Interface Manual

Sentinel Modbus with 2DI

SignalFire Model: Sentinel-485-2DI-XXXX

The SignalFire Sentinel Node is an Intrinsically Safe device with the following features:

- RS485 connection to a single Modbus RTU sensor device
- Configurable Modbus register polling map
- Two digital inputs, perfect for high level alarms
- Reports state of dry contact inputs, open/closed, totalizer. Report on state change
- Can power an attached Modbus sensor at 5.3V or 7.6V with configurable warm-up time
- Low power operation from an intrinsically safe high capacity lithium primary battery pack
- Optional solar battery system for routing nodes, high power draw sensors, or rapid data collection
- Sends data to a SignalFire Buffered Modbus Gateway
- AES 128bit Encryption

Specifications

Enclosure Size	3.5" tall × 5.0" wide × 5.0" deep
Power Source	Internal IS Lithium battery pack *SignalFire Part Number: 3BIS* External Solar battery system *SignalFire Part Number: Sentinel-HCSolar* DC-DC Converter *SignalFire Part Number: DCDC-Sentinel* Other external power supply meeting the power entity parameters from the control drawing.
Temperature Rating	-40°C to +60°C
Radio Frequency	902-928MHz Ism Band, FHSS radio, internal antenna
Compliance	Certified for use in Class I, Division 1 groups C and D. EXi [EXi] FCC/IC Certified.

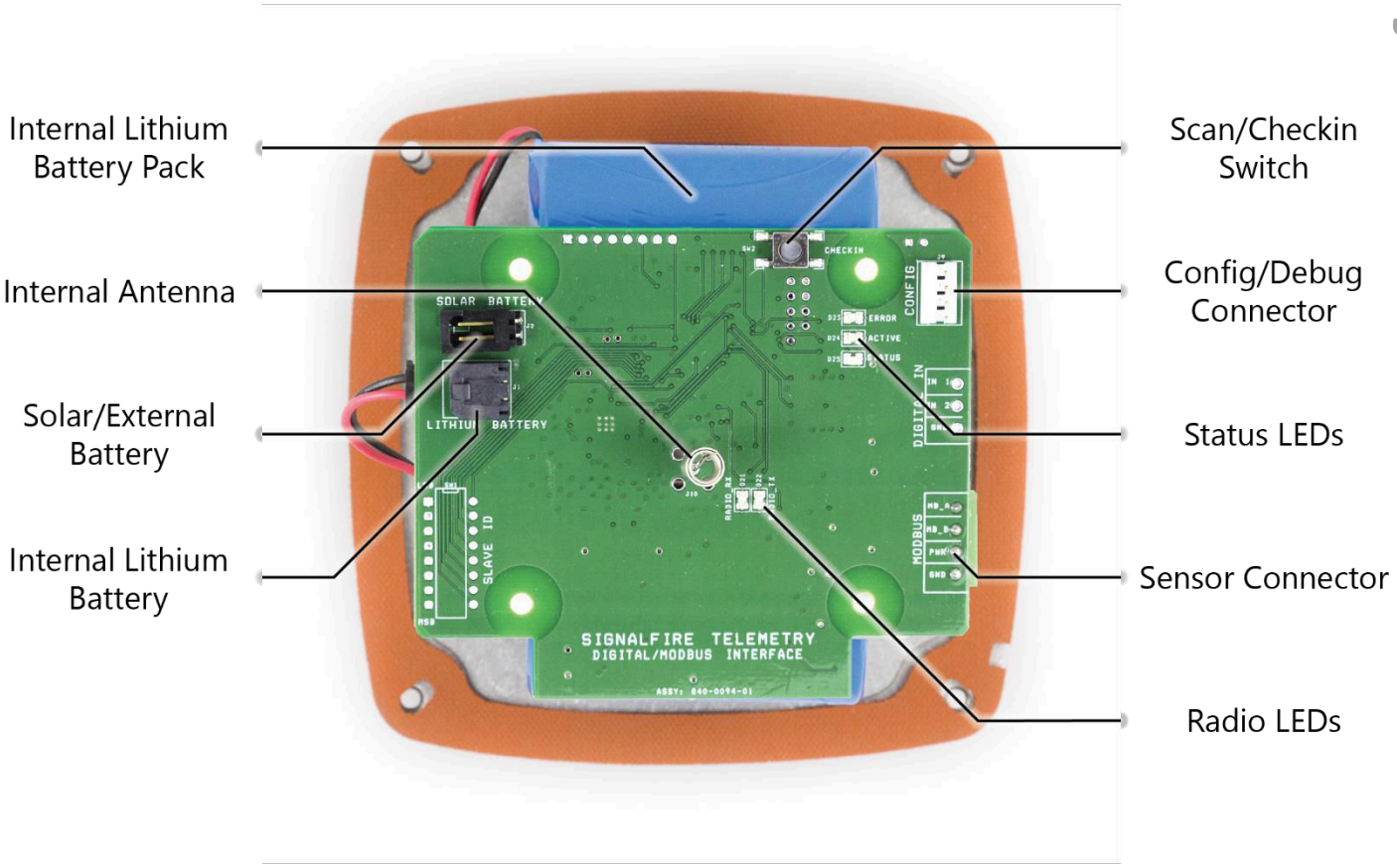
WARNING: Use of this equipment in a manner not specified by the manufacturer may impair the protection provided by the equipment.

WARNING: The use of any parts not supplied by the manufacturer violates the safety rating of the equipment.

The associated apparatus provides intrinsically safe outputs.
L'appareil associé fournit des sorties à sécurité intrinsèque.

Refer to control drawing "Sentinel – Control Drawing – Modbus 2DI" for requirements when used in a Class I Division 1 area.

Connections and Components



Radio LEDs

- The Radio TX LED (green) flashes each time a radio packet is sent. This LED will blink rapidly while searching for the radio network.
- The Radio RX LED (red) blinks on each received radio packet.

Status LEDs

- The Active LED (green) will blink at boot up and will blink rapidly when the sensor is being powered and read.
- The ERROR LED (red) will blink to indicate an error condition.

Scan/Checkin Button

- If this button is pressed the Sentinel will power the sensor on for the configured time, read the pre-configured Modbus registers from the sensor, and forward those values to the gateway.

Setup

The nodes need to be set up for correct operation before being fielded. The configurable items include:

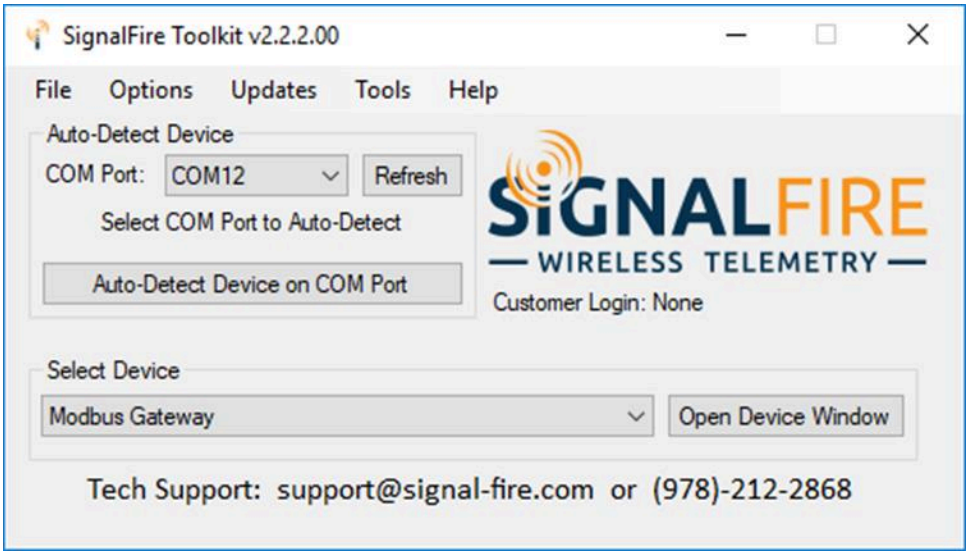
- Network selection
- Check-in period selection
- Modbus registers to be polled
- Modbus sensor power on time

All settings are made using the SignalFire Toolkit PC application and a serial programming cable.

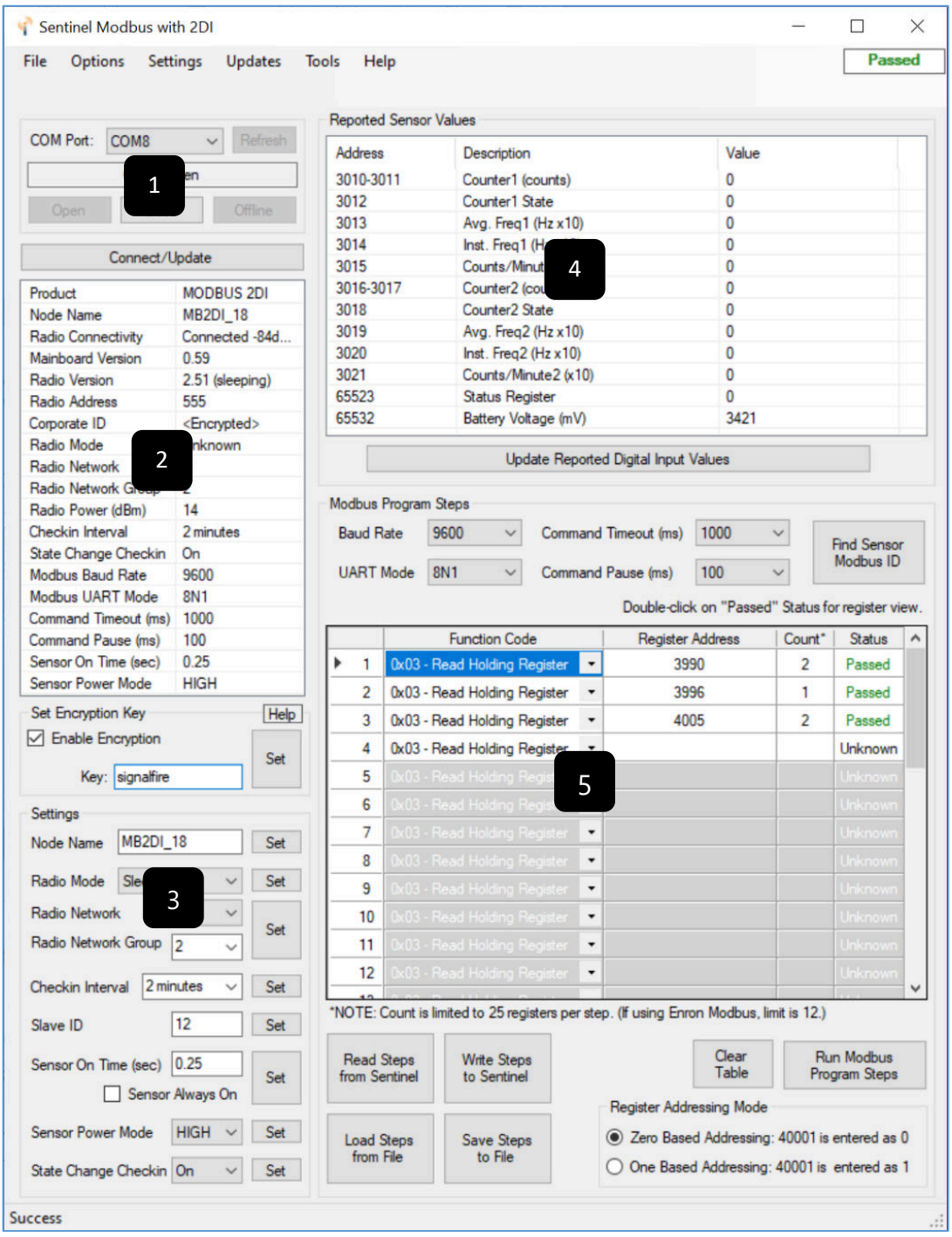
WARNING: Perform the steps in this section (Setup) in a safe location only.

Using the SignalFire Toolkit

The SignalFire Toolkit application can be downloaded at www.signal-fire.com/customer. After installation, launch the software and the main toolkit window will open:



Select the COM port associated with the Sentinel node and click “Auto-Detect Device on COM Port.” This will open the device configuration window, where all device settings can be configured.



❶ COM Settings

❷ Node Information

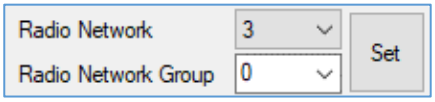
❸ Configurable Node Settings

❹ Register Values

❺ Current Program Steps

Network Setting

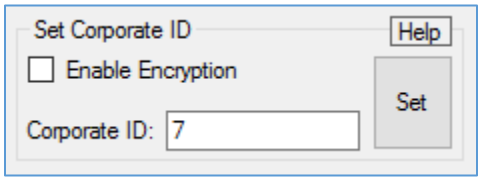
The network is set using the SignalFire Toolkit. **The network, network group, and corporate ID/encryption key settings must match those of the gateway for them to communicate**.



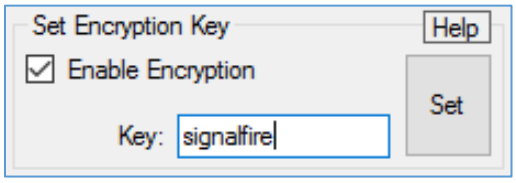
Encryption

To protect your over-the-air data and prevent tampering, SignalFire networks come with encryption. Legacy products use a Corporate ID, but can be switched over to use an encryption key if the firmware and toolkit are up to date.

To set up a legacy Sentinel to use encryption, click the checkbox labeled **Enable Encryption** inside the **Set Corporate ID** box. All newer Sentinels come with this option enabled with "signalfire" as the default encryption key.



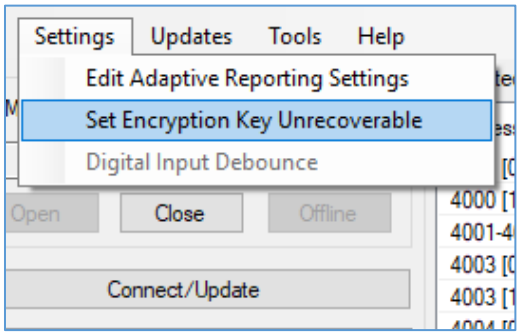
Corporate ID



Encryption Enabled

The box will then change into a **Set Encryption Key** box, and it will prompt instead for the encryption key you would like to use. Note that keys may not contain spaces or angle brackets. Enter it and then press **Set**. If you are setting up a new network, you will need to set the encryption key on all of your devices. If you are adding a Sentinel to a legacy network, you can simply set the Corporate ID without clicking the Enable Encryption box, and it will remain compatible with the older system.

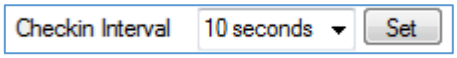
It is also possible to hide your encryption key so it cannot be read. This is the most secure option, but if you forget your key, there is no way to recover it – you have to reset the key on every device on its network. To enable this option, select **Set Encryption Key Unrecoverable** under the **Settings** menu.



Setting the encryption key to be unrecoverable.

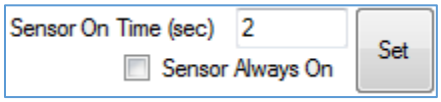
System Check-In Period

This setting controls how often the node will read the Modbus device and forward the register data to the gateway.



Modbus Sensor Warm-up Time

The sensor warm-up time controls how long power is applied to the Modbus sensor prior to data collection. The default is 2 seconds which is used for most simple sensors, some may require longer warm-up times. Contact your sensor manufacturer or SignalFire for details.



Operating Mode

The Sentinel Modbus-2DI node will report the status of the digital inputs as a set of Modbus registers at its configured Modbus ID. The Sentinel may also be configured using the SignalFire Toolkit application with a list of Modbus registers to be read from the attached sensor. Note that the attached Modbus sensor must be set to the same Modbus ID as the Sentinel.

The preconfigured set of registers is automatically read from the attached Modbus sensor device and forwarded to the Modbus gateway on a pre-defined schedule (1 minute to 5 minutes is typical). The register data is then buffered in the gateway and is available to be read by the RTU at any time.

If the check-in on state change option is set, the Sentinel will read the programmed Modbus register set and forward all data to the Gateway on any state change on either of the digital inputs.

When configured for a non-sleeping radio (i.e., radio always on) real-time Modbus reads/writes may be done from the Gateway to the end Modbus device. Note that this mode of operation requires a high capacity solar battery system (Sentinel-HC-Solar).

Sensor Connections

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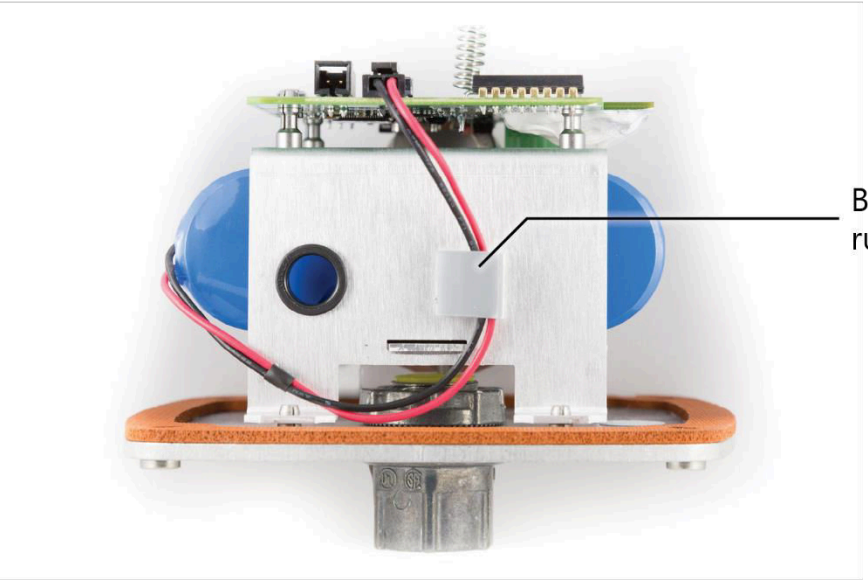
Wiring Requirements

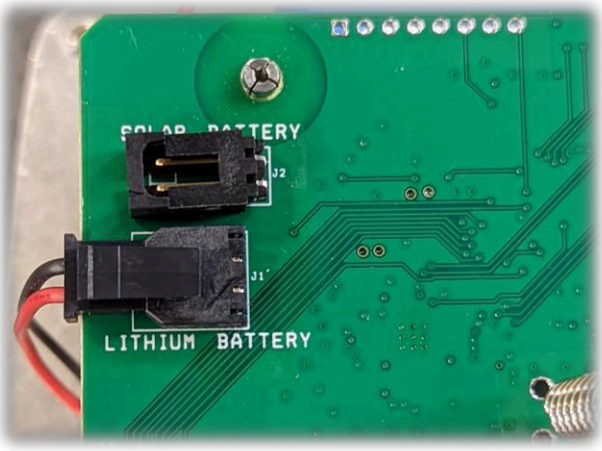
To ensure intrinsic safety is maintained it is required that the installer follow these guidelines when connecting sensors to the SignalFire node. See pictures for proper wire routing examples.

- Sensor wires entering the enclosure must be run as pictured.
- The battery wire must be routed through the battery cable hold-down clamp.
- Strip the wires so that there is minimal exposed un-insulated wire when inserted into the screw terminal.
- All wiring should be neat and orderly.

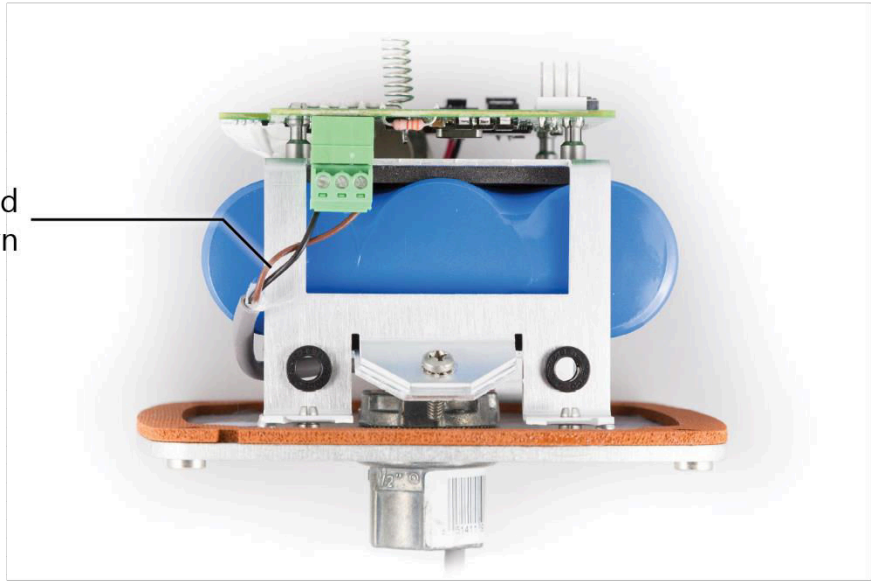


Plug the internal lithium battery pack into the connector labeled LITHIUM BATTERY as show below. Be careful to insert the battery connector as pictured with the locking tab facing up.

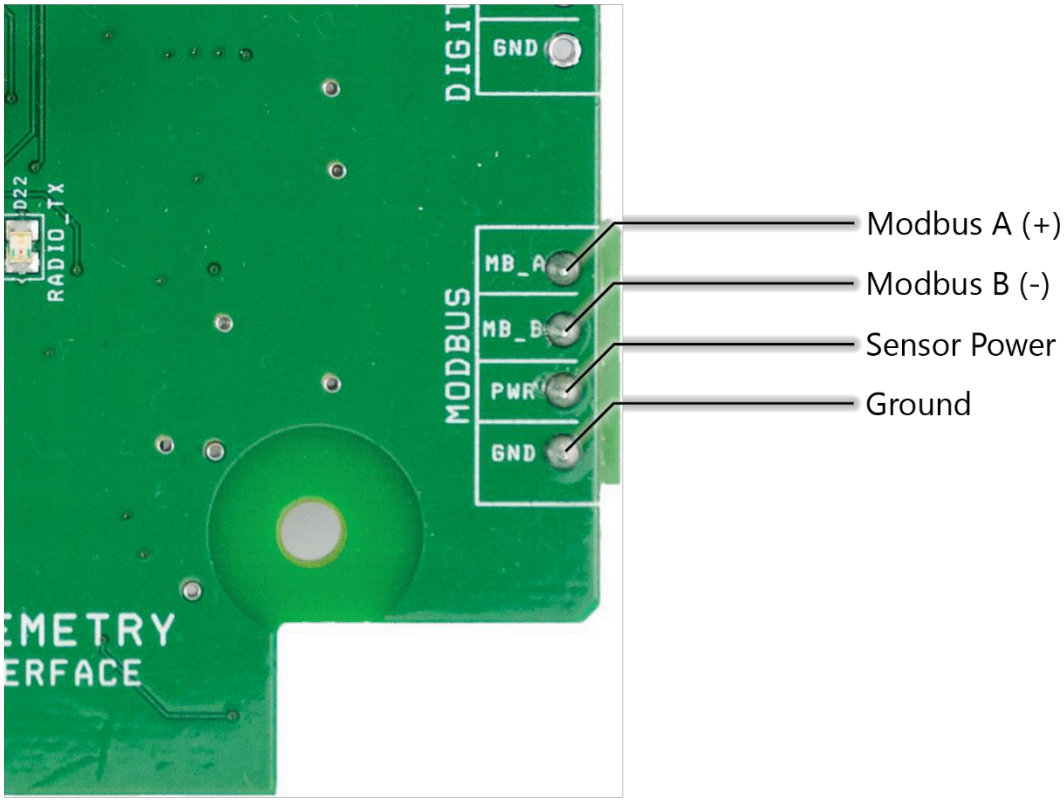
Forcing the battery connecter in backward or into the SOLAR BATTERY connector can damage the battery pack fuse making it inoperable.



Only connect either the Lithium batter OR the Solay battery. **Never connect both at the same time.**

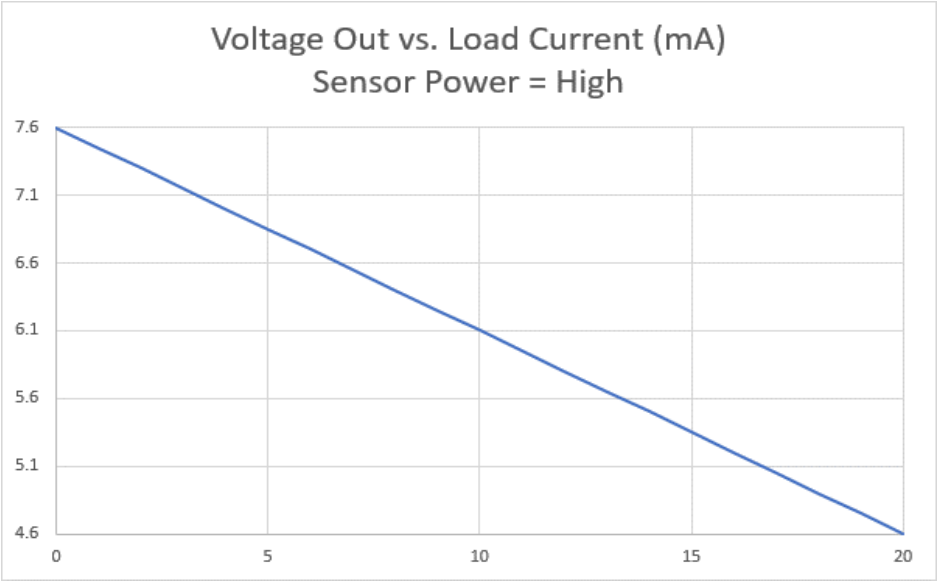


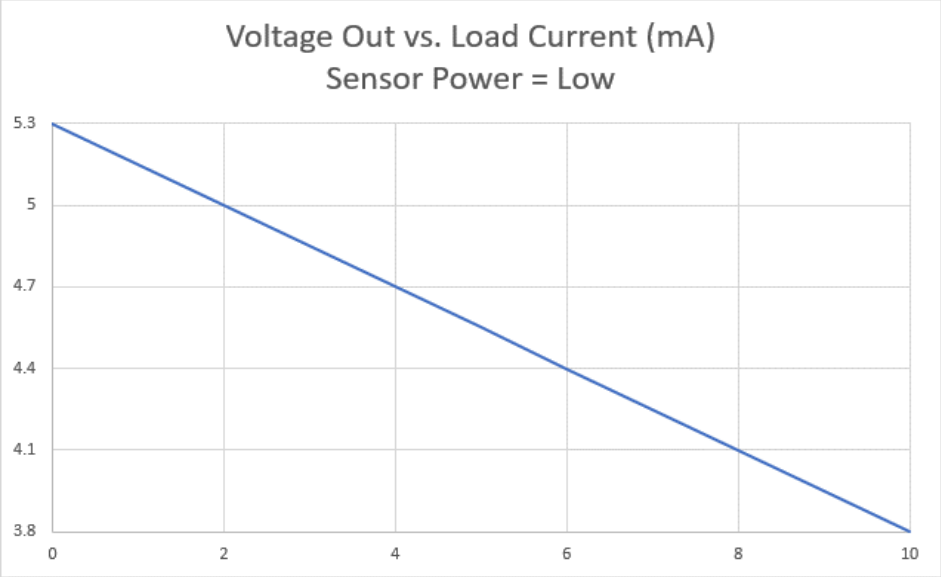
Sensor Connection



The Sentinel Modbus-2DI node has a single terminal block for connection to a Modbus sensor.

The Sentinel has a current limiting resistor of 150 ohms. The voltage available to the sensor depends on the sensor current load. See the graphs below for details:





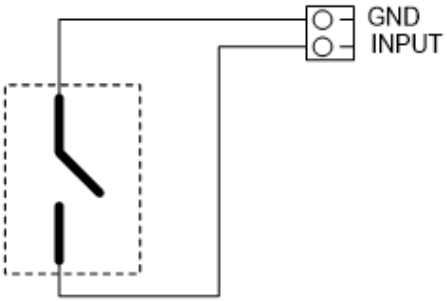
If the Sentinel-Solar is used the maximum load current is limited to 14mA.

Digital Inputs Connection

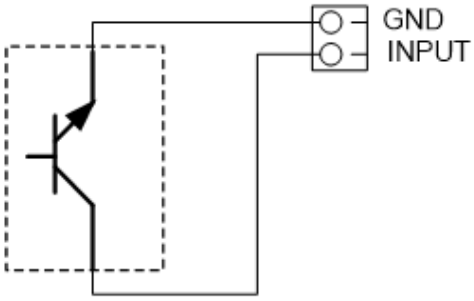
The Sentinel Node has two digital input channels; one or both may be used.

Each counter input may be open collector type (sinking ground), dry contact inputs, or voltage pulse type. The inputs can count up to 2000 Hz.

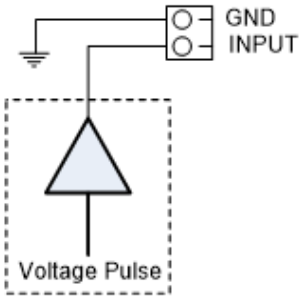
The digital outputs may be connected to the board as shown in the following diagrams:



Dry Contact Connection



Open Collector Connection



Voltage Pulse Connection

The counts accumulate, and the current counts are stored into non-volatile memory every two hours. If the system is reset the counts will revert to the last stored value from non-volatile memory.

The system also reports the state of the contact closure input (open or closed) at the time of check-in.

Digital Input Debounce

In cases where it is desired to accurately totalize digital input counts it may be necessary to enable the digital input debounce timer. The debounce timer is useful when dealing with dry contacts that may otherwise produce extra counts when they close. To enable the digital debounce, open the configuration window for the node in the SignalFire Toolkit and select **Digital Input Debounce** from the **Settings** menu. A typical value for a dry contact would be 100mS. Any extra counts due to contact bounce within the debounce time setting will be ignored.

Digital Input State Latch

The state latch feature is useful in cases when the state of one or both of the digital inputs is “latched” to a value for a configurable number of seconds. This is useful in a cases where a fast transition would be sensed by the Sentinel by may happen too quickly to be read from the Gateway. The state latch feature is configured using the toolkit. For example, if the state latch is set to latch closed for 3 seconds, then any close sensed on the digital input will be reported as closed for 3 seconds even in the input opens in less than 3 seconds.

RS-485 Modbus Communication

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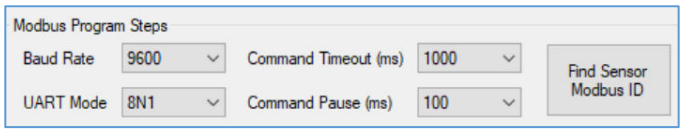
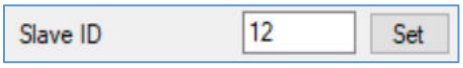
Communication Settings

The Sentinel Modbus needs to have its serial RS-485 parameters set to match the device it's communicating with. Default settings are a baud rate of 9,600bits/s, UART mode 8N1 (8 data bits, no parity bit, 1 stop bit), command timeout of 1000ms, and command pause of 100ms. This should be sufficient for most devices but check your device's datasheet to confirm. Note that the Gateway and Sentinel's RS-485 settings are unrelated and do not need to match.



The Modbus ID should match the ID of the connected Modbus device. Click **Find Sensor Modbus ID** if the ID of the connected sensor is unknown.



Make sure that there are no duplicate Modbus IDs in a given network; the gateway will only cache one set of data for each Modbus ID, so the duplicate will be overwritten.

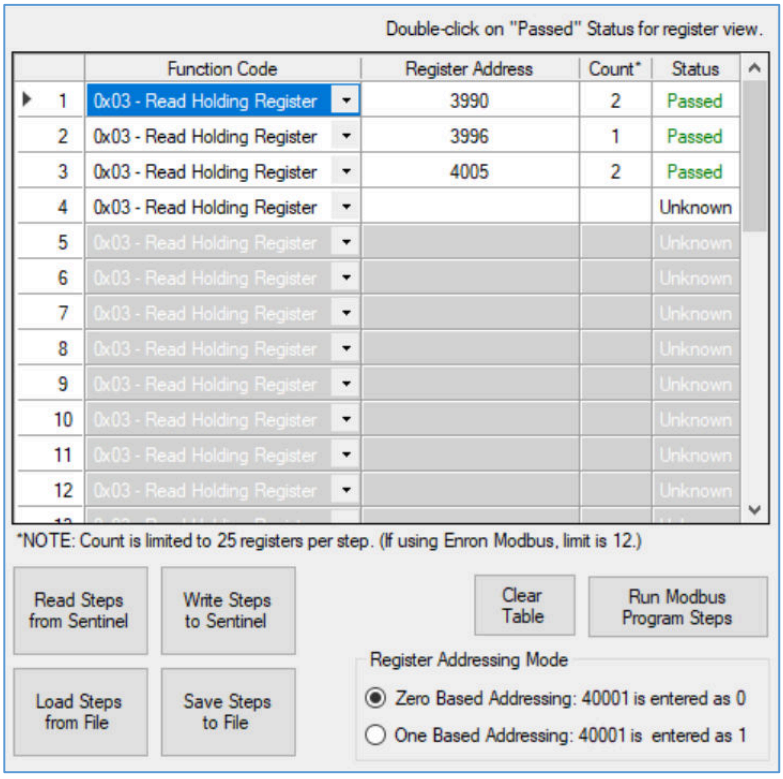
Modbus Program Steps Configuration

The register set to poll on each check-in must be defined using program steps. The Sentinel Modbus can have up to 34 program steps. A program step consists of a function code, starting address, and number of consecutive registers.

Possible function codes are:

- 0x01: Read discrete output (limit: 1 coil)
- 0x02: Read discrete input (limit: 1 coil)
- 0x03: Read holding register
- 0x04: Read input register
- 0x05: Write discrete output

The register address entered is subtracted by the offset in the Register Addressing Mode. The offset can be 0 or 1. For example, with One Based Addressing, a holding register of address 3990 should be entered as function code 0x03, address 3991.



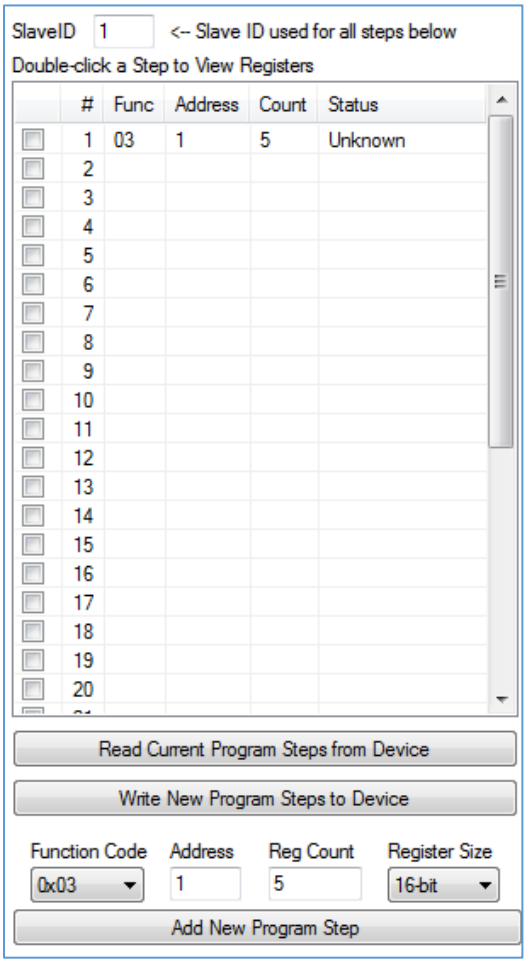
A count of 25 registers per step can be set unless using Enron Modbus. In that case, the limit is 12 registers per step. Keep in mind that one 32-bit floating point register should be read as two 16-bit registers. When writing the steps to the Sentinel, a warning will pop-up if too many registers are requested.

Click **Read Steps from Sentinel** to view the current program steps in the table. To add a new program step, fill in the next empty line. To delete a step, click on the line number and press the Delete key. Lines can also be copy/cut and pasted. Once all the desired program steps have been entered, click **Write Steps to Sentinel** to save the changes.

Modbus Program Steps Configuration (Legacy)

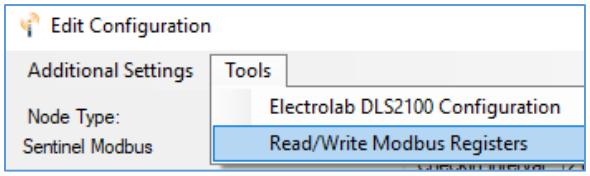
If using toolkit version 2.2.18 or earlier, the menu to enter program steps will be different.

Click **Read Current Program Steps from Device** to view the current program steps in the table. They can then be deleted or re-ordered using the buttons to the right of the table. To add a new program step, fill in the 4 boxes at the bottom, and click **Add New Program Step**. If the step is valid, it will be added to the table. Finally, click **Write New Program Steps to Device** to save the changes.

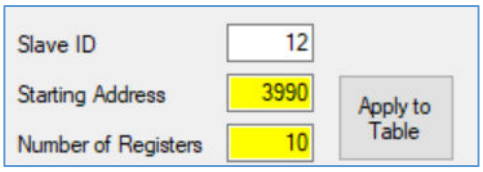


Note: In the legacy menu, the Register Addressing Mode is locked to One Based Addressing, so 3990 should be entered as 3991.

Read/Write Modbus Registers

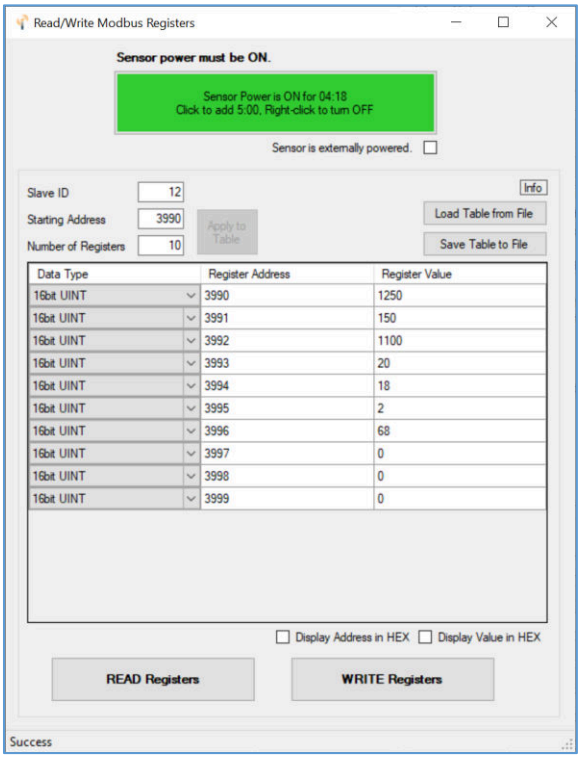


Modbus registers of devices that have an RS-485 interface can be read and written through the Gateway when the device is in remote configuration mode. This is useful for testing or for setting configuration parameters in the end Modbus device. For information on remote configuration, see the Gateway manual. Once the Modbus remote configuration window has been brought up, select 'Tools' and then 'Read/Write Modbus Registers.'



Create the register list by entering the Modbus ID (defaults to the Modbus id of the device), starting address, number of registers and click Apply to Table. The form will populate with the number of registers starting at the start address and a default data type of unsigned 16-bit integer.

Click 'READ Registers' to read the current Modbus registers from the device. The Data Type and Register Value fields can be edited, and the changes will be highlighted. Click WRITE Registers to write the changes to the Modbus registers in the device.



Both 16-bit (default) and 32-bit register sizes are supported. Whenever Modbus registers are read, the register size is changed to match the incoming data. The Data Type pull-down only lists data types that support the register size and unsupported data types in the register list are changed to the default data type for the register size.

Remote Modbus Register Mapping

The Sentinel node sends data to a SignalFire Telemetry Modbus Gateway. The data that is sent to the gateway is available at the gateway in registers where it can then be read by a Modbus RTU.

In addition to the pre-configured registers read from the attached sensor, the Sentinel will send system information in 16-bit registers listed in the table below. This data is accessible at the same Modbus ID as the connected Modbus device.

Register Map

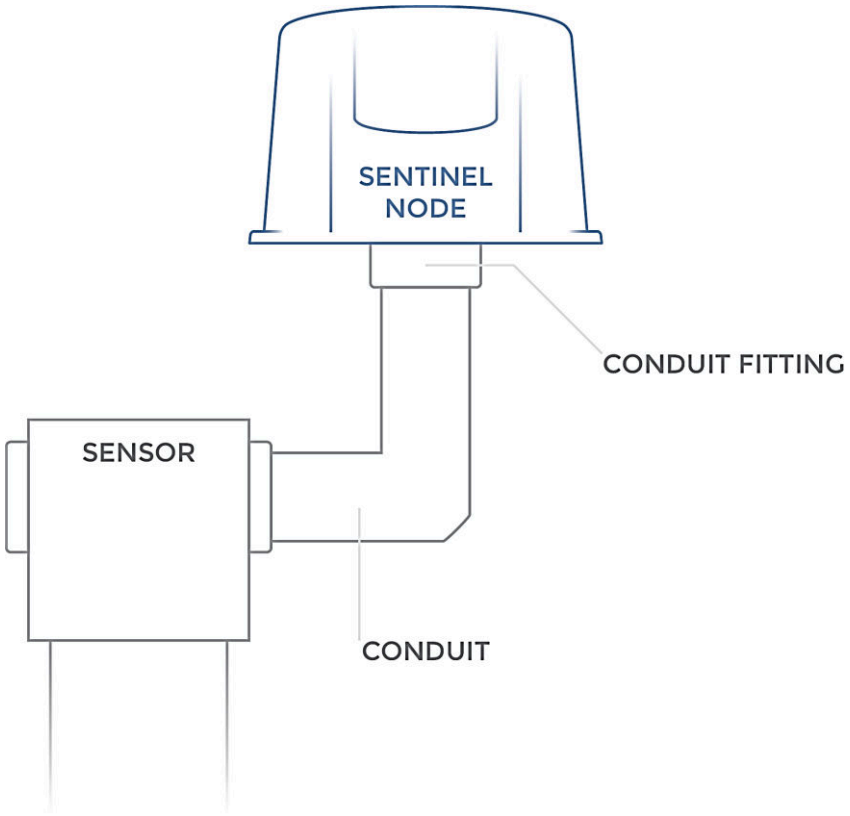
Register Number	Register Address (Offset)	Description
43011-43012	3010-3011	32-bit Hardware counter 1, 3010=high word (two registers)
43013	3012	Digital Input 1 state (1=closed, 0=open)
43014	3013	Average frequency over the last check-in period times 10
43015	3014	Frequency over 2 seconds at check-in time times 10
43016	3015	Avg. counts per minute over the check-in period times 10
43017-43018	3016-3017	32-bit Hardware counter 2, 3016=high word (two registers)
43019	3018	Digital Input 2 state (1=closed, 0=open)
43020	3019	Average frequency over the last check-in period times 10
43021	3020	Frequency over 2 seconds at check-in time times 10
43022	3021	Avg. counts per minute over the check-in period times 10
49986	9985 or 65522	Checkin Interval (in seconds)
49987	9986 or 65523	Status (0=no errors, 1=low battery (3V Threshold), 2=failed sensor read, 3=low battery and failed sensor read)
49988	9987 or 65524	Major revision number for the mainboard
49989	9988 or 65525	Minor revision number for the mainboard
49990	9989 or 65526	Major revision number for the radio
49991	9990 or 65527	Minor revision number for the radio
49992	9991 or 65528	High 16 bits of SFTS node address
49993	9992 or 65529	Low 16 bits of SFTS node address (the radio ID)
49994	9993 or 65530	Modbus ID readback
49995	9994 or 65531	Received signal strength of last packet from the Sentinel
49996	9995 or 65532	Battery voltage of the Modbus client, in millivolts
49997	9996 or 65533	Minutes until this device will time out, unless new data is received
49998	9997 or 65534	Number of registers cached for this device
49999	9998 or 65535	Remote device type. 53 for Sentinel Modbus with 2DI

Mounting and Care

The unit comes with a watertight ½" NPT conduit fitting on the bottom mounting plate. The Sentinel is then directly mounted to the sensor with a short section of conduit.

Direct Mount to Sensor with Short Conduit

This mounting method uses a short conduit run from the sensor and the unit is held in place by the conduit.



WARNING: The Sentinel must be mounted in a location free of high vibrations. Over time vibrations can damage the Sentinel or battery pack, which could impair its safety ratings. Do not mount directly to continuous vibrating equipment such as pumps or compressors.

Internal Lithium Battery Replacement

Battery Packs can be changed with the node in place.

1. Open the cover from the enclosure.
2. Unplug the battery from the PCB, by depressing the locking clip on the connector.
3. Loosen the screw holding the battery door and slide the old battery out.
4. Slide in the new battery pack and tighten the battery door screw.
5. Connect the battery to the main PCB battery connector.
6. Install the enclosure cover.

WARNING: Use of any battery other than the SignalFire part number 810-0008-02 will impair the protection provided by the equipment.

WARNING: If the internal battery is installed the external solar battery system or other power source may not be connected!

Cleaning Instructions

The outside of the enclosure may be cleaned with water, mild soap, and a damp cloth as needed. High pressure washing is not recommended.

WARNING: Electrostatic Discharge Hazard! Care must be taken to avoid the potential of creating a change on the enclosure or antenna. Do not wipe with a dry cloth. Do not brush against the enclosure with clothing or gloves.

Configuration / Debug

Debug and configuration information is available if a connection is made via the debug port on the main board. A USB converter cable (available from SignalFire) must be used for this interface.

Debug and advanced configuration may be done using the SignalFire Toolkit PC application.

WARNING: Only connect to the debug port in a safe area!

Technical Support and Contact Information

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Revision History

Revision	Date	Changes/Updates
1.0	6/9/16	Initial release
1.1	9/14/17	Added section on encryption, updated warnings
1.2	2/7/19	Updated descriptions Minor formatting updates
1.3	5/28/19	Added output voltage graphs
1.4	3/31/2020	Remote Modbus R/W
1.5	7/9/2020	Updated Modbus program steps menu, new checkin register
1.6	5/24/2021	Updated load line graphs
1.7	1/20/2022	Updated screen shots. Added usage of **Find Sensor Modbus ID** button. Added description of register count.
1.8	6/3/22	Added detail on battery connection

APPENDIX - FCC and IC Statements

Changes or modifications not expressly approved by SignalFire Telemetry, Inc could void the user's authority to operate the equipment.

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

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

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

Only the supplied coil antenna (Part number 810-0012-01) which is permanently soldered to the PCB may be used. This antenna has a maximum gain of 3dB.

WARNING!
FCC and IC Radiation Exposure Statement:
This equipment complies with FCC's and IC's RF radiation exposure limits set forth for an uncontrolled environment under the following conditions:

1. This equipment should be installed and operated such that a minimum separation distance of 20cm is maintained between the radiator (antenna) & user's/nearby person's body at all times.
2. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a maximum (or lesser) gain approved for this transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.r.i.p.) is not more than that necessary for successful communication.

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante.

This device complies with Industry Canada licence-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes : (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.