# Wireless High-Precision Tilt Sensor

## User Guide

VERSION 1.3
SEPTEMBER 2019

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# 1. QUICK START

To start using your sensor, simply go to:

https://console.radiobridge.com

From here you can register your device and immediately start receiving messages from the sensor.

The sensor configuration, message monitoring, and setting up alerts is usually self-explanatory through the user interface. For further explanations of any sensor features, you may refer to this user guide

# 2. OVERVIEW

## 2.1. Sensor Overview

The wireless sensors designed and manufactured by Radio Bridge provide full sensor to cloud solutions for Internet of Things (IoT) applications. The high-precision tilt sensor uses an accelerometer to detect the angle from a 0-degree vertical orientation. When the sensor is tilted either away from or toward the vertical orientation by a specified amount, an alert is sent to the wireless network. The high-precision tilt sensor has precision to 0.1 degrees. The thresholds for triggering a tilt event are configurable over the air.

Features include:

- Built-in radio that talks directly with LoRaWAN wireless networks
- Two types of tamper detection: enclosure tamper and wall mount tamper
    - Enclosure tamper detects if the packaging of the sensor itself is opened or broken Available on the RBSx01, RBSx05, and RBSx06 sensors.
    - Wall mount tamper detects if the sensor has been removed from the wall or mounting point. Available on the RBSx01 and RBSx05 sensors.
- 200,000+ transmissions on a single battery and a 5-10 year battery life depending on usage. See Battery section for more detail.
- Fully integrated internal antenna
- Over the air sensor configuration in the field
- Automatic low battery reporting and supervisory messages

## 2.2. Revision History

*Table 1 Revision History*

| Revision | Date | Description |
|---|---|---|
| 1.0 | April 2019 | Initial release of the document |
| 1.1 | May 2019 | Modified precision on measurement |
| 1.2 | May 2019 | Added temperature for compensation |
| 1.3 | September 2019 | Updated common sections |

## 2.3. Document Conventions

*Table 2 Document Conventions*

| Font / Icon | Meaning |
|---|---|
|  | Important notes |
|  | Warnings and cautions |

## 2.4. Part Numbers

*Table 3 Part Numbers*

| Part Number | Rating | Wireless | Region |
|---|---|---|---|
| RBS306-TILT-HP-US | Outdoor/Industrial | LoRaWAN | North America, South America |
| RBS306-TILT-HP-EU | Outdoor/Industrial | LoRaWAN | Europe |

# 3. TECHNICAL SPECIFICATIONS

## 3.1. Absolute Maximum Ratings

*Table 4 Absolute Maximum Ratings*

| Parameter | Rating | Units |
|---|---|---|
| Operating ambient temperature | -40 to +70 | °C |
| Storage ambient temperature | -40 to +100 | °C |

# 4. BATTERY LIFE

The sensor uses a lithium non-rechargeable battery and is capable of 200,000+ total messages depending on the wireless standard and usage. For an accurate estimate of battery life, please refer to the "Sensor Battery Estimator.xlsx" spreadsheet on the Radio Bridge website. This spreadsheet combines usage information such as average number of messages per day and estimates the battery life for a particular sensor.

Refer to the spreadsheet "Sensor Battery Estimator.xlsx" on the Radio Bridge website for specific battery life estimates.

The power required for a message transmission is much greater than the "sleep current" (the power consumed when the sensor is inactive) for high power radio technologies such as LoRaWAN. This means that the battery life for most sensors is primarily dependent on the number of transmissions per day.

Different battery types will deplete over time with different voltage profiles. For instance, a lithium battery will maintain a relatively high voltage for the life of the battery and then experience a rapid drop near the end, whereas an alkaline battery will experience a more gradual reduction in voltage over time. Radio Bridge sensors are shipped with lithium batteries, and these are recommended when the battery needs to be eventually replaced.

Temperature also plays a role in battery life. The battery life estimates in the online spreadsheet assume room temperature, but temperatures close to the maximum and minimum ratings will have a negative impact on battery life. For example, battery voltage tends to be lower in cold temperatures and the internal circuitry needs a certain minimum voltage to operate properly before it will shut down. Thus, battery life will tend to be shorter when running the sensor in cold environments.

Battery voltage will be lower in cold temperatures and thus battery life will be reduced in cold environments.

The battery voltage is reported by the supervisory messages as well as a low battery indicator. See the section on Message Protocol for more detail.

# 5. TEST MESSAGES

The sensor can be triggered to send test messages by placing a magnet next to the side of the sensor. The location of the magnet is indicated by the triangular notch on the side of RBSx01 and RBSx05 sensors. RBSx04 sensors do not have this capability. There is a small magnetic Hall effect sensor that will detect the presence of a magnet and send a message. This can be used for diagnostic purposes to ensure the sensor is within range and connected to the network.

# 6. MESSAGE PROTOCOL

This section defines the protocol and message definitions for the sensor.

Radio Bridge provides a web-based console at console.radiobridge.com to configure and monitor sensors. Usage of this console is highly recommended for most customers rather than implementing the protocols defined in this section.

If the standard Radio Bridge console (console.radiobridge.com) is not used, refer to this section to decode the sensor data and configure the sensor through downlink messages.

## 6.1. Common Messages

There are common messages across all wireless sensors that are defined in the document “Common Sensor Messages” which is available on the Radio Bridge website.

Refer to the document “Common Sensor Messages” for definitions of all common messages. Common messages are not defined in this document.

Common messages include basic error messages, tamper, supervisory, and downlink ack. It is important to refer to that document prior to decoding the messages defined in this section.

## 6.2. Uplink Messages

The uplink message (sensor to web application) specific to the sensor is defined in following table. The common uplink messages are not included in this section (see common messages document).

*Table 5 Uplink Message 0x0F: High-Precision Tilt Event*

| Byte | Description |
|---|---|
| 0x00 | Tilt event |
| 0x01 | Tilt angle from vertical axis – whole degrees |
| 0x02 | Tilt angle from vertical axis – fractional degrees |
| 0x03 | Temperature in degrees C |

The high-precision tilt sensor has precision to 0.1 degrees. Byte 1 of the uplink message is the whole integer component and byte 2 is in tenths of a degree. For example, a measurement of 48.7 degrees would be represented as 0x30 and 0x07 respectively.

The tilt events are defined in the following table.

*Table 6 Uplink Tilt Event Definitions*

| Event | Description |
|---|---|
| 0x00 | Periodic report |
| 0x01 | Sensor transitioned toward the 0-degree vertical orientation |
| 0x02 | Sensor transitioned away from the 0-degree vertical orientation |
| 0x03 | Report on change toward the 0-degree vertical orientation |
| 0x04 | Report on change away from the 0-degree vertical orientation |

The first two event messages are sent when the tilt angle exceeds the threshold toward or away from the 0-degree vertical orientation. Note that the angle is relative to a 0-degree vertical orientation, so small angles will be reported when the sensor is oriented vertically.

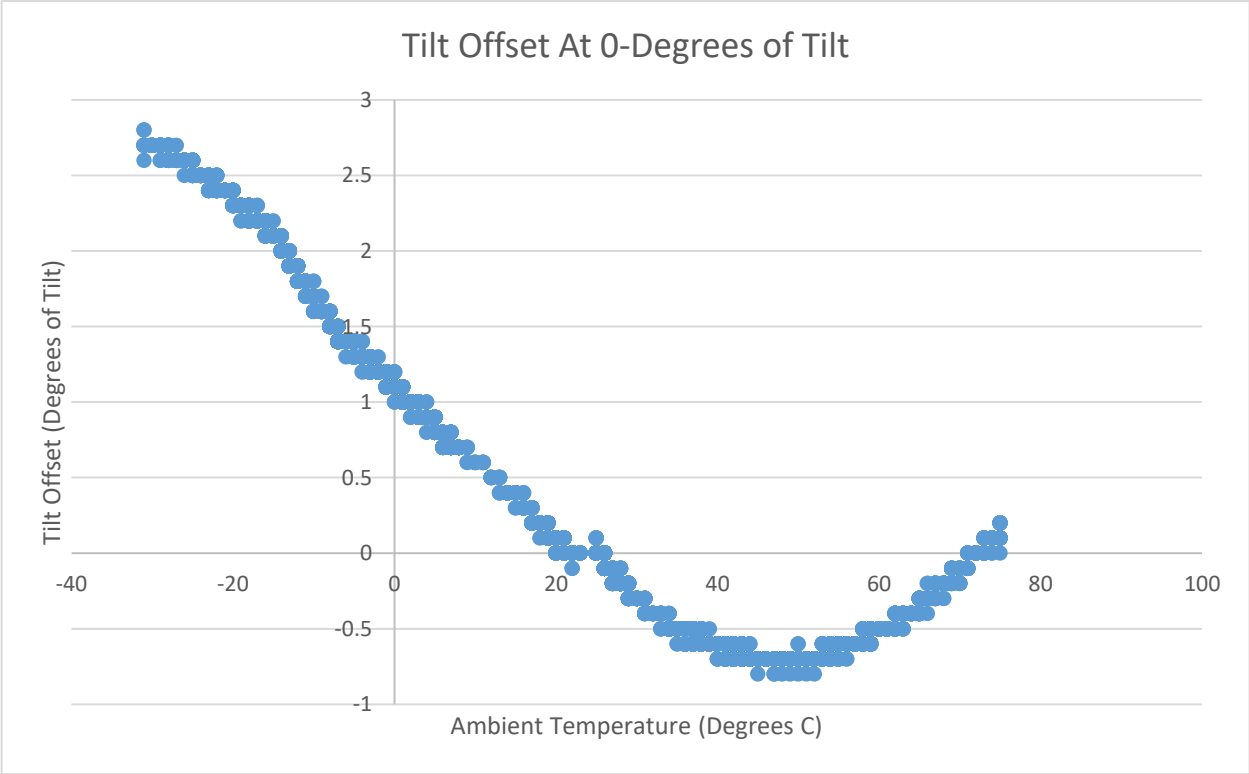
The report-on-change messages are sent when the tilt angle increases away from vertical or decreases back to vertical a specified amount from the last report. For example, consider a report-on-change value that is set to 5 degrees and the current angle from the vertical axis is 15 degrees. If the angle increases to 20 degrees an 0x04 event is sent. If the angle decreases back to 15 degrees, an 0x03 event is sent.

### 6.2.1. Temperature Compensation

The temperature reported in byte 0x03 of the uplink message is a two's compliment signed integer value representing the ambient temperature inside the sensor in degrees C. This is reported because MEMS-based accelerometers are sensitive to temperature and thus skew the tilt angle at temperatures significantly above or below room temp.

If tilt precision under 1 degree is required and the sensor is not at or near room temperature (25 degrees C), then the temperature output can be used to further calibrate the device. A temperature dependence curve is shown below at an orientation of 0-degrees.

The tilt measurement is skewed when the temperature is significantly above or below room temp.



The shape and magnitude of the temperature-dependence curve will be different depending on the orientation of the sensor. Thus, this curve alone should not be used for temperature compensation.

## 6.3. Downlink Messages

The downlink message (web application to sensor) specific to the sensor configuration is defined in following table. The common downlink messages are not included in this section (see common messages document).

*Table 7 Downlink Configuration Message 0x0F*

| Bytes | Description |
|---|---|
| 0 | Mode – Threshold or Report-on-Change |
| 1 | Periodic reporting |
| 2 | Hold time |
| 3-6 | Defined by Mode selection |

A Mode setting of 0x00 selects Threshold Mode (default) and a setting of 0x01 selects Report-on-Change mode. This selection defines bytes 3-6 as shown in the sections below.

### 6.3.1. Periodic Reports

The tilt sensor can also send periodic updates, and this is defined in byte 1 of both modes. A setting of 0 will disable periodic reporting. The period is defined in 1-hour increments when the most significant bit is 0, and it is defined in 1 minute increments when the most significant bit is 1 as shown in the following table.

*Table 8 Period Bye (byte 1) from Downlink Configuration Message*

| Bit 7 | Bits 6:0 |
|---|---|
| 0 | Period defined in hours (1-127 hours) |

| | |
|---|---|
| 1 | Period defined in minutes (1-127 minutes) |

For example, to receive a report every 4 hours, byte 1 would be set to 0x04. To receive a periodic report every 15 minutes, byte 1 would be set to 0x8f.

Periodic reporting is not recommended as it will increase data service fees and significantly reduce battery life. Wherever possible, use thresholds or report-on-change only.

### 6.3.2. Hold Time

The hold time is an 8-bit value that represent the amount of time the tilt sensor must be held in a particular orientation (or exceeding a particular threshold) before a message is sent. This is a way to add extra "debounce" to the sensor so that it does not send excessive messages oscillating around a threshold. The hold time values range from 1-255 and are represented in 250ms increments. This gives the hold times a range of 250 milliseconds – 1 minute. If the hold time is 0, the feature is disabled and an alert will be sent any time the orientation changes.

### 6.3.3. Threshold Mode

The angles in bytes 3-6 define the angle in degrees relative to the vertical axis that the sensor must be tilted to generate an alert. For example, if the sensor is used to detect garage open/close events, the toward-vertical threshold might be set at 35 degrees and the away-from-vertical threshold may be set at 55 degrees. It is not recommended to set both to the same values (both at 45 degrees for instance) since this may generate multiple alerts when it is oriented near the threshold. The range for each threshold is 0-180 degrees where 0 is completely vertical, 90 is horizontal, and 180 is inverted.

*Table 9 Threshold Mode Bytes for Configuration Message 0x0F*

| Bytes | Description |
|---|---|
| 3 | Angle for transition away from the 0-degree vertical state, whole integer value. Default 55 degrees |
| 4 | Angle for transition away from the 0-degree vertical state, fractional value |
| 5 | Angle for transition toward the 0-degree vertical state, whole integer value. Default 35 degrees |
| 6 | Angle for transition toward the 0-degree vertical state, fractional value. |

Since the high-precision tilt sensor has precision to 0.1 degrees, the angles are defined by both an integer value and a fractional value. For example, to define an angle of 16.8 degrees, the values would be 0x10 and 0x08 respectively.

### 6.3.4. Report-On-Change Mode

The report-on-change feature will create an alert when the angle of the tilt increases or decreases by a specified amount. This allows for detecting a tilt when the initial orientation is not completely vertical. For example, one could place the sensor on a telephone pole and set a report-on-change event for 10 degrees. This configuration will send an alert if the pole leans another 10 degrees from its current position.

*Table 10 Report-On-Change Mode Bytes for Configuration Message 0x0F*

| Bytes | Description |
|---|---|
| 3 | Angle for report-on-change mode away from 0-degree vertical position (toward the 180 degree inverted position), whole integer value. |
| 4 | Angle for report-on-change mode away from 0-degree vertical position, fractional value. |
| 5 | Angle for report-on-change mode toward the 0-degree vertical position, whole integer value. |

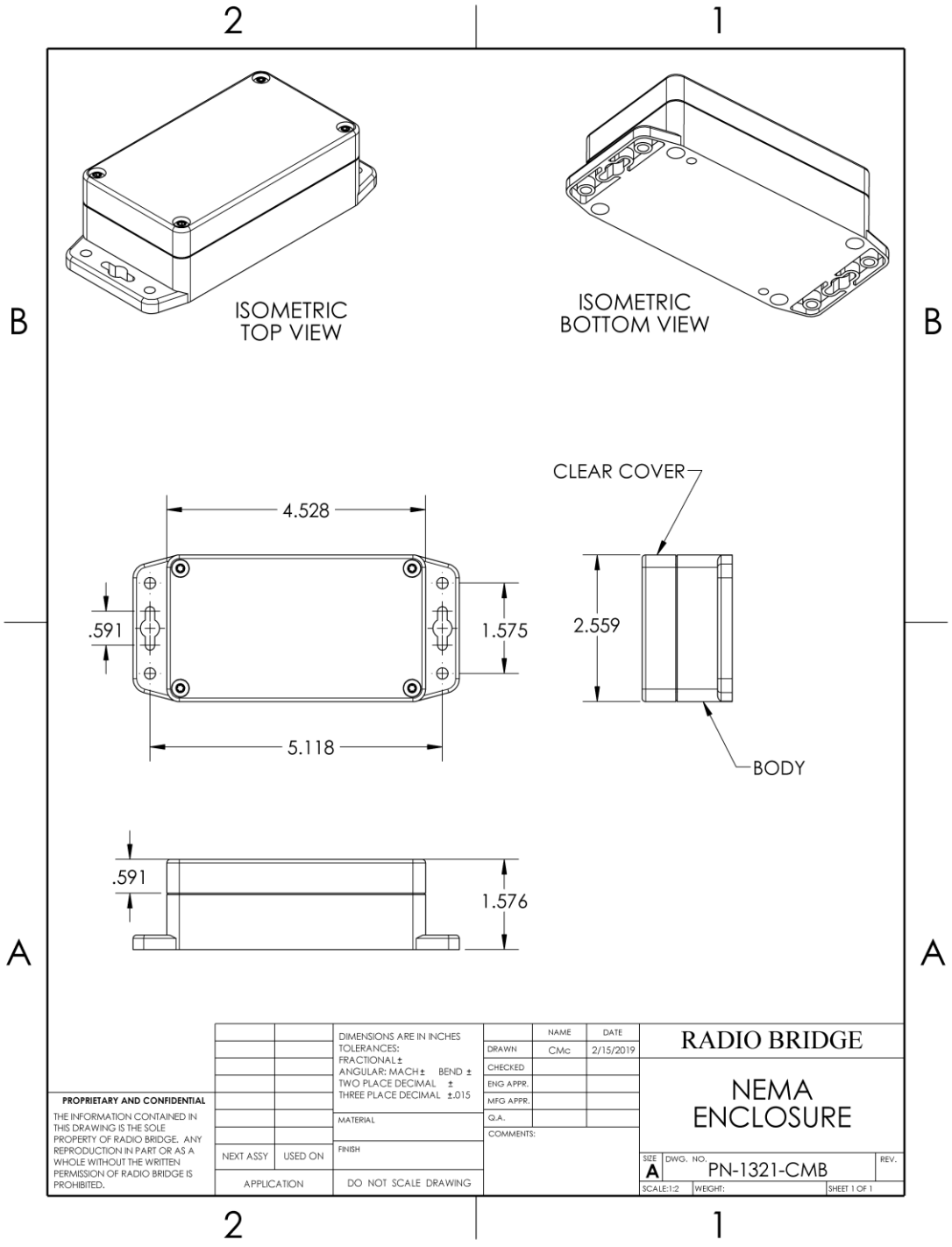
| | |
|---|---|
| 6 | Angle for report-on-change mode toward the 0-degree vertical position, fractional value. |

Since the high-precision tilt sensor has precision to 0.1 degrees, the angles are defined by both an integer value and a fractional value. For example, to define an angle of 16.8 degrees, the values would be 0x10 and 0x08 respectively.

# 7. MECHANICAL DRAWINGS

The mechanical drawings provided in this section are for the main body of the sensor. All dimensions are inches unless otherwise noted.

## 7.1. ARMORED OUTDOOR/INDUSTRIAL RBSX06 SENSORS



# 8. REGULATORY AND COMPLIANCE

## 8.1. Federal Communications Commission (FCC)

Per FCC 15.19(a)(3) and (a)(4) 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.

Per FCC 15.21, Changes or modifications not expressly approved by Radio Bridge could void authority to operate the devices.

Sigfox RBS101, RBS104, and RBS105 sensors FCC ID: 2APNUSFM10R2

LoRaWAN RBS301, RBS304, and RBS305 sensors FCC ID: 2APNUCMABZ

LoRaWAN RBS306 sensors: This device contains FCC IAU792U13A16858

This device contains equipment certified under IC: 125A-0055

## 8.2. Harmonized Commodity Description (HS Code)

The Harmonized Commodity Description and Coding System generally referred to as "Harmonized System" or simply "HS" is a multipurpose international product nomenclature developed by the World Customs Organization (WCO).

HS Code: 8531.90

## 8.3. Export Control Classification Number (ECCN)

ECCNs are five character alpha-numeric designations used on the Commerce Control List (CCL) to identify dual-use items for export control purposes. An ECCN categorizes items based on the nature of the product, i.e. type of commodity, software, or technology and its respective technical parameters.

ECCN: 5a992.c

# 9. CUSTOMER SUPPORT

Radio Bridge offers free technical support at:

https://support.radiobridge.com

Radio Bridge also offers technical support plans and service packages to help our customers get the most out of their Radio Bridge products.

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