

User Guide

SentriusTM RS1xx

Version 2.4

REVISION HISTORY

Version	Date	Notes	Contributor	Approver
1.0	05 Dec 2017	Initial version	Christopher Hofmeister	Jonathan Kaye
1.1	09 Apr 2018	Indicated that the Sentrius™ Sensor with an external sensor port (RJ45) <i>will be available</i> rather than <i>is available</i> .	Mark Cai	Jonathan Kaye
1.2	17 Oct 2018	Updated for firmware version 4.4. Added in Packet Format and Packet Type sections.	Colin Anderson	Jonathan Kaye
1.3	19 Dec 2018	Updated logos and URLs	Sue White	Jonathan Kaye
1.4	May 2019	Reset button, LIFO, and FIFO backlog retrieval. Updated rest of doc for clarity.	Colin Anderson	Jonathan Kaye
1.5	July 2019	Introduction of AS923 and AU915 regions.	Colin Anderson, Mark Monson, Daniel Cesarz	Jonathan Kaye
1.6	15 Aug 2019	Added AS923 Region Label Support within various sections and created Section 16	Robert Gosewehr	Jonathan Kaye
1.7	28 Aug 2019	Reflect new part numbers and modified ext. probe specification	Chris Boorman	Jonathan Kaye
1.8	04 Nov 2019	Added details of Laird 2 packet format	Greg Leach	Chris Boorman
1.9	02 Dec 2019	Added AS923 Region Supported Label Section Changed <i>Guide</i> and <i>Manual</i> references to <i>Configuration</i> .	Robert Gosewehr	Chris Boorman
1.10	29 Jan 2020	Added the following: <ul style="list-style-type: none"> ▪ Details of Open/Closed sensor packet format ▪ Details of Open/Closed sensor configuration ▪ Details of Open/Closed sensor state machine 	Greg Leach, Robert Gosewehr, Chris Hofmeister	Chris Boorman
1.11	21 April 2020	<ul style="list-style-type: none"> ▪ Updated for firmware version 6.0 release ▪ Updated region labels reflect addition of Singapore ▪ Added the following: <ul style="list-style-type: none"> – Details of backlog configuration and behavior – Details of battery life calculation algorithms 	Greg Leach, Robert Gosewehr, Chris Hofmeister	Chris Boorman
1.12	22 June 2020	<ul style="list-style-type: none"> ▪ Updated Cayenne packet format tables ▪ Updated region part numbers table 	Greg Leach	Chris Boorman
1.13	21 Sept 2020	<ul style="list-style-type: none"> ▪ Corrected Join Procedure figure 	Greg Leach	Chris Boorman
2.0	18 Dec 2020	Updated all regulatory information	Maggie Teng	Jonathan Kaye
2.1	05 Feb 2021	Updated humidity measurement guidance. Updated to User Guide.	Chris Boorman	Jonathan Kaye
2.2	16 Feb 2021	Transferred regulatory detailed information to a separate document	Sue White	Jonathan Kaye
2.3	25 Feb 2022	Added information on maximum operating voltage in Battery Types	Erik Lins	Jonathan Kaye
2.4	3 May 2022	Updated max supply voltage to 3.6V	Dave Drogowski	Erik Lins

CONTENTS

1	About this Guide	6
2	Introduction	6
2.1	Product Overview	6
2.2	Specifications	6
2.3	Architecture Overview	7
3	Powering Up the Sensor	7
3.1	Battery Types	7
3.1.1	Changing Battery Type	8
3.2	Inserting Batteries	8
3.3	Battery Level Measurement	9
3.3.1	Alkaline Battery Level Measurement	9
3.3.2	Lithium Battery Level Measurement	10
4	Connecting to a LoRa Network Server	11
4.1	AppEUI	11
4.1.1	Default AppEUI	11
4.1.2	Reading or Changing the AppEUI	11
4.2	DevEUI	11
4.2.1	Reading the DevEUI Back Label	11
4.3	AppKey	12
4.3.1	Reading the AppKey	12
5	Configuring the Packet Format	13
6	Configuring the Packet Type	15
7	Adaptive Data Rate (ADR)	16
7.1	Definitions	16
7.2	Data Rate, Sensor Performance, and Tradeoffs	16
7.2.1	Range	16
7.2.2	Battery Life	16
7.2.3	Bandwidth	16
7.2.4	EU Considerations	16
7.3	MAC Commands and the LoRa Standard	16
7.3.1	902-928 MHz US and Canada	16
7.3.2	863-870 MHz EU	16
7.3.3	915-928 MHz AS	17
7.3.4	915-928 MHz AU	17
7.3.5	Data rate control	17
8	Device Operation	18
8.1	Care and Maintenance	18

8.2	Positioning of the Sensor	18
8.3	Important Operational Consideration.....	18
8.4	LoRa Messages	18
8.5	Join Sequence	19
8.6	Ack/Retries	19
8.7	Disconnect	20
8.8	Network Time	20
8.9	Logging Feature	21
8.9.1	On Fail	21
8.9.2	Continuous	21
8.10	Backoff Period.....	22
8.10.1	Operation at 902-928 US with DR0	22
8.11	Measuring Humidity.....	22
8.12	Setting Up the Sensor	22
8.12.1	Sensor Read Period	22
8.12.2	Sensor Aggregate	22
8.12.3	Alarm Levels.....	23
8.12.4	LED Behavior	23
8.13	Sensor Firmware Version.....	23
8.14	Resetting the Sensor.....	23
9	Configuration	24
9.1	Device Configuration	24
10	Mobile Application	25
10.1	Overview	25
10.2	Install Sentrius Sensor Mobile App on Device.....	25
10.3	Connect to Sentrius Sensor	25
10.3.1	Select Device	26
10.4	Main Screen	26
10.4.1	Sensor Configuration.....	27
10.5	View Sensor Data.....	28
10.6	LoRa Configuration	28
10.7	LoRa Network	28
10.8	BLE Info	29
10.9	Update Firmware.....	29
10.10	Alerts and Backlogs.....	31
10.11	Battery Life Calculator	31
10.12	Integrating Sentrius™ Sensor into a Third-Party Application	32
11	Bluetooth SIG	32
12	Regulatory	32

13	Ordering Information.....	33
13.1	Evaluation Kit Details (applies to 455-0001, 455-0002, and other regional variants)	33
14	Other Variants	34
14.1	External Temperature Sensor	34
14.2	External Open/Closed Sensor.....	34
14.3	External RTD Sensor	35
15	Label Info.....	38
15.1	Back Label	38
15.1.1	QR Code 1 Info	38
15.1.2	QR Code 2 Info	38
15.1.3	QR Code 3 Info	38
15.2	Label (Back Label Space)	38
15.3	AS923 Region Labels.....	39
15.3.1	Singapore (SG – 923 MHz)	39
15.3.2	Taiwan (TW – 923 MHz).....	39
15.3.3	New Zealand (NZ – 923 MHz).....	39
15.3.4	Hong Kong (HK – 923 MHz).....	39
15.3.5	Australia (AU – 915 MHz or 923 MHz)	39
16	Additional information	40
17	Appendix A - Cayenne packet format	40

1 ABOUT THIS GUIDE

This document provides a comprehensive guide on how to configure the Sentrius™ RS186 and RS191 sensors to suit the intended application. It covers all Sentrius™ RS1xx functionality, including Bluetooth and LoRa configurations in detail, as well as setting up the sensor on a LoRa network server.

In order to comply with the LoRaWAN spec, Laird offers several different versions of the Sentrius Sensor. Regions covered include Europe (EU), North America (US) and Australia (AU915) and a growing number of countries in the Asia(AS) region.

In order to meet local regulatory requirements, these regions are covered by individual firmware versions for each country. The regional setting of the Sentrius Sensor cannot be modified by customers.

Note: Step by step instructions, screen shots, and images are based on the Sentrius™ RS191, but the same are applicable for the Sentrius™ RS186 or other variants. Any differences are noted.

2 INTRODUCTION

2.1 Product Overview

The Sentrius™ RS1xx LoRa-Enabled Sensor from Laird is the ultimate in secure, scalable, robust LoRa solutions for end-to-end control of your private LoRaWAN network. Based on the Semtech SX1272 chipset, it offers a long range up to ten miles, perfect for highly scalable, flexible IoT networks. The Sentrius RS1xx Sensor works with Laird's Sentrius™ RG1xx Series Gateways for simple out-of-the-box integration and is compatible with third-party and LoRa network servers.



Figure 1: Top of the Sentrius RS1xx sensor

1. Temperature and humidity sensor
2. Bluetooth button
3. LEDs
4. Fixing holes



Figure 2: Back side of the Sentrius RS1xx sensor

Note: Laird has a comprehensive staff of design services engineers available to help customize the sensor. Please contact your local Laird sales representative for more details.

2.2 Specifications

See the RS1xx product brief for detailed specifications. It's available from the Documentation tab of the RS1xx Series product page: <https://www.lairdconnect.com/wireless-modules/lorawan-solutions/sentrius-rs1xx-lora-enabled-sensors>

2.3 Architecture Overview

The major pieces of a LoRa network can be seen in Figure 3. The RS1xx sensor is an *End Node* in the diagram below. The RS1xx requires the other components in the diagram below to operate.

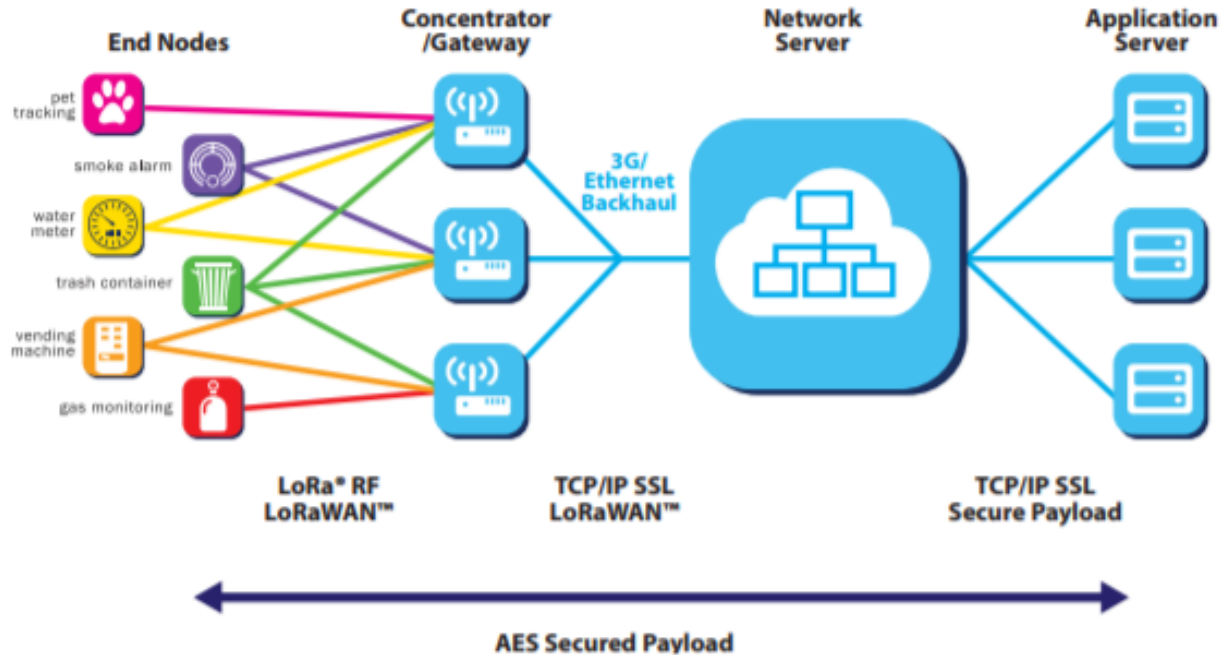


Figure 3: LoRa architecture

3 POWERING UP THE SENSOR

Note: The Sentrius Sensor has no power switch. Inserting the batteries powers up the device.

3.1 Battery Types

The Sentrius Sensor is designed for use with primary cell AA batteries, either lithium or alkaline 1.5V cells. Lithium batteries have more capacity but are costlier. Lithium batteries also have a lower temperature range of -40° C, as opposed to -20° C for alkaline.

Note: The maximum operating voltage of the RS1xx is 3.6V. It is recommended to check the batteries' data sheet to make sure not to exceed this value under all environmental circumstances (especially over temperature).

Figure 4 displays the results of an experiment done with lithium and alkaline batteries at cold (-20° C) temperatures. A discharge profile was set up on a power analyzer that consumed 75 mA for 200 mS and then rested 400 mS before repeating. This resulted in an average current of 25 mA continuous.

The lithium batteries lasted around 130 hours, or (25 mA x 130 hours) 3250 mA/hours. The rated capacity is 3500 mA/hours, so it lasted 93% of its rated value.

The alkaline battery shows signs of instability at -20° C. It descended below the 2.1V cutoff, but then recovered some time later. In a real-world situation, the devices would have stopped operating around 28 hours, or (25 mA x 28 hours) 700 mA/hours. The rated capacity is 2500 mA/hours, so it lasted only 28% of its rated value.

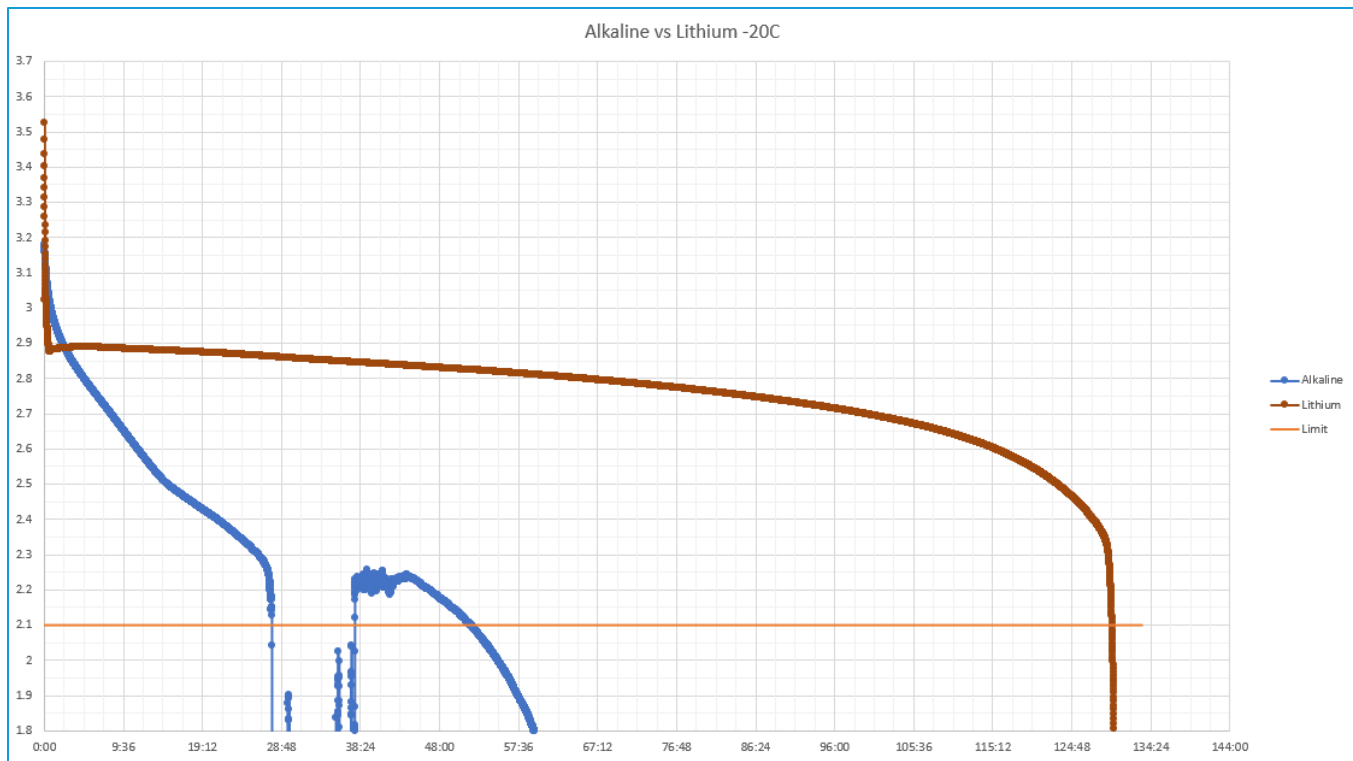


Figure 4: Lithium vs alkaline batteries

You must specify the type of battery being used because the algorithm that determines the percentage of remaining battery life must account for the battery type.

Default Battery Type for the Sentrius Sensor: Alkaline batteries

3.1.1 Changing Battery Type

The battery type can be changed via the Sentrius™ mobile application. Refer to the [Configuration](#) section for details.

3.2 Inserting Batteries

The batteries are inserted on the rear panel of the RS1xx sensor, as shown in [Figure 2](#).

Note: The battery door cover has a gasket inside to keep out liquids. It is important that all screws on the back of the unit are properly inserted and tightened. Failure to do so could result in liquid ingress which would void the device warranty.

3.3 Battery Level Measurement

The battery level is measured each time a sensor data uplink is performed, with a scale of 0 through 5 being used to represent remaining percentage of 0 through 100%, as shown in [Table 1](#).

Table 1 - Battery percentage values

Value	Percentage Range
0	< 5
1	5 – 20
2	21 - 40
3	41 - 60
4	61 - 80
5	81- 100

Depending upon the battery type in use, different algorithms are used to calculate the remaining battery level. These are described in the following sections.

3.3.1 Alkaline Battery Level Measurement

The relatively linear effect of temperature upon alkaline battery discharge permits a look up table system for calculating the remaining battery life. Temperature dependent voltages (combined series voltages of the two AA batteries inserted), as shown in [Table 2](#) through [Table 7](#), are used to determine the remaining battery life, with an internal temperature sensor being used to determine the best possible match.

Table 2 - Alkaline battery levels at -40° C

Level Remaining	Voltage (V)
5	>2.65
4	>2.5
3	>2.35
2	>2.25
1	>2.2

Table 3 - Alkaline battery levels at -20° C

Level Remaining	Voltage (V)
5	>2.65
4	>2.55
3	>2.45
2	>2.35
1	>2.3

Table 4 - Alkaline battery levels at 0° C

Level Remaining	Voltage (V)
5	>2.7
4	>2.6
3	>2.5
2	>2.4
1	>2.3

Table 5 - Alkaline battery levels at 20° C

Level Remaining	Voltage (V)
5	>2.78
4	>2.68
3	>2.55
2	>2.48
1	>2.3

Table 6 – Alkaline battery levels at 40° C

Level Remaining	Voltage (V)
5	>2.85
4	>2.75
3	>2.65
2	>2.5
1	>2.3

Table 7 - Alkaline battery levels at 60° C

Level Remaining	Voltage (V)
5	>2.95
4	>2.8
3	>2.7
2	>2.55
1	>2.3

3.3.2 Lithium Battery Level Measurement

To account for the temperature effects on voltage of lithium batteries, the sensor calculates a voltage offset based on the measured temperature which is applied to the raw voltage data.

The temperature compensated battery voltage is compared against the values in [Table 8](#) to determine the final battery capacity value.

Table 8 – Lithium battery levels with temperature compensation applied

Level Remaining	Voltage (V)
5	>2.95
4	>2.8
3	>2.7
2	>2.55
1	>2.3

4 CONNECTING TO A LoRa NETWORK SERVER

The exact steps needed to connect to a LoRa network server vary by network provider but in all cases, the following three described LoRa keys described must be known by the external LoRa network server.

4.1 AppEUI

The AppEUI is an 8-byte ID used to uniquely identify your application and/or installation. For example, imagine you are installing the Sentrius™ Sensor in a store chain. You could use a specific AppEUI to identify a specific store or perhaps the entire chain of stores.

4.1.1 Default AppEUI

The default AppEUI is 0xf9,0xc6,0x0e,0xce,0xa3,0xad,0xc6,0xbd, and it is set in the device by Laird at the time of manufacturing.

4.1.2 Reading or Changing the AppEUI

The AppEUI can be read or changed via the Sentrius™ mobile application. The number is generated by the end-user, so any number can be used.

4.2 DevEUI

The DevEUI is an 8-byte ID used to uniquely identify your device. It is assigned and set in the device by Laird at the time of manufacturing.

4.2.1 Reading the DevEUI Back Label

The DevEUI is printed on the back label of the sensor as highlighted in red in [Figure 5](#).

In previous versions of the label, there is a large area of whitespace which can be used to apply a secondary label or write in information. The AS923 region supported label only has the green box area for this feature.

4.2.1.1 Barcode

The DevEUI is also accessible via the barcode on the back label where the last comma separated value is the DevEUI in the previous revision of the label. The AS923 region supported back label has a dedicated QR Code for the DevEUI.

Example Readout in previous label version:

450-0182, 1,915 MHz Sentrius™
Sensor, 0213117, 0025CA0A00000844

Note: The sensor labels may change at any time. Please reference [Label Info](#) for the latest label changes.

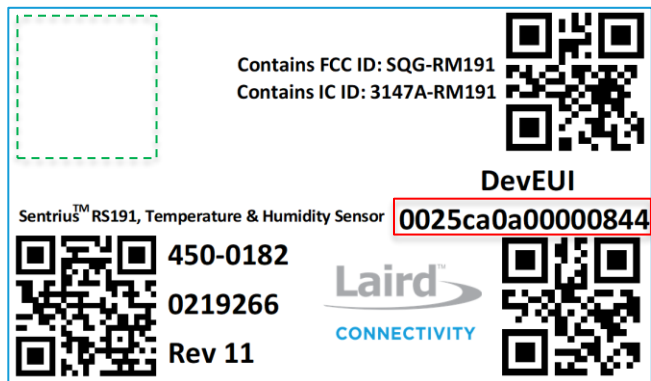


Figure 5: Back label – See Label Info for any possible label updates.

4.2.1.2 Reading or Changing the DevEUI via Mobile App

Normally there is no need to change the DevEUI. However, if necessary, it can be read or changed via the Sentrius™ mobile application. Because the IEEE governs the generation of the number, you must be familiar with these standards in order to change the DevEUI.

4.3 AppKey

The AppKey is a 16-byte security key assigned to the device. Laird assigns and sets it in the device at the time of manufacturing.

4.3.1 Reading the AppKey

4.3.1.1 Removeable Label

The AppKey is printed on a **removeable** label that is attached to the device when it is shipped ([Figure 6](#)).

IMPORTANT! It is the user's responsibility to keep track of the assigned AppKey and to keep it secure.

4.3.1.2 Barcode

The AppKey is also accessible via the barcode printed on this removeable label.



Figure 6: AppKey removeable label

4.3.1.3 Reading or Changing the AppKey

Normally, there is no need to change the AppKey. However, it can be changed via the Sentrius mobile application if necessary.

Note: This key is write-only as there is a security risk in making it readable via the mobile application.

5 CONFIGURING THE PACKET FORMAT

The RS1xx offers three packet format options:

- Laird
- Cayenne
- Laird 2

Prior to version 4.0, only the Laird option was available. If using the Laird packet format, the sensor must receive a network time packet (in Laird binary format) before data is stored in memory for future transmission.

Data logging is not available with the Cayenne packet format, so network time is not required for this packet format. Refer to the [Network Time](#) section for more information.

The Laird 2 format was introduced in firmware version 5.4. The data format is the same as that of the Laird packet format, and a time packet is also required from the network.

It differs from the Laird packet format in that it can be configured for unconfirmed packet transmission to the network, and defaults to this behavior. Furthermore, a sensor data packet is sent immediately upon successfully joining the network such that sensor data is immediately available to the server. Selection of the Laird 2 packet format can be observed physically in that the green product LED is held on for 3s upon successfully joining the network.

The packet format can be configured on the Mobile App through the **LoRa Radio Settings and Info** option.

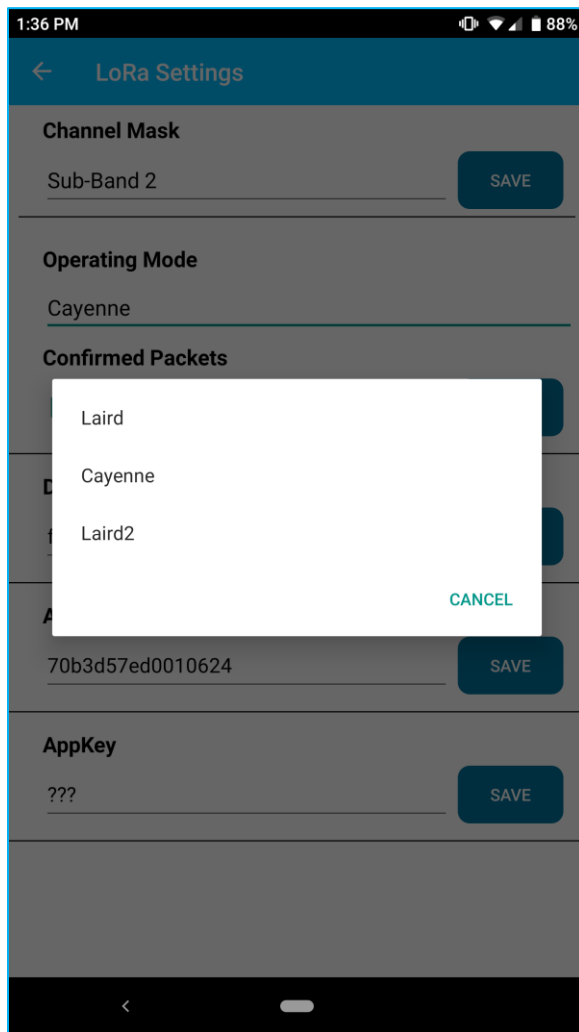


Figure 7: Packet format menu

A brief summary of the different formats is shown in [Table 9](#).

Table 9: Comparison of packet formats

Format	Data	Behavior
Laird		Backlogs fixed to On Fail (see logging section) Confirmed packets only
Laird 2	<ul style="list-style-type: none"> Time stamp, synchronized to the network time Temperature and humidity data Number of alarms Number of backlog packets stored Aggregated packets Remaining battery capacity 	<ul style="list-style-type: none"> Configurable logging modes, On Fail and Continuous Local indication of joining a network by holding of the LoRa LED for three seconds Sending of a sensor data packet immediately upon having joined a network Configurable confirmed and unconfirmed packets
Cayenne	<ul style="list-style-type: none"> Temperature, Humidity, Open/Closed data Remaining battery capacity <p>Note: No timestamp is transmitted</p>	Configurable confirmed and unconfirmed packets

The Cayenne packet format is described in greater detail in [Appendix A - Cayenne packet format](#).

Refer to the [Network Time](#) section for more information.

6 CONFIGURING THE PACKET TYPE

With the Cayenne and Laird 2 packet format selected, the RS1xx can be configured to transmit either confirmed or unconfirmed packets. You can configure this option through the **LoRa Radio Settings and Info** option in the Sentrius Mobile application. This option is **NOT** available with the Laird packet format, which only transmits confirmed packets.

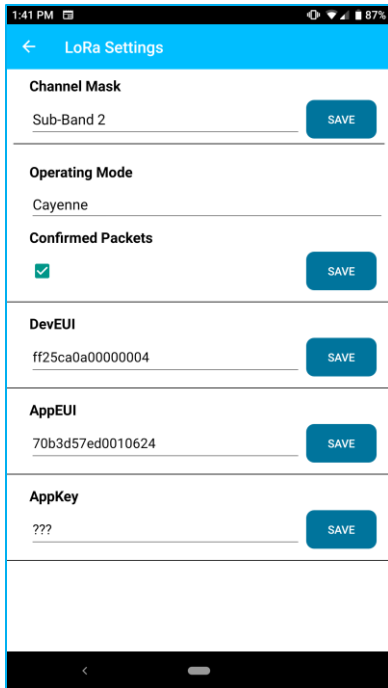


Figure 8: Packet type menu

With confirmed packets, there is a higher likelihood that an uplink data packet is successfully transmitted to the servers, as the RS1xx automatically resends a packet if an acknowledgement is not received (refer to the [Ack/Retries](#) section for more details on the Ack/Retry process). However, one downside is using up more bandwidth on the network as there is a downlink packet for each uplink.

With unconfirmed packets, the uplink packet is transmitted only once. If the packet is not received by the server, then the data is lost. It is not stored internally in the RS1xx for transmission at a later time.

With confirmed packets, if three successive uplinks are not acknowledged, the sensor tries to rejoin. Unconfirmed packets continue to be transmitted while the sensor is powered.

7 ADAPTIVE DATA RATE (ADR)

See the LoRaWAN Specification for a complete discussion of ADR. The LoRaWAN specification can be obtained from the [LoRa Alliance](#).

7.1 Definitions

Knowledge of the following terms is important for this section:

- **Uplink/Upstream** – Transmissions originating from the sensor and received by the LoRa Network Server via the LoRa Gateway.
- **Downlink/Downstream** – Transmissions originating from the LoRa Network Server and received by the sensor via the LoRa Gateway.

7.2 Data Rate, Sensor Performance, and Tradeoffs

7.2.1 Range

As the data rate decreases, the RF range increases.

7.2.2 Battery Life

As the data rate decreases, each packet takes longer to transmit which decreases battery life.

7.2.3 Bandwidth

As the data rate decreases, it takes longer to transmit a packet, decreasing available bandwidth on the network and increasing the probability of RF collisions or interference.

7.2.4 EU Considerations

In the EU, many bands are highly restricted regarding how much airtime a device can use. For example, some bands allow only a 0.1% duty cycle, although in most use cases the channels set in the sensor are in a 1% band. The duty cycle is the transmit time of the device relative to the non-transmit time. If a device transmits a packet that was one second long, it could not transmit for another 1000 seconds ($1/1000 = 0.1\%$) (1000 seconds is over 15 minutes) in a 0.1% band.

Remember to take LoRa gateway duty cycle restrictions into consideration, regarding the number of sensors at certain data rates that a gateway can support, if confirmed packets are configured.

Plan carefully to ensure that a device does not exceed this duty cycle limitation, including possible retries. The LoRa stack running inside the sensor monitors the duty cycle of the device and does not allow a device to transmit if it exceeds the allowable duty cycle.

7.3 MAC Commands and the LoRa Standard

Configuration of the LoRa parameters are handled by the LoRa stack contained within the RS1xx firmware. Any changes to this configuration are handled automatically by the stack or via a downlink MAC command from the network server.

7.3.1 902-928 MHz US and Canada

On power up, the Sentrius™ Sensor starts transmitting Join requests alternately on a random 125-kHz channel at data rate 0 in the selected sub-band and then a random 500-kHz channel at data rate 6. It continues this sequence until the sensor joins the network.

7.3.2 863-870 MHz EU

On power up, the Sentrius™ Sensor starts transmitting Join Requests at data rate 5, reducing the data rate by one each attempt until it reaches data rate 0. If data rate 0 fails, the sequence repeats until the sensor joins the network.

7.3.3 915-928 MHz AS

On power up, the Sentrius™ Sensor starts transmitting Join Requests at data rate 5, reducing the data rate by one each attempt until it reaches data rate 2. If data rate 2 fails, the sequence repeats until the sensor joins the network.

7.3.4 915-928 MHz AU

On power up, the Sentrius™ Sensor starts transmitting Join requests alternately on a random 125-kHz channel at data rate 2 in the selected sub-band and then a random 500-kHz channel at data rate 6. It continues this sequence until the sensor joins the network.

7.3.5 Data rate control

The LoRa specification defines the commands necessary to manage the sensor data rate in response to changing RF conditions.

Information transferred between the LoRa stack contained within the RS1xx and the LoRa Network automatically adjust the system data rate to optimize communication reliability and power consumption.

8 DEVICE OPERATION

8.1 Care and Maintenance

The sensor can be cleaned with a mild, non-abrasive detergent. The sensor is IP65 rated, not fully waterproof, as such do not immerse it in water. The sensor does not require any calibration.

8.2 Positioning of the Sensor

For optimum response to temperature change, position the sensor in a way that air can flow through the sensor air channel.

The white material is a Gortex cover that allows airflow through the channel, while preventing liquids from coming into direct contact with the sensor.

Placing the sensor on a large thermal mass negatively impacts the temperature response.



Figure 9: Air flow through sensor

Note: An application note named *Successful Sensor Installation* is available from the [RS1xx product page](#) offering a guide for how to install/position sensors.

8.3 Important Operational Consideration

Operators must take precautions to prevent water from condensing within their Sentrius sensors when moved from cold environments back to normal warm, humid conditions, especially in areas with high humidity, such as kitchens.

Condensation within electronics will directly cause or contribute to premature failure by corrosion and shorting electronic circuitry, also promoting dendrite growth.

Damage caused by condensation will void the warranty.

Fortunately, condensation can be avoided by operators being aware of the risk and taking precautions.

Causes of condensation:

The Sentrius RS1xx sensors are IP65 rated but even with that level of protection, there are known contributing factors to moisture accumulation internally including:

- Battery housing improperly sealed
- Sensors moved from a cold environment to warm and humid environment

Actions to prevent condensation:

- For sensors in cold environments, where possible (inside walk-in chillers/freezers) do not move the sensor to a different environment to replace batteries, do it in situ
- When removing a sensor from a cold environment, allow sensor to warm in a **dry** environment.

Before removing from the chiller/freezer, place the sensor in a sealed bag (like a food cold bag, or a zip-lock bag). Remove as much air as possible. Allow sensor to slowly warm to room temperature.

- Most importantly, keep the sensor away from warm/humid environments after removing from the chiller/freezer

8.4 LoRa Messages

Note: The LoRa API is available in the '[RS1xx LoRa Protocol Guide](#)' which is available from the [RS1xx product page](#).

8.5 Join Sequence

Before any temperature or humidity data can be transmitted to the application servers, the sensor must first join the network. This is done by the Over the Air Activation (OTAA) method. On power-up, the sensor automatically attempts to join the network by transmitting a Join Request packet. If a join-accept message is received in return by the sensor, the sensor then transmits its current firmware version and the current uplink configuration parameters to the server.

The network time should be sent to the sensor as part of the first downlink message. If the network time fails to be received, the module continues to request it at each data uplink transmission. The module transmits logs to the server without being synchronized to the network time. Data logging cannot be performed until a timestamp is received from the Network Server.

If a join-response message is not received by the sensor, it continues to attempt to join the network server periodically (approximately every minute), depending on band specific duty cycle and back-off restrictions. The sensor continues to operate in this mode until the join procedure has been successfully completed.

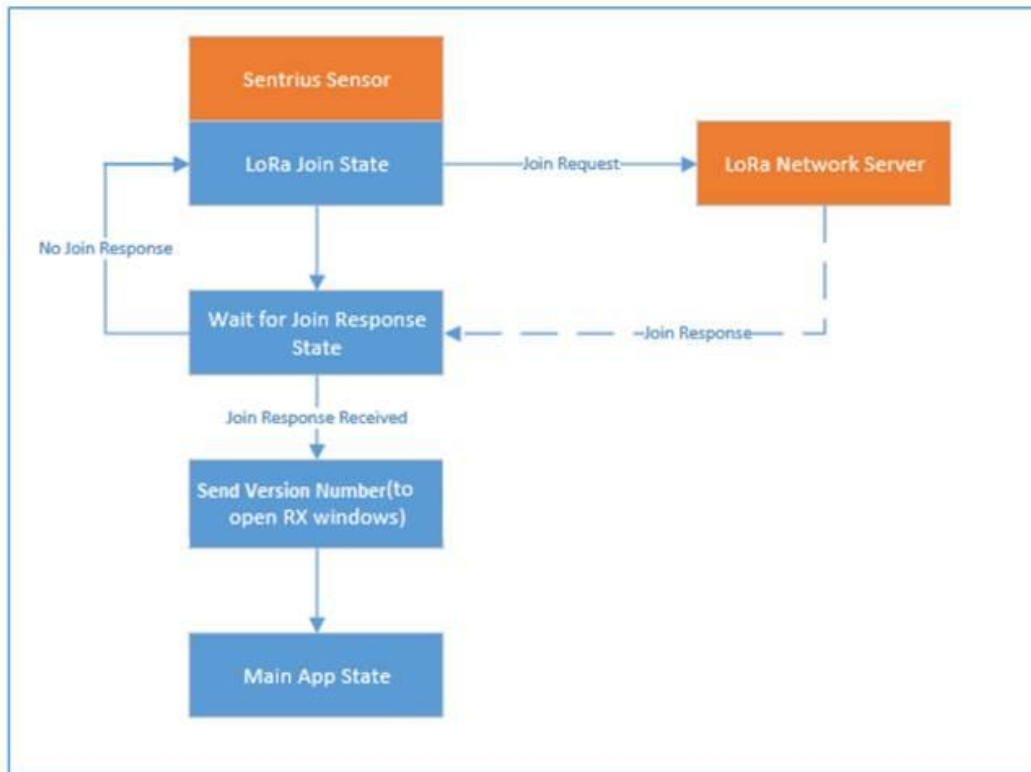


Figure 10: Join procedure

8.6 Ack/Retries

Sensor to LoRa network server RF messages can be configured to transmit Confirmed Packets, requiring an acknowledgement. Every RF message sent to the network server is expecting an acknowledgement message back from the network server telling the sensor, in effect, *I got your message*. The sensor retransmits the message a certain number of times depending on the current data rate if an acknowledgement is not received. Every two unsuccessful attempts at a data rate causes the sensor to lower its data rate by one. Refer to the following tables for how many attempts are made at each data rate.

US – RS191

Table 10 - US retransmissions per data rate

Uplink Data Rate	Total Number of Retransmissions
DR4	8
DR3	8
DR2	6
DR1	4
DR0	2

EU – RS186

Table 11 - EU retransmissions per data rate

Uplink Data Rate	Total Number of Retransmissions
DR7	8
DR6	8
DR5	8
DR4	8
DR3	8
DR2	6
DR1	4
DR0	2

For example, if in the US and at DR4, the maximum number of transmissions before a message is considered to have failed is eight. This means it transmits twice at DR4, twice at DR3, twice at DR2, and twice at DR1. If all transmissions are unsuccessful, the next time the device transmits, it is at DR0. If any of the data rates before that are successful, the unit remains at that data rate until the server deems its link is good enough to step up the data rate via ADR.

8.7 Disconnect

If the sensor detects three consecutive confirmed RF messages are lost, the sensor assumes the connection to the server is lost and stops sending data. It reverts to the join sequence described in the [Join Sequence](#) section of this guide.

8.8 Network Time

If configured for the Laird or Laird 2 Packet Formats, after the sensor joins a network, it can start sending data packets to the server. However, before the sensor can use the backlog feature it must first get the network time. This is sent in epoch time, number of seconds since January 1, 2015. Once the network time is received, the device can be configured to store unacknowledged packets in the Flash device.

On the successful reception of a Join Request, the server may automatically transmit the network time message to the sensor as part of the first downlink message. If the network server does not provide a Laird format time message, the sensor requests it. This is achieved by setting bit 0 of the options byte of a data uplink message to 1. More information on this can be seen in the RS1xx LoRa Protocol document available from the RS1xx product page.

IMPORTANT!!

When configured for the Laird and Laird 2 packet formats, the Sentrius™ Sensor is intended to work with a LoRa network server that provides network time in the custom Laird Format. See the **RS1xx LoRa Protocol** document which can be found at the link located in the [Additional information](#) section.

This is required for the sensor to store data in the internal log flash. The sensor transmits data without the network time being available, but it cannot commit this to flash storage. This does not apply when configured for the Cayenne packet format, due to the protocol not supporting a timestamp.

8.9 Logging Feature

The Sentrius sensor incorporates a flash memory chip that is used to store records of sensor data. Separate areas, with a capacity of 4096 records, are maintained for normal sensor data, and for data that has triggered alarm limits. Each backlog log or alarm includes the time that reading was taken. During data retrieval, the alarm section is prioritized over the non-alarm data.

The backlog data can be retrieved via the LoRa interface or the Bluetooth interface. Note that in some situations, such as the lowest data rate in the US or AS regions, it may not be practical to retrieve backlog data over LoRa due to bandwidth limitations.

There are separate commands for retrieving the backlogs in FIFO or LIFO mode. With FIFO, the oldest log is retrieved first. With LIFO the latest log is retrieved first. Both commands are identical as described in the sections below.

Once retrieval of logs commences in a certain mode, ALL logs must be retrieved using that mode or a reformat performed (erase all of the logs) of the flash memory once all logs required have been retrieved. Using the LIFO option means there can be gaps of already retrieved logs in flash. The LIFO option can handle this; FIFO cannot.

Note: The backlog feature only functions if the sensor has received a timestamp from the server. In situations where the timestamp is not available, any logs that are not successfully received by the server are lost.

Note: For the Laird Packet Format, the Logging Mode is fixed to 'On Fail'.

For the Laird 2 Packet Format, logging can be configured to work in one of two ways, as follows.

8.9.1 On Fail

In the 'On Fail' mode of operation, Confirmed Packets, that are not acknowledged by the Network Server are stored to the flash memory. For successful operation of this mode, Confirmed Packets must be enabled.

8.9.2 Continuous

In the 'Continuous' mode of operation, all sensor data is stored to the flash memory. Limitations on storage space result in increasing Read Periods of the sensor consuming available space more rapidly. The Logging Duration parameter is used to determine how many days (between 1 and 7) of data should be stored before wrapping around and overwriting the oldest data.

The relationship between Sensor Read Period and the number of days of data that can be stored is shown in [Table 12](#).

Table 12 – Number of days of data available depending upon Sensor Read Period

Maximum Read Period (s)	Maximum Number of Days	Total Records at Maximum Update Rate
< 43	1	2057
< 64	2	2743
< 85	3	3085
< 106	4	3291
< 126	5	3456
< 148	6	3550
-	7	(Read Period dependent)

Note: When the Logging Mode is changed, existing backlog data is lost due to the flash memory needing to be resynchronised.

8.10 Backoff Period

The backoff period is one of the LoRa messages that you can send to the sensor from the server (see the **RS1xx LoRa Protocol Guide** which is available from the [RS1xx product page](#)). Because retrieving the backlog may consume a large percentage of the bandwidth, it may be wise to make use of the backoff message. This message can be used to stop the sensor from sending data for a period of time, thus opening more bandwidth for the sensor. While a unit is in the backoff state, it continues to read the sensor, but it stores its data to FLASH. The backoff period could be assigned to the sensor from which the backlog is extracted, other sensors in the network, or both, depending on the application.

8.10.1 Operation at 902-928 US with DR0

Normally the sensor attempts to package up to six backlog readings into a single backlog uplink message. This keeps the total number of bytes in the packet less than 51 bytes, which is the limiting factor in the EU.

See [863-870 MHz EU](#) for details. Only 11 payload bytes are available when operating at DR0 in the 902-928 (NA) band. At this data rate, the sensor only sends one backlog message at a time as this is all the data that can be fit into an 11-byte message.

8.11 Measuring Humidity

Measuring humidity accurately in certain circumstances can be difficult. Temperature swings, dew points, and other factors can lead to condensation on the sensor, leading to inaccurate humidity readings.

The RS1xx humidity sensor is designed to work in environments where humidity is maintained between 20%RH and 80%RH. The sensor can work below 20%RH and above 80% RH, however the environment must be non-condensing.

To combat moisture buildup there is a heating element on the sensor itself which can be turned on to burn off this condensation and restore the sensor to proper operation. This is activated by means of a downlink command, with the heater being switched on as soon as the command is received. See the **RS1xx LoRa Protocol** document for more information on this command.

This allows the API server (see [Figure 3](#)) to implement an algorithm that is appropriate for the sensor environment while minimizing the power used in order to maximize battery life. Refer to the [SiLABS si7021 datasheet](#) for details on the Heater Control Register.

8.12 Setting Up the Sensor

8.12.1 Sensor Read Period

The read period defines how often the sensor is read. For example, for a setting of 60, the sensor is read every 60 seconds.

8.12.2 Sensor Aggregate

The aggregate number is used to aggregate or bundle multiple sensor readings into a single RF packet. For example, with an aggregate number of two and a sensor read period of 60, a RF message is sent every (60 seconds x 2) 120 seconds. Obviously setting the aggregate count has a big effect on the battery life of the device; the less the device talks, the longer the batteries will last.

8.12.2.1 Operation at 902-928 NA with DR0

Only 11 payload bytes are available when operating at DR0 in the 902-928 band. This can create a conflict with an aggregate count greater than one, as the sensor cannot fit all the sensor data into the packet. In this case the sensor sends the last sensor reading to the LoRa server and logs the remaining data to FLASH. A flag is set in the uplink message notifying the server of the configuration error. It is the responsibility of the server to update the sensor configuration to use an aggregate count of one if it is desired not to backlog data in this case.

8.12.3 Alarm Levels

Minimum and maximum alarm levels may be set for both temperature and humidity. When an alarm condition is met, the sensor indicates an alarm flag in the options byte of the next scheduled payload it sends.

In this case, the Aggregate Count is ignored, and the single set of sensor data that triggered the alarm is sent. Alarm messages are sent once an hour. Following sending of an alarm message, the Aggregate Count is further updated until the required number of sensor measurements have accumulated.

This function is only available when using the 'Laird' or 'Laird 2' packet formats.

In addition, on the proviso of a timestamp having been sent to / set on the sensor, setting alarm levels puts sensor backlog data into a separate section of FLASH so that it may be prioritized during backlog retrieval.

8.12.4 LED Behavior

The first LED indicator is used for LoRa status (see [Figure 1](#)). The device can be configured to flash a LED based on the LoRa network status. A green LED flash indicates that the device is connected to the LoRa network server, an orange LED flash indicates that the device is not connected to the LoRa network server. See the [Sensor Configuration](#) section of this guide.

The second LED indicator is used for Bluetooth. The device can be configured to flash a blue LED when the device is connectable, or advertising. See the Sensor Configuration section of this guide.

8.13 Sensor Firmware Version

The LoRa network server can request the sensor firmware version from the sensor.

8.14 Resetting the Sensor

Reset the sensor by holding down the Bluetooth button for a minimum of five seconds.

9 CONFIGURATION

9.1 Device Configuration

Table 13: Device configuration

Name	Description	Bluetooth	LoRa
Format App FLASH	Format the external FLASH on the device to clear out backlog data		x
Set Battery Type	Set the battery type being used on the device	x	x
Set BLE LED Behavior	Configure Blue LED to flash when advertising (connectable)	x	x
Set Humidity Alarm Thresholds	Set the min/max humidity values that will trigger an alarm condition	x	x
Set LoRa AppEUI	Read/Write	x	
Set LoRa AppKey	Write Only	x	
Set LoRa DevEUI	Read/Write	x	
Set LoRa LED Behavior	Configure Green/Orange LED behavior based on LoRa status	x	x
Set Temperature Alarm Thresholds	Set the min/max temperature values that will trigger an alarm condition	x	x
Set Temp Humidity Sensor Read Options	Set parameters related to reading the sensor and sending data over LoRa	x	x
Set Friendly Name	Set a user-friendly name on the device	x	

10 MOBILE APPLICATION

10.1 Overview

The Sentrius mobile application allows a user to configure a device, troubleshoot a device, see real-time sensor data, and update firmware.

10.2 Install Sentrius Sensor Mobile App on Device

Search the appropriate app store (Apple or Android) for the Sentrius Sensor App and install on device.

10.3 Connect to Sentrius Sensor

Press the Bluetooth button (see #2 on [Figure 11](#)).



Figure 11: Top of the Sentrius

The Sentrius Sensor begins advertising and become connectable.

10.3.1 Select Device

The DevEUI printed on the pack of the label is sent as part of the Bluetooth advertisement. Look for that DevEUI in the Device List as shown in [Figure 12](#).

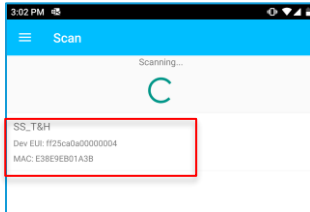


Figure 12: Select the applicable device

10.4 Main Screen

[Figure 13](#) is the main screen of the mobile application when an integrated temp/humidity Sentrius sensor is connected.

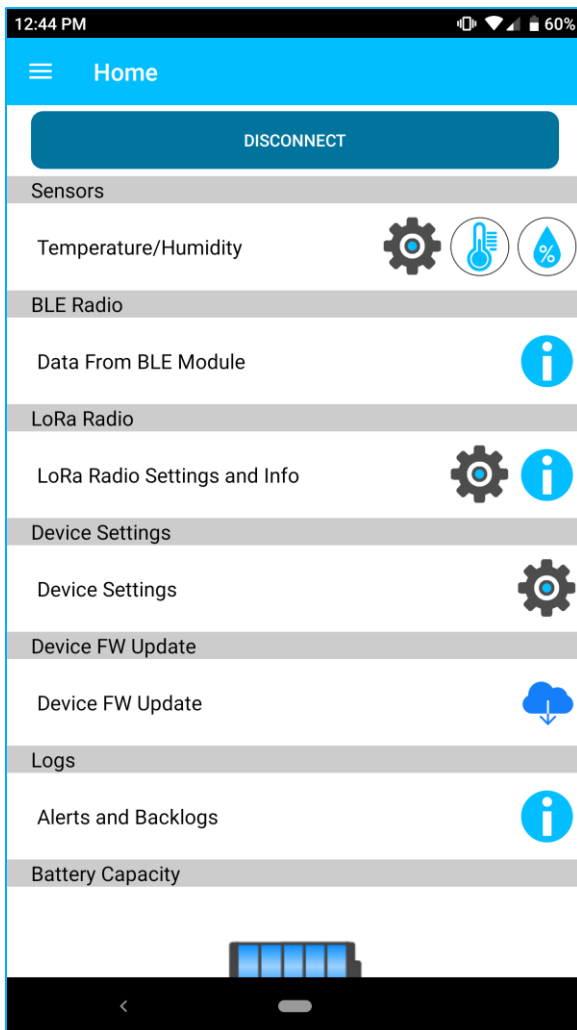


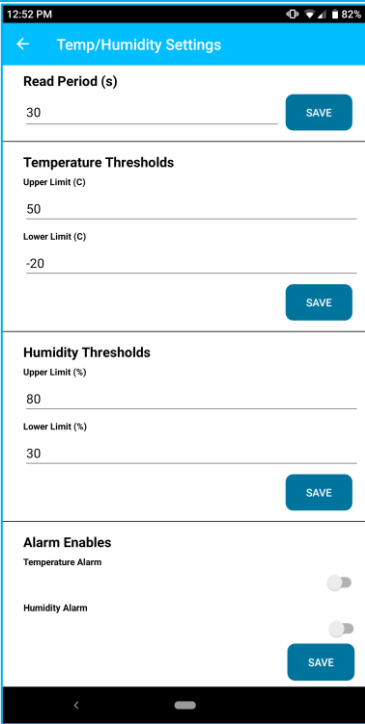




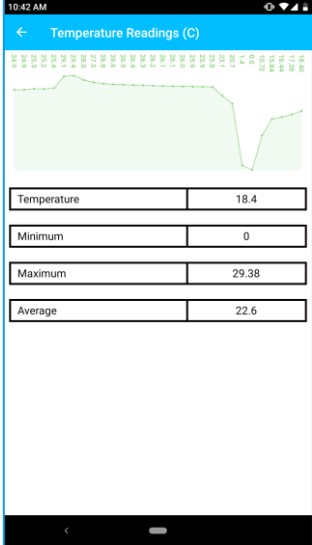


Figure 13: Mobile application main



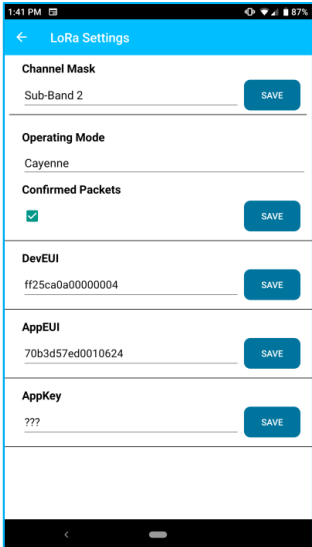
10.4.1 Sensor Configuration

Navigation	Screen	Comments
<div> <div>Sensors</div> <div> <div>Temperature/Humidity</div> <div></div> <div></div> <div></div> </div> </div>	 <p>The screen displays the following settings:</p> <ul style="list-style-type: none"> Read Period (s): 30 Temperature Thresholds: <ul style="list-style-type: none"> Upper Limit (C): 50 Lower Limit (C): -20 Humidity Thresholds: <ul style="list-style-type: none"> Upper Limit (%): 80 Lower Limit (%): 30 Alarm Enables: <ul style="list-style-type: none"> Temperature Alarm: <input type="checkbox"/> Humidity Alarm: <input type="checkbox"/> 	<p>The read period, aggregate number, as well as temperature and relative humidity alarms can be configured. See Setting Up the Sensor Section for more information.</p>
<div> <div>Device Settings</div> <div> <div>Device Settings</div> <div></div> </div> </div>	 <p>The screen displays the following settings:</p> <ul style="list-style-type: none"> Friendly Name: Sentrius-Sensor Heartbeat LED Flash period: 10 BLE LED Behavior: 10 Battery Type: Alkaline 	<p>Friendly Name – Used to assign a user-friendly name to the device, such as its location.</p> <p>LoRa LED Behavior – Used to control the cadence of the heartbeat LED (time in seconds). For example, a setting of 10 flashes the appropriate LED every ten seconds. A setting of 0 turns off the LED. With a setting of 65535, the device flashes the green LED during LoRa transmit and the orange LED during LoRa receive.</p> <p>See the LED Behavior section of this guide for additional information.</p> <p>Note: The LED flash has an impact on battery life.</p>



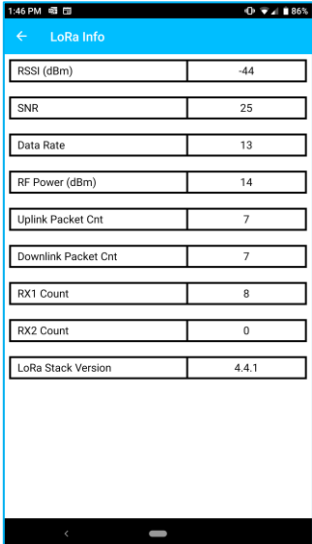
10.5 View Sensor Data

Navigation	Screen	Comments
<div> <div>Sensors</div> <div>Temperature/Humidity</div> <div>    </div> </div>		<p>Humidity graph is similar, only the temperature graph is displayed in this example.</p> <p>Note: The graphs might not show contiguous data. A graph will only get updated when that page is selected, so no new values are added or deleted if the app is not showing that page. If a user switches from the graph to another page and then returns several minutes later the graph will start being updated from where it was previously. As there is no indication of time on the graph this can cause confusion.</p>


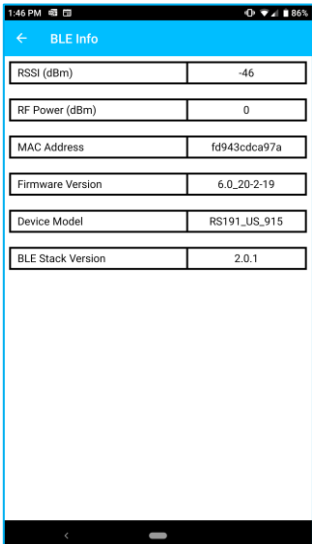
10.6 LoRa Configuration

Navigation	Screen	Comments
<div> <div>LoRa Radio</div> <div>LoRa Radio Settings and Info</div> <div>   </div> </div>		<p>Use to update LoRa Keys.</p> <p>Note: AppKey is write-only for security reasons.</p>


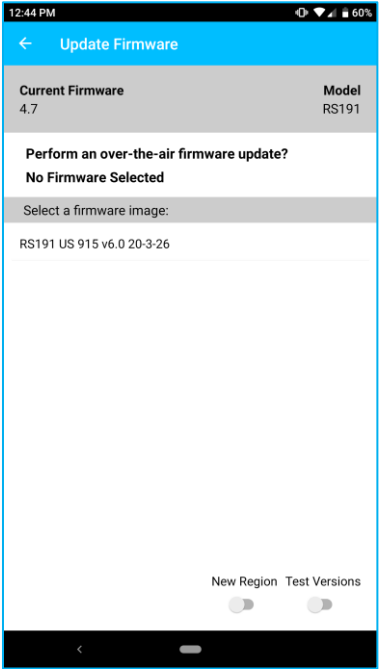
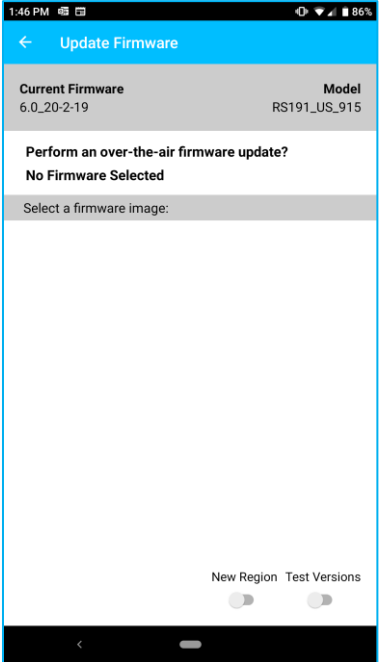
10.7 LoRa Network

Navigation	Screen	Comments
<div>LoRa Radio</div> <div>LoRa Radio Settings and Info  </div>		Use the LoRa Info page to view data on the LoRa Network.





10.8 BLE Info

Navigation	Screen	Comments
<div>BLE Radio</div> <div>Data From BLE Module </div>		Use the BLE Info page to view information on the BLE connection.

10.9 Update Firmware

Navigation	Screen	Comments
<div> <div>Device FW Update</div> <div>Device FW Update</div> <div>  </div> </div>	 	<p>Click the Update FW link.</p> <p>Select Update on the page that is displayed.</p> <p>The released firmware builds from Laird are stored in the cloud. The Sentrius App will look in this location and display available versions of the firmware. Select the appropriate file to start the update process.</p> <p>The Test Versions and New Region button are for internal Laird use only. They are password protected so as to avoid incorrect use.</p> <p>Note: The sensor does not allow downgrading the firmware. Firmware versions that are lower than the version the device is running are not displayed.</p>

10.10 Alerts and Backlogs

Navigation	Screen	Comments															
<div><div>Logs</div><div>Alerts and Backlogs</div></div> <div></div>	<div><div>Logging Settings</div><div><div>Logging Duration</div><div>1 day</div><div>Save</div></div><div><div>Logging Mode</div><div>On Fail</div><div>Save</div></div><table><thead><tr><th>Sensor Read Period (s)</th><th>Maximum Number of Days</th></tr></thead><tbody><tr><td>< 43</td><td>1</td></tr><tr><td>< 64</td><td>2</td></tr><tr><td>< 85</td><td>3</td></tr><tr><td>< 106</td><td>4</td></tr><tr><td>< 126</td><td>5</td></tr><tr><td>< 148</td><td>6</td></tr><tr><td>-</td><td>7</td></tr></tbody></table></div> <div>The Logging Settings page is used to configure the sensor backlog behaviour. Note that the Real Time Clock value must be set by the Network Server before any backlogs are created. Note that this page is only available for the Laird 2 Packet Format. For the Laird Packet Format, the Logging Mode is fixed to 'On Fail'. For the Cayenne Packet Format, logging is not supported due to no Real Time Clock value being available.</div>	Sensor Read Period (s)	Maximum Number of Days	< 43	1	< 64	2	< 85	3	< 106	4	< 126	5	< 148	6	-	7
Sensor Read Period (s)	Maximum Number of Days																
< 43	1																
< 64	2																
< 85	3																
< 106	4																
< 126	5																
< 148	6																
-	7																
<div><div>Logs</div><div>Alerts and Backlogs</div></div> <div></div>	<div><div>Backlog Info</div><table><tbody><tr><td>Backlog Count</td><td>0</td></tr><tr><td>Alarm Count</td><td>0</td></tr><tr><td>Backlog Index</td><td>1/260</td></tr><tr><td>Backlog Timestamp</td><td>2020/04/14 08:59:21</td></tr><tr><td>Backlog Temperature</td><td>22.79</td></tr><tr><td>Backlog Humidity</td><td>37.84</td></tr></tbody></table><div><div>Retrieve</div><div>Previous</div><div>Next</div><div>Email</div></div></div> <div>The Backlog Info page is used to extract and view backlog data. 'Retrieve' is clicked to begin readback of backlog data from the sensor. 'Previous' and 'Next' are used to view backlog data locally. Once retrieval is complete, 'Email' can be used to trigger sending of log data in CSV format to a configurable email address.</div>	Backlog Count	0	Alarm Count	0	Backlog Index	1/260	Backlog Timestamp	2020/04/14 08:59:21	Backlog Temperature	22.79	Backlog Humidity	37.84				
Backlog Count	0																
Alarm Count	0																
Backlog Index	1/260																
Backlog Timestamp	2020/04/14 08:59:21																
Backlog Temperature	22.79																
Backlog Humidity	37.84																

10.11 Battery Life Calculator

Warning: The Battery Life Calculator should only be used as a general guide.

The Battery Life Calculator provided is only intended as a general guide. The formula used within the tool does not factor in environmental conditions, such as temperature, which have a large influence on battery longevity.

What is more, we have no way of knowing the number of retries and rejoins a sensor may perform and the data rate is dynamic in live deployments, while the calculation only assumes 1 data rate (configurable) over the life of the battery.

10.12 Integrating Sentrius™ Sensor into a Third-Party Application

The GATT tables used on the Sentrius Sensor are bundled together with the Mobile Application Source code and made available at the discretion of Laird Connectivity. Please send requests to support@lairdconnect.com

Note: The mobile application is written in Xamarin (C#), a product by Microsoft designed for cross-platform (Android + iOS) development. The source code for the project is available from Laird Connectivity as mentioned above.

11 BLUETOOTH SIG

The Sentrius™ Sensor is certified by the Bluetooth® SIG as a Bluetooth v4.2, End Product. The Qualified Design ID (QDID) is 100178.

12 REGULATORY

Note: For complete regulatory information, refer to the [RS1xx Regulatory Information](#) document which is also available from the [Sentrius RS1xx product page](#).

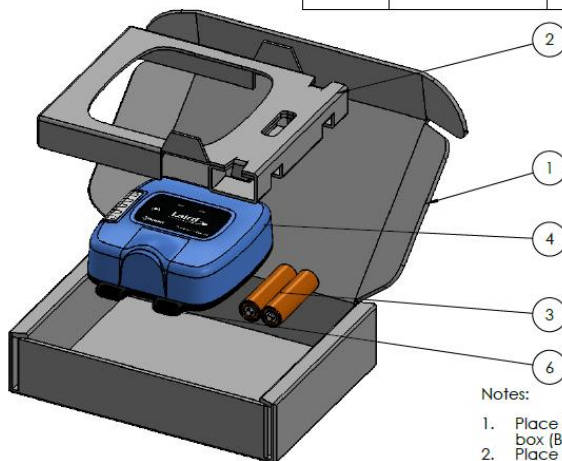
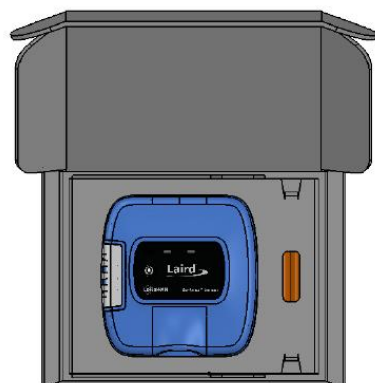
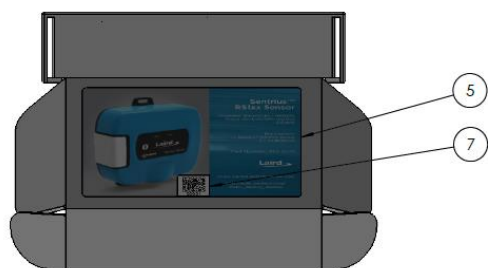
The RS1xx holds current certifications in the following countries:

Country/Region	Regulatory ID			
USA (FCC) – <i>RS191 only</i>	SQG-RM191			
EU – <i>RS186 only</i>	N/A			
Canada (ISED) – <i>RS191 only</i>	3147A-RM191			
Taiwan (NCC) – <i>RS191 only</i>	Temp/Humidity Sensor:	External Temp Sensor:	Temp/Humidity Open/Closed Sensors:	Ext. Port RTD Temp Sensor:
	CCAF20LP1460T0	CCAF20LP146AT2	CCAF20LP146BT4	CCAF20LP146CT6
Australia – <i>RS191 only</i>	N/A			
New Zealand – <i>RS191 only</i>	N/A			

13 ORDERING INFORMATION

See the Laird [RS1xx product page](#) for ordering information.

13.1 Evaluation Kit Details (applies to 455-0001, 455-0002, and other regional variants)



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	920-0047	Box, Sentrius Sensor, 180mm x 130mm x 42mm	1
2	920-0048	Cardboard, Sentrius Sensor, Insert, 148mm x 120mm x 20.6mm	1
3	060-0007	Battery, AA, Alkaline, Mitsubishi	2
4	450-0182	Sensor, Sentrius, Temp Controller, LoRa & BLE, Temp & RH, 915 MHz	1
5	630-0259	Label, Kit, Sensor, Sentrius, 915MHz	1
6	920-0050	Poly Bag, Antistatic, 3mil, 125mm x 230mm	1
7	630-0261	Label, Kit Box, Generic Serial Number	1

Notes:

1. Place Sensor into bag before putting into box (Bag not shown for clarity)
2. Place all items into box

14 OTHER VARIANTS

14.1 External Temperature Sensor

The Sentrius™ Sensor is available with an external sensor port – RJ45 (Figure 14). It allows users to connect an external one-wire temperature probe to make remote temperature measurements.



Figure 14: External Temperature Sensor port and temp probe

14.2 External Open/Closed Sensor

The Sentrius™ Sensor is available with an external sensor port – RJ45 (Figure 15). It allows users to connect an external Open/Closed sensor to perform remote contact state measurements.

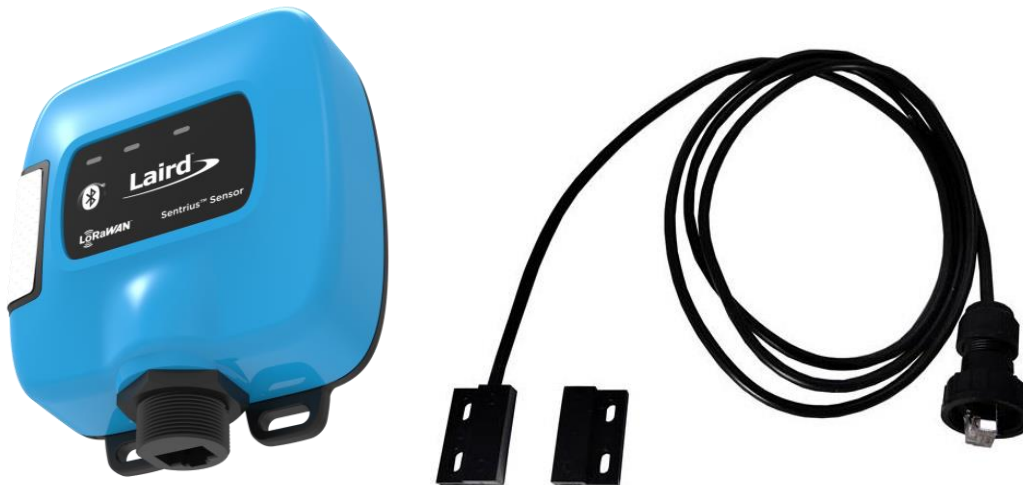


Figure 15: External Open/Closed Sensor port and cable assembly

14.3 External RTD Sensor

The Sentrius™ Sensor is available with an external sensor port – RJ45 ([Figure 16](#)). It allows users to connect an external resistance temperature detector (RTD) probe to make remote temperature measurements at a higher temperature range (up to 180°C) .



Figure 16: External RTD Temperature Sensor port and temp probe

For the latest product briefs and user guides for the RTD Probe, External Temperature Probe or Open/Closed Sensors please see the Documentation tab on the [RS1xx product page](#).

Note: The sensor cable assemblies available as part of the Sentrius product range are NOT interchangeable between Sentrius sensor enclosures (blue housing) with an RJ45 port. Users must be sure to connect the appropriate sensor cable assembly with the intended enclosure. Please check the product description on the sensor label / part number on the packaging if in doubt.

Table 14: Top level kit and associated sensor part numbers

Top-Level Sensor Enclosure (blue box) Part #	Associated Sensor Sub-Assy Number (as found on the sensor back label)	Sensor Description
Associated Cable Assembly - External Temp Probe (213 mm Stainless Steel Probe – 455-00036B)		
455-00069	450-0181	Sentrius RS186 Sensor, Ext. Temp Probe, EU, 868 MHz
455-00070	450-0180	Sentrius RS191 Sensor, Ext. Temp Probe, NA, 915 MHz
455-00064	450-0180	Sentrius RS191 Sensor, Ext. Temp Probe, TW, 923 MHz
455-00065	450-0180	Sentrius RS191 Sensor, Ext. Temp Probe, NZ, 923 MHz
455-00066	450-0180	Sentrius RS191 Sensor, Ext. Temp Probe, HK, 923 MHz
455-00067	450-0180	Sentrius RS191 Sensor, Ext. Temp Probe, AU, 915 MHz
455-00068	450-0180	Sentrius RS191 Sensor, Ext. Temp Probe, AU, 923 MHz
455-00097	450-0180	Sentrius RS191 Sensor, Ext. Temp Probe, SG, 923 MHz
Associated Cable Assembly - External RTD Temp Probe (100 mm Stainless Steel Probe – 455-00112B)		
455-00103	450-00098	Sentrius RS191 Sensor, Ext. RTD Temp Probe (Smoker), NA, 915 MHz
455-00104	450-00099	Sentrius RS186 Sensor, Ext. RTD Temp Probe (Smoker), EU, 868 MHz
455-00105	450-00098	Sentrius RS191 Sensor, Ext. RTD Temp Probe (Smoker), TW, 923 MHz
455-00106	450-00098	Sentrius RS191 Sensor, Ext. RTD Temp Probe (Smoker), NZ, 923 MHz
455-00109	450-00098	Sentrius RS191 Sensor, Ext. RTD Temp Probe (Smoker), HK, 923 MHz
455-00110	450-00098	Sentrius RS191 Sensor, Ext. RTD Temp Probe (Smoker), AU, 915 MHz
455-00111	450-00098	Sentrius RS191 Sensor, Ext. RTD Temp Probe (Smoker), AU, 923 MHz
455-00108	450-00098	Sentrius RS191 Sensor, Ext. RTD Temp Probe (Smoker), SG, 923 MHz
Associated Cable Assembly - External Open/Closed Sensor (29 mm x 19 mm Sensor – 455-00046B)		
455-00040	450-00096	Sentrius Multi-Sensor, Ext. Open/Closed + Integrated Temp & Humidity, NA, 915 MHz
455-00041	450-00097	Sentrius Multi-Sensor, Ext. Open/Closed + Integrated Temp & Humidity, EU, 868 MHz
455-00071	450-00096	Sentrius Multi-Sensor, Ext. Open/Closed + Integrated Temp & Humidity, TW, 923 MHz
455-00072	450-00096	Sentrius Multi-Sensor, Ext. Open/Closed + Integrated Temp & Humidity, NZ, 923 MHz
455-00073	450-00096	Sentrius Multi-Sensor, Ext. Open/Closed + Integrated Temp & Humidity, HK, 923 MHz
455-00074	450-00096	Sentrius Multi-Sensor, Ext. Open/Closed + Integrated Temp & Humidity, AU, 915 MHz
455-00075	450-00096	Sentrius Multi-Sensor, Ext. Open/Closed + Integrated Temp & Humidity, AU, 923 MHz
455-00100	450-00096	Sentrius Multi-Sensor, Ext. Open/Closed + Integrated Temp & Humidity, SG, 923 MHz
Integrated Temp and Humidity Sensors (Internal Temp. and RH Sensor)		
455-0001	450-0182	Sentrius RS191 Sensor, Temp & Humidity, NA, 915 MHz
455-0002	450-0183	Sentrius RS186 Sensor, Temp & Humidity, EU, 868 MHz
455-00059	450-0182	Sentrius RS191 Sensor, Temp & Humidity, TW, 923 MHz
455-00060	450-0182	Sentrius RS191 Sensor, Temp & Humidity, NZ, 923 MHz

Top-Level Sensor Enclosure (blue box) Part #	Associated Sensor Sub-Assy Number (as found on the sensor back label)	Sensor Description
455-00061	450-0182	Sentrius RS191 Sensor, Temp & Humidity, HK, 923 MHz
455-00062	450-0182	Sentrius RS191 Sensor, Temp & Humidity, AU, 915 MHz
455-00063	450-0182	Sentrius RS191 Sensor, Temp & Humidity, AU, 923 MHz
455-00095	450-0182	Sentrius RS191 Sensor, Temp & Humidity, SG, 923 MHz

15 LABEL INFO

15.1 Back Label

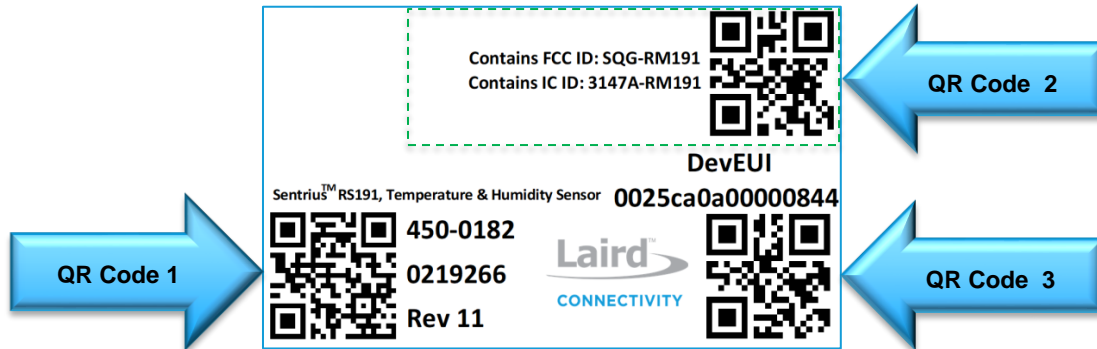


Figure 17: Back Label

15.1.1 QR Code 1 Info

The QR Code contains the Part Number, Hardware Revision, Date Code, and DevEUI.

Example Readout: 450-0182,11,0213117,0025ca0a00000844

15.1.2 QR Code 2 Info

The QR Code contains the unique Firmware part number associated with the region the sensor will be installed in and certified for. For example, a sensor certified and installed in Europe would have a firmware part number 480-0114.

Example Readout: 480-0111

15.1.3 QR Code 3 Info

The QR Code contains the DevEUI. All constants are lowercase.

Example Readout: 0025ca0a00000844

15.2 Label (Back Label Space)

The large open white space on the back label can be used to apply a secondary label by the end user. For example, it may be useful to write a friendly name on the device.

Note: The AS923 region sensor labels have limited space for this feature.

Warning The larger white space area is only available on older versions of the sensor which will have the label shown in the lower left below. The label layout generally may change at any time.

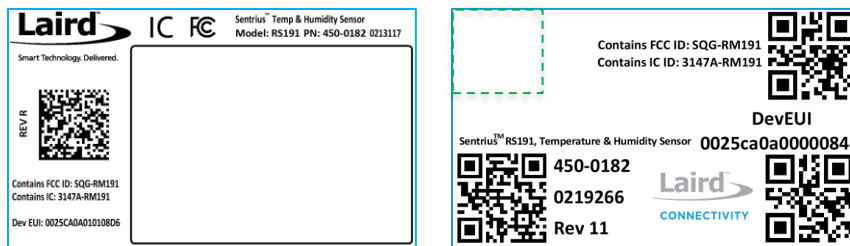


Figure 18: Back label white space.

15.3 AS923 Region Labels

- Depending on the region the sensor will be installed in, there is a unique region label that is placed over the back-sensor label which contains the region's necessary certification logos and ids (Green Box Area in [Figure 17](#)).

The RS191 is the base sensor which is updated for each specific AS923 or AU915 supported region.

- The QR Code contains the specific region 480 FW part number which is used with the Mobile App to program the sensor with the correct region FW.

15.3.1 Singapore (SG – 923 MHz)

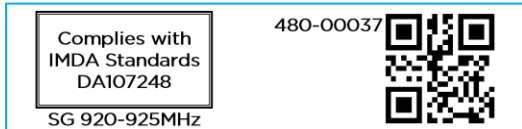


Figure 19: Singapore AS923 Region Label

15.3.2 Taiwan (TW – 923 MHz)

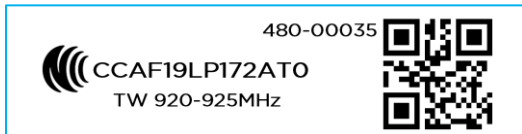


Figure 20: Taiwan AS923 Region Label

15.3.3 New Zealand (NZ – 923 MHz)

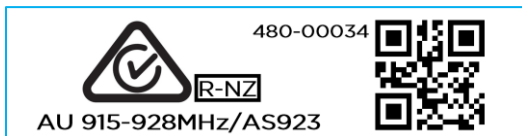


Figure 21: New Zealand AS923 Region Label

15.3.4 Hong Kong (HK – 923 MHz)

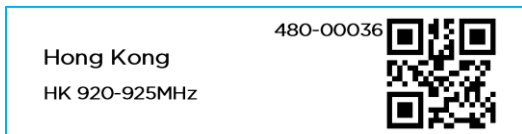


Figure 22: Hong Kong AS923 Region Label

15.3.5 Australia (AU – 915 MHz or 923 MHz)

Note: The different 480-part numbers.

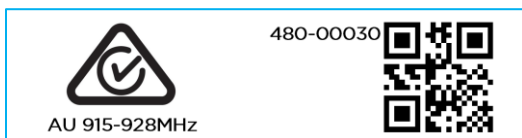


Figure 23: Australia AU915 Region Label



Figure 24: Australia AS923 Region Label

16 ADDITIONAL INFORMATION

For the latest version of this manual, quick start guide, regulatory information and firmware updates, please see the Documentation tab the RS1xx page: <https://www.lairdconnect.com/wireless-modules/lorawan-solutions/sentrius-rs1xx-lora-enabled-sensors>

17 APPENDIX A - CAYENNE PACKET FORMAT

A full description of the Cayenne system can be found at <https://github.com/myDevicesIoT/cayenne-docs/blob/master/docs/LORA.md> and the packet format details can be found under the Reference Implementation section.

The Cayenne formatted packet transmitted from an Internal T/H and Open/Closed RS1xx is shown in Table 15 below.

Table 15: Cayenne Packet Format – Internal T/H & Open/Closed sensor

Index	Value	Description
0	0x01	Data Channel Header
1	0x67	Temperature Data Header
2	0xFF	Temperature Data MSB
3	0xFF	Temperature Data LSB
4	0x02	Data Channel Header
5	0x68	Humidity Data Header
6	0xFF	Humidity Data
7	0x03	Data Channel Header
8	0x02	Analog Input Header (remaining battery life)
9	0xFF	Battery Voltage MSB
10	0xFF	Battery Voltage LSB

Packets transmitted by RTD and External Temperature Sensor variants omit humidity data, as shown in Table 16.

Table 16: Cayenne Packet Format – RTD and External Temperature sensor

Index	Value	Description
0	0x01	Data Channel Header
1	0x67	Temperature Data Header
2	0xFF	Temperature Data MSB
3	0xFF	Temperature Data LSB
4	0x02	Data Channel Header
5	0x02	Analog Input Header (remaining battery life)
6	0xFF	Battery Voltage MSB
7	0xFF	Battery Voltage LSB

For the Open/Closed sensor variant, additional packets are sent to indicate the condition of the Open/Closed sensor. The format of the packets is shown in [Table 17](#).

Table 17: Cayenne Open/Closed sensor packet format

Index	Value	Description
0	0x04	Data Channel Header
1	0x66	Presence Data Header
2	0xXX	Open/Closed sensor status, 0 = Closed, 1 = Open