in Modbus registers as two's complement signed numbers. Using two's complement allows negative numbers to be stored in Modbus registers.

Although not technically a sign bit, the most significant bit (MSB) indicates a negative number when the value is set to one (1). When the most significant bit is zero (0), the value is greater than or equal to zero.

Modbus register values of 32768 through 65535 (decimal) represent negative temperatures. These numbers in binary form are: 1000 0000 0000 0000 through 1111 1111 1111 1111.

To convert to a negative temperature value from a Modbus register value, first convert the value from the two's complement number. To convert from a two's complement number in binary form, invert all the bits (0 changes to 1, 1 changes to a 0), then add 1. Convert this binary value to a decimal value and divide by either 20 (high resolution mode) or 2 (low resolution mode) to calculate the negative temperature.

Register Value		Converted Decimal	Calculated Temperature
Two's Complement Value	Decimal Value		(Converted Decimal ÷ 20)
0000 0000 0000 0101	5	5	0.25
0000 0000 0000 0100	4	4	0.20
0000 0000 0000 0011	3	3	0.15
0000 0000 0000 0010	2	2	0.10
0000 0000 0000 0001	1	1	0.05
0000 0000 0000 0000	0	0	0
1111 1111 1111 1111	65535	-1	-0.05
1111 1111 1111 1110	65534	-2	-0.10
1111 1111 1111 1101	65533	-3	-0.15
1111 1111 1111 1100	65532	-4	-.20
1111 1111 1111 1011	65531	-5	-0.25
1111 1100 0001 1000	64536	-1000	-50

8.2.5 Mapping Unit Types

Using signed or unsigned value types allows the user to generically map any input to any output. The signed and unsigned values read the null and span parameters to create the linear translation between one scale and another. The output type is set to mA or V.

Output = (Fullscale/Span)(InputValue – Null) + Offset

Output Scale	Fullscale (range)	Offset
0 to 20 mA	20 mA	0 mA
4 to 20 mA	16 mA	4 mA
0 to 10 V	10 V	0 V

    Fullscale. Defined in the table; the output range.
    Span. The total range of values mapped to the output.
    Null. The starting point for the output scale.
    Input Value. The value mapped to the output.
    Offset. Defined in the table; the starting output value.

Example: Mapping a Temperature
Map a temperature input from a Node to a 4 to 20 mA output. The starting temperature is –20 °F and the last temperature will be 50 °F (4 mA = –20 °F, 20 mA = 50 °F). This defines the null as –20 °F and the span as 70.

With an input temperature value of –5 °F, the output value will be:

Output = (Fullscale ÷ Span)(InValue − Null) + Offset
(Fullscale ÷ Span) = 16 ÷ 70 = 0.22857
(Value − Null) = −5 − (−20) = 15
Offset = 4
Output = 0.22857 × 15 + 4 = 7.42 mA

Example: Mapping a Distance

Map a distance input from a Node to a 0 to 10 V output. The starting distance is 200 mm and the last distance will be 2000 mm (4 mA = 200 mm and 20 mA = 2000 mm). This defines the null as 200 and the span as 1800.

With an input distance reading of 1560 mm, the output value will be:

Output = (Fullscale ÷ Span)(InValue − Null) + Offset
(Fullscale ÷ Span) = 10 ÷ 1800 = 0.00555
(Value − Null) = 1560 − 200 = 1360
Offset = 0
Output = 0.00555 × 1360 + 0 = 7.54 V

Alarm Conditions. The standard alarm conditions are as follows:

Unsigned Alarm = 0xFFFF
Signed Alarm = 0x7FFF

If special alarm conditions are needed, consult the factory for details.

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