TEKTELIC Communications Inc.

LoRa IoT Industrial Sensor

User Guide

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Revision History

Version	Date	Editor	Comments
0.1	Feb 9, 2018	Devin Smith	First release
1.0	May 27, 2019	Taras Kuzyk	Updates for Rev C1 PCBAs
1.1	Jun 6, 2019	Reza Nikjah	• Cleanups (titles, versions, etc.) • Added Acronyms and Glossary • Updated cable gland specs and compatible cables/wires
1.2	June 12, 2019	Conor Karperien	Removal of Industry Canada Section as certification will not cover IC
1.3	June 14, 2019	Conor Karperien	Removal of EU and CN variants for Certification activity
1.4	June 17, 2019	Conor Karperien	Removal of NA variant for certification activity, addition of FCC information

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Acronyms and Glossary

ADC ..... analog-to-digital converter
AWG ..... American wire gauge
bps ..... bits per second
DC ..... direct current
FCC ..... Federal Communications Commissions
FET ..... field-effect transistor
(Industrial) Sensor ..... any variant of the TEKTELIC LoRa IoT Industrial Sensor
I/O ..... input/output
IoT ..... Internet of things
IP ..... ingress protection
LED ..... light emitting diode
LoRa ..... a patented “long-range” IoT technology acquired by Semtech
LoRaWAN ..... LoRa wide area network (a network protocol based on LoRa)
LSB ..... least significant bit
LTC ..... lithium thionyl chloride (chemistry of LTC batteries)
MCU ..... microcontroller unit
NC ..... not connected
OC ..... open circuit
OTA ..... over the air
PCB ..... printed circuit board
PCBA ..... PCB assembly
PTC ..... positive temperature coefficient
Rev ..... revision
RF ..... radio frequency
RS ..... recommended standard (as in RS-232, RS-422, RS-485)
RTU ..... remote terminal unit (as a Modbus type)
Rx ..... receiver / receive
SC ..... short circuit
SSR ..... solid-state relay
Tx ..... transmitter / transmit
UV ..... ultraviolet
ver. ..... Version
WSOR ..... weld-slag and oil-resistance

1 Product Description

1.1 Overview

The TEKTELIC LoRa IoT Industrial Sensor is a multi-purpose LoRaWAN IoT sensor intended for interfacing automation and control instrumentation to a LoRaWAN network. The Industrial Sensor supports up to three analog and digital inputs allowing for the remote capture of data, and two switched outputs to actuate externally connected devices. The built-in serial relay allows for serial communication over a RS-232 or RS-485/422 bus. Table 1-1 presents the currently available LoRa IoT Industrial Sensor models.

Table 1-1: Industrial Sensor Models

Product Code & Revision	Description	RF Region	Tx Band (MHz)	Rx Band (MHz)
T0005500 Rev A	Industrial Sensor Module, DN	DN915	902.3–914.9	725.9 MHz, 726.5 MHz

The main features of the Industrial Sensor are the following:

- **Temperature & Relative Humidity Sensor:** Reports temperature and relative humidity of the local environment.
- **Digital Input**: Reports open-drain or driven signals.
- **Analog 0 mA – 20 mA Current Input:** Monitors and reports current outputs of remote equipment.
- **Analog Thermistor Input**: Monitors and reports the voltages corresponding to the variable impedance of a remote 10-*k*Ω temperature probe.
- **60 V DC Output (FET Based)**: Non-isolated open-drain output.
- **60 V DC Output (SSR)**: Isolated relay output.

Figure 1 illustrates the Industrial Sensor in the enclosure with both solid and transparent views.

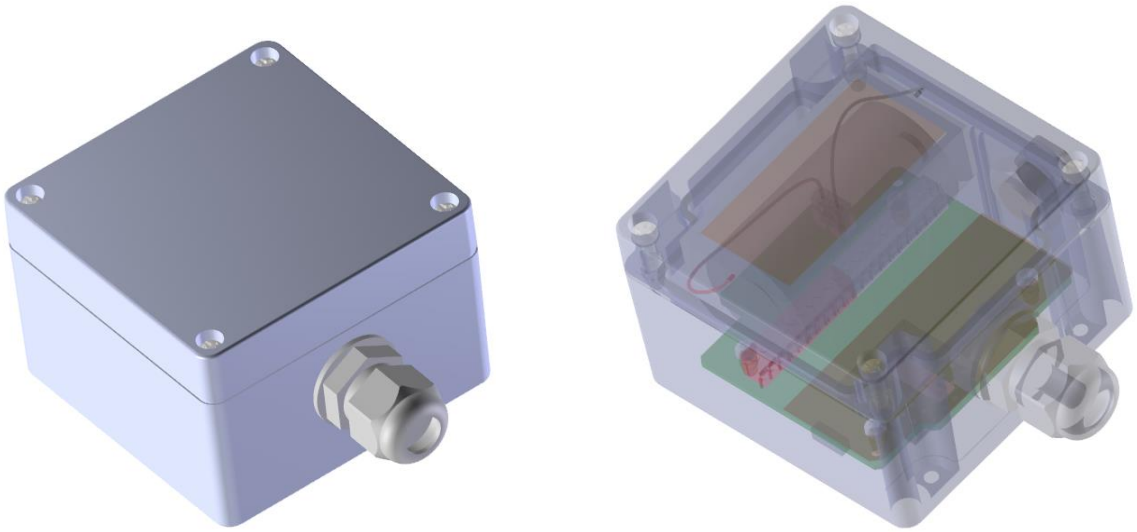

Figure 1-1: The LoRa IoT Industrial Sensor views.

1.2 Physical Interfaces

Figure 1-2 illustrates the terminal block on the PCBA, which provides customer accessible interfaces for the Industrial Sensor. All models share the same layout.

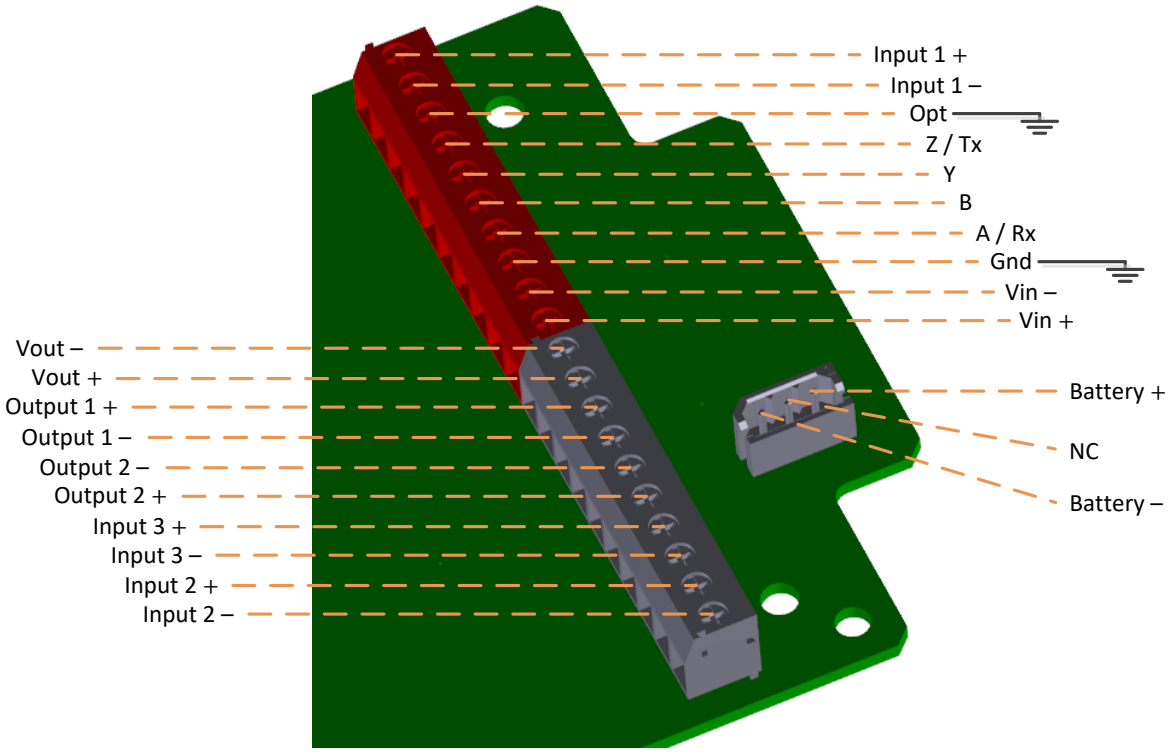

Figure 1-2: The Industrial Sensor interface layout (terminal block and battery connector pinout).

1.3 Specifications

The Industrial Sensor specifications are listed in Table 1-2. Also, Table 1-3 shows the Sensor serial interface operating specifications. Moreover, Table 1-4 indicates the absolute maximum ratings for the Sensor.

Table 1-2: LoRa IoT Industrial Sensor Specifications

Attribute	Specification
Use Environment	Industrial, indoor/outdoor commercial/residential
Environmental Rating	IP67
Enclosure	Hammond Manufacturing 1554E2GY UL 508 approved which includes 720-hour UV testing
Cable Gland	Bud Industries MPG-22311 IP68 metal (nickel plated brass) cable gland Cable diameter range 0.2”–0.39”
Humidity Vent	Mobi 3-FJ-S1-00-055 UV rated as part of other safety filings
Operating Temperature	-40°C–85°C
Storage Temperature for Optimal Battery Life	-40°C–75°C
Operating Relative Humidity	0%–100%, condensing
Storage Relative Humidity	0%–100%, condensing
Size	90 mm x 90 mm x 60.5 mm
Weight	Without battery: 205 g With D-cell LTC battery: 295 g
Power Source	• Battery powered: 1x D-cell LTC (or 3.0 V–3.7 V DC) with keyed battery connector and reverse polarity protection • Externally powered: 10 V–26 V DC (typically 12 V–24 V DC) with reverse polarity protection
Network technology/Frequency band	LoRaWAN in several variants (see Table 1-1): US915, EU868, DN915, CN470
Air Interface	LoRa
Battery Lifetime	25 years[1]

[1] This is for transmission at maximum power every 15 minutes at room temperature, with an LTC battery having a nominal capacity of 19 Ah and self-discharge rate of 0.7%. Large variations to this estimate can occur depending on the ambient temperature, amount of usage, battery capacity, and battery self-discharge rate. For example,

Maximum Tx Power	22 dBm
LED	Green: Joining the network activity Red: LoRa Tx or Rx activity
Sensing Functions	Temperature (MCU & ambient), 1x digital input, 2x analog input, 2x digital output
MCU Temperature Measurement Accuracy	$< \pm 5$°C between -40°C and 85°C
Ambient Temperature Measurement Accuracy	± 0.5°C between 15°C and 40°C ± 1°C between 0°C and 60°C [as per the HTS221 datasheet]
Digital Input (Input 1)	Input open drain or driven signals Input Low: SC or 0 V–1.8 V Input High: OC or 1.8 V–60 V Asynchronous response
Analog Current (Input 2)	Measurement of input over the range 0mA–20mA. Use of 12-bit ADC gives a precision of 5.4 μA/LSB (with input range up to 22.3 mA corresponding to the ADC reference voltage of 1.25 V).
Thermistor (Input 3)	Measurement of a 10-kΩ thermistor as a remote temperature probe (e.g. Vishay BCcomponents NTCAIMME3C90686 or Cantherm CWF3AA103G3380).
Serial Interface	Support of Modbus RTU device over RS-232/422/485 (half- or full-duplex mode) with a baud rate support of up to at least 250 kbps.
FET Output (Output 1)	Grounded source FET that allows open drain style operation on external lines up to 60 V. Output impedance 10.2 Ω when turned on, > 40 MΩ when turned off.
SSR Output (Output 2)	An isolated, polarity agnostic relay switch for operation on external lines up to ±60 V. Output impedance 35.6 Ω when turned on, > 40 MΩ when turned off.

continuously being at -30°C and transmitting at maximum power every 30 seconds, the same battery may not last above a year.

Table 1-3: Serial Interface Operating Specifications

Parameter	Min	Typical	Max
RS-232 Tx	±5 V	±5.5 V	–
RS-232 Rx	-15 V	–	+15 V
RS-485/422 Tx[2,3]	1.5 V differential	–	3.3 V differential
RS-485/422 Rx Threshold[2,3]	-200 mV differential	-125 mV differential	-50 mV differential

Table 1-4: Sensor Absolute Maximum Ratings

Parameter	Absolute Maximum[4]
Operating Temperature Range	-40°C–85°C
Battery Vin	3.7 V
External Vin	42 V
Digital Input (Input 1)	60 V
Current Input (Input 2)	46 mA
FET Output (Output 1)	Voltage rating: 60 V DC operating 100 V DC no damage Current rating: 75 mA at -40°C 50 mA at 23°C 25 mA at 85°C
SSR Output (Output 2)	Voltage rating: ±60 V DC operating ±100 V DC no damage Current rating: 75 mA at -40°C 50 mA at 23°C 25 mA at 85°C
Serial Interface	+/-18 V

[2] RS-485 signals are differential and are measured as such.
[3] The serial transceiver in the design is compliant with both RS-232 and RS-422/485 standards.
[4] Operating outside of these ranges will damage the Sensor or battery.

2 Installation

2.1 Included Product and Installation Material

The following items are shipped with each sensor:

- LoRa IoT Industrial Sensor
- LTC Battery, D-size
- Ruggedized IP67 Polycarbonate Enclosure
- Product Manual

2.2 Safety Precautions

The following safety precautions should be observed:

- Use only LTC cells.
- Do not exceed the maximum specified terminal voltages.
- All installation practices must be in accordance with the local and national electrical codes.
- Sensor inputs and outputs do not provide electrical isolation to system ground, or between each other.

2.3 Unpacking and Inspection

The following should be considered during the unpacking of a new Industrial Sensor:

- Inspect the shipping carton and report any significant damage to TEKTELIC.
- Unpacking should be conducted in a clean and dry location.
- Do not discard the shipping box or inserts as they will be required if a unit is returned for repair or re-configuration.

2.4 Equipment Required for Installation

The following tools are required to install the Industrial Sensor:

- #2 Phillips screwdriver (4 x enclosure screws)
- #0 Phillips screwdriver (internal terminal block connections)
- Wire Stripper
- Wire Cutter

2.5 Industrial Sensor Mounting

When the cover is removed, four (4) mounting holes are exposed See Figure 3. These mounting holes can be used to screw the enclosure to a solid surface. The recommended mounting screw size is M3 or #6. Mounting screws are not provided with the sensor.

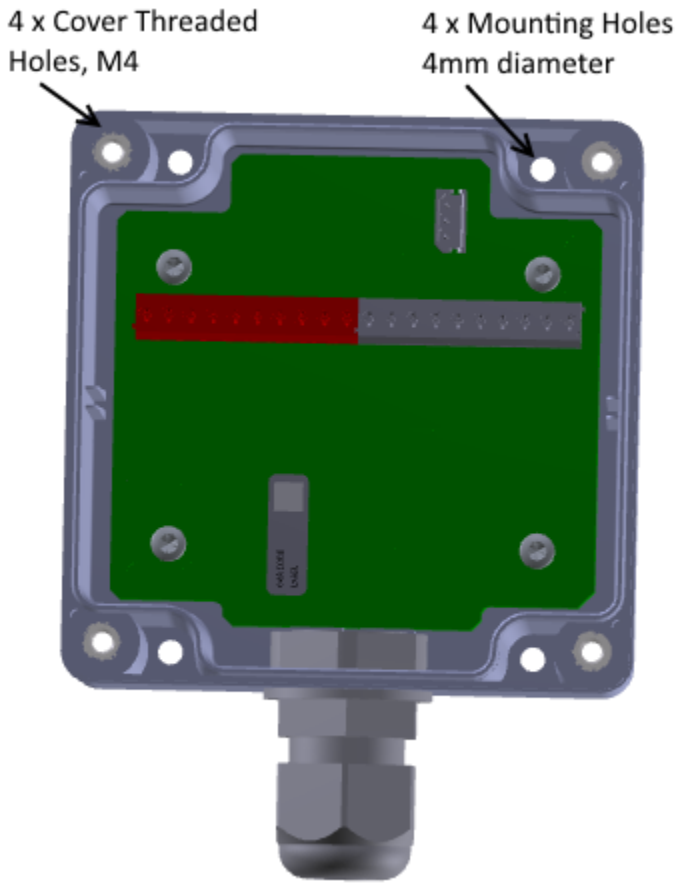

Figure 2-1: The mounting holes and threaded cover holes.

The mounting surface must be capable of holding more than 2 kg (4.5 lbs). Clearance must be provided for the modules cable gland and input cable.

2.6 Cable Installation

The Industrial Sensor enclosure is provided with an IP68 cable gland through which all connections must be routed. The supplied cable gland size is PG-11. This gland supports cables with a straight jacket of diameter of 5.0 mm to 9.9 mm (0.2" to 0.39"). The customer supplied cable must be rated for outdoor use and have **a single, smooth, and straight jacket** to achieve a watertight seal and IP68 rating with the gland. The recommended gland nut torque is 4 Nm (35 in-lbs).

Suggested cable: Molex 155220-0047 (Flamar Sensor Cable, WSOR Jacket, Unshielded, 12 Circuits, 24 AWG, 6.90 mm Diameter).

The I/O terminal block accepts 18–26 AWG wires. Select a cable that meets the application requirements and local and national electrical codes.

Figure 4 shows the terminal block wiring connections. To install the cable, first make the appropriate connections between the input cable and the terminal block. Next dress the internal wires so that the cable gland seals against the outer cable jacket. Finally, tighten the cable gland.

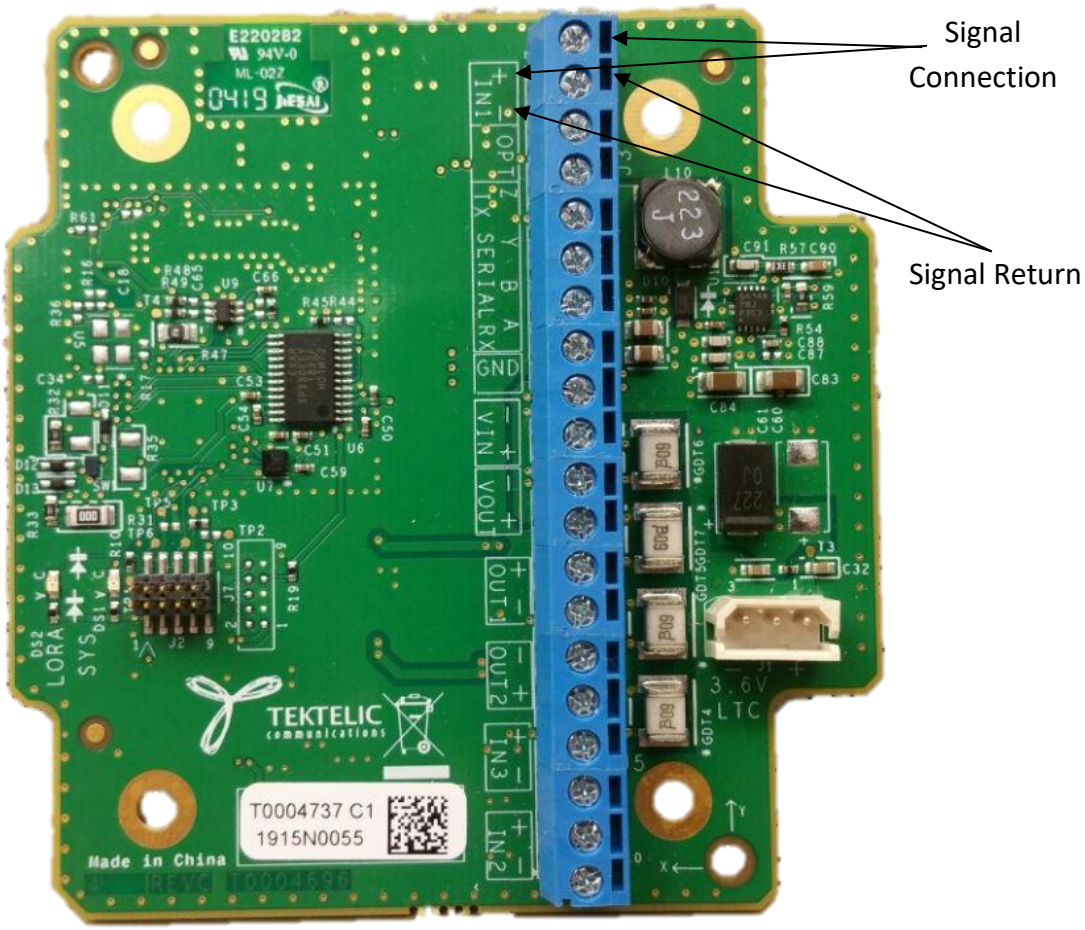

Figure 2-2: The Industrial Sensor external connector signals.

The inputs and outputs are labeled on the PCB. Signal connections should be connected to the positive terminal (labeled '+') of the desired I/O channel as indicated by the silkscreen. Similarly, the return path should be connected to the negative terminal (labeled '-') of the matching I/O channel.

NOTE: Industrial Sensor I/O are referenced to the sensor ground and are not isolated (except for Output 2 that is isolated relay switch).

The Industrial Sensor serial port provides a means to connect the Sensor to devices communicating over RS-232, RS-422, or RS-485 standard channels. No hardware flow control is offered for RS-232 operation. Full and half duplex modes are available in RS-485 operation as required.

The serial port connections on the terminal block have been shown in Table 2-1.

Table 2-1: Serial Port Connections

Terminal	RS-232	RS-422	RS-485 Half Duplex	RS-385 Full Duplex
Z / TX	Tx	Tx-	Tx-	Data-
Y	NC	Tx+	Tx+	Data+
B	NC	Rx-	Rx-	NC
A / RX	Rx	Rx+	Rx+	NC
GND	Ground	(Shield)	(Shield)	(Shield)

The GND labeled terminals provide a signal reference for single ended RS-232 signalling. When differential mode RS-422/485 is used, the GND terminals may be used for cable shield connections.

NOTE: Industrial Sensor serial I/O are referenced to the sensor ground and are not isolated, even in differential mode the I/O present no isolation.

3 Power Up, Commissioning, and Monitoring

3.1 Required Equipment

- A #2 Phillips screwdriver
- If a battery replacement is required the Industrial Sensor accepts D-size, 3.6 V, LTC batteries. Suggested replacement batteries:
  - Saft LS33600
  - Tadiran TL-5930
  - Xeno XL-205F

3.2 Power Up/Down Procedure

- The sensor is shipped with the battery wire unplugged. Remove 4 screws holding the cover, to gain access to the Sensor battery connector. Be careful not to misplace the silicone cover gasket.
- Once the sensor is configured on the Network Server and input cable is installed, plug the battery into the sensor circuit board. See Section 4.3 for the LED behaviour.
- Once the Sensor is powered, replace the cover and gasket. Make sure that the gasket is properly seated in the cover before placing on the Sensor housing. Tighten the 4 cover screws to 2.5 lbf-in (30 N-cm).
- To reset or turn off the device the battery must be unplugged from the circuit board. The unit must remain un-powered for 1 minute to completely reset.

4 Operation, Alarms, and Management

4.1 Configuration

The Industrial Sensor supports a full range of OTA configuration options. Specific technical details are available in the Industrial Sensor Technical Reference Manual. All configuration commands need to be sent OTA during a sensor's downlink windows.

4.2 Default Configuration

The default configuration on the Industrial Sensor is as follows:

- Report Temperature every one (1) hour.
- Report Battery Voltage every one (1) hour.
- Report actuation of the digital input element every one (1) actuation.
- Report Input 1 (Digital), Input 2 (Current) and Input 3 (Thermistor) reading every fifteen (15) minutes.

The default configuration of the Industrial Sensor serial port is as follows:

- Protocol RS232
- Baud rate 115200 bps
- 8 Date Bits, No Parity Bits, 1 Stop Bit

4.3 LED Behaviour

See Figure 1-2 for the location and identification of the sensor LEDs.

During the boot and join procedure:

- Both LEDs will come on briefly when power is first applied.
- After a small delay ($<$ 1 second) the LEDs will turn off and one of them will blink briefly.
  - If the System LED blinks, then all health checks on the board have passed.
  - If the LoRa LED blinks, then one of the health checks has failed. Consider replacing the battery, or moving the sensor to an environment within the temperature range.
- Immediately after the delay, the join procedure will begin. During the time the System LED will blink continuously until the sensor joins a network.
- The LoRa LED will now blink whenever LoRa activity occurs on the sensor (transmitting or receiving packets)

During normal operation:

- The LoRa LED will blink whenever LoRa activity occurs on the sensor (transmitting or receiving packets)
- The System LED can be controlled via the downlink command interface.

4.4 Inputs and Outputs

Three input channels and two output channels are present on the Industrial Sensor. All channels are connected to external devices (transducers) via the screw down terminal block (see Figure 2-2).

4.4.1 Digital Input (Input 1)

The digital input channel allows an open drain/relay based or driven signal to be monitored. This input is compliant to 60 V. The signal to this input is treated as an interrupt and read asynchronously. Example applications for this input include leak detection and reading a magnetic reed switch.

4.4.2 Current Input (Input 2)

A current input channel on the sensor allows the measurement of the industry standard 4–20mA current signal. This is achieved by converting the input current to a voltage through a sensing resistor that is within the ADC measurement range. The 4–20mA current loop is a widely use signalling standard in the industrial environment as it offers good noise immunity and is relatively simple.

4.4.3 Thermistor Input (Input 3)

The thermistor input permits measurement of remote temperature through a 10-*k*Ω thermistor probe. The sensor reports voltage values corresponding to the variable impedance of the thermistor. The voltage values can then be converted to temperatures using a conversion table or formula.

4.4.4 Open Drain FET (Output 1)

The FET based output channel features a grounded source FET that allows open drain style operation on external lines up to 60 V. The PTC in the circuitry limits the operating current to 75 mA at -40°C, 50 mA at 23°C, and 25 mA at 85°C. As the FET source is connected to the PCB ground, this output switch is not isolated from the system.

4.4.5 Solid State Relay (Output 2)

Unlike the open drain output, the SSR output is isolated from the rest of the system (i.e. the PCB ground and other signals). The connection of the relay is polarity agnostic and is compliant to 60 V. Again, the PTC in the circuitry limits the operating current to 75 mA at -40°C, 50 mA at 23°C, and 25 mA at 85°C.

5 Compliance Statements

Federal Communications Commission:

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.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment. 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.

To comply with FCC exposure limits for general population / uncontrolled exposure, this device should be installed at a distance of 20 cm from all persons and must not be co-located or operating in conjunction with any other transmitter.

References

[1] LoRa Alliance, "LoRaWAN Specification," ver. 1.0.2, 2016.

[2] LoRa Alliance, "LoRaWAN 1.1 Regional Parameters," ver. 1.1, rev. B, Jan 2018.

[3] TEKTELIC Communications Inc., "LoRa IoT Industrial Sensor Technical Reference Manual," ver 1.1, May 2019.