## Revision History

<table>
<thead>
<tr>
<th>Version</th>
<th>Date</th>
<th>Notes</th>
<th>Contributor</th>
<th>Approver</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>05 Dec 2017</td>
<td>Initial Release</td>
<td>Robert Gosewehr</td>
<td>Jonathan Kaye</td>
</tr>
<tr>
<td>1.1</td>
<td>19 Dec 2018</td>
<td>Updated template, logos, and URLs</td>
<td>Sue White</td>
<td>Jonathan Kaye</td>
</tr>
</tbody>
</table>
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1 OVERVIEW

This guide provides instructions on configuring a Sentrius RG1xx gateway and Sentrius RS1xx sensor(s) using the Things Network (TTN) server and node-RED web-based user interface.

**Note:** Step-by-step instructions, screen shots, and pictures are based on the Sentrius RG191 and Sentrius RS191, but the same is applicable for the Sentrius RG186 and Sentrius RS186. If there are differences, they are noted.


2 DATA FLOW ARCHITECTURE

The following block diagram (Figure 1) displays the overall architecture described in this demo. This is a high-level representation of how the sensor LoRaWAN data is transferred through the gateway using the TTN packet forwarder to the Things Network servers where the data packets are processed. They are then forwarded to the MQTT Broker (Data API). The node-RED application contains an MQTT client that receives sensor data and displays it on a browser-based user interface.

![Data Flow Architecture](image)

**Figure 1: Data flow architecture**

This guide shows a step-by-step approach to setting up a test LoRa network. It starts on the left side of the block diagram with the Gateway configuration and progresses toward the UI application on the right. Sensor devices are added when configuring the TTN backend.

3 GATEWAY FACTORY RESET

If setting up a previously configured gateway, we recommend that you clear any prior settings by resetting the gateway to its factory default values. To do this, complete the steps described in the *Factory Reset* section of the RG1xx User Guide. You can access this guide on the *RG1xx product page* from the Documentation tab.
4 Creating the Things Network (TTN) Account

4.1 Account Setup

Before performing any actions, ensure that Network Ports 1900, 1901 (these are the LoRaWAN traffic ports) and Port 1883 (TTN_MQTT traffic) are open on the network. You must establish an external TCP socket and HTTP/2 connection for this to work properly. We recommend that you work with your IT to provide access for this install.

To set up an account with The Things Network (TTN), follow these steps:

1. Go to https://www.thethingsnetwork.org/ and click Sign-Up in the upper right of the window to start the process or, if you already have an account, Login (skip to step four).

   ![Figure 2: TTN account setup](image)

   **Note:** It is important that you have access to the email address entered in the account setup since The Things Network requires you to validate your email before proceeding with the rest of the setup.

2. Log in to TTN after the email is verified.

   ![Figure 3: TTN login page](image)

3. On the main page, click your profile name and picture.
4. Click Console in the drop-down selection.
4.2 Registering Your Gateway

**Note:** Registering your gateway on the TTN network and configuring the Gateway LoRa connection on the web interface should be performed at the same time since you need the TTN-generated gateway key to finish the TTN packet forwarder setup using the gateway’s web interface.

To register your gateway with the TTN network, follow these steps:

1. Click **Gateways** on the console screen (Figure 4).

![Figure 4: TTN console screen (Gateways)](image)

2. Click **register gateway** (Figure 5).

![Figure 5: Click Register Gateway](image)

3. Enter the gateway ID (Figure 6). You can find your gateway ID either on the label on the bottom of the gateway (Figure 7) or on the Sentrius RG1xx web interface (see Figure 21).

   **Note:** If using the bottom gateway label for reference, enter rg1xx plus the last three bytes of the M2 EUI. For example: M2 EUI is C0:EE:40:FF:FF:29:37:8B, the gateway ID would be **rg1xx29378B**.
Figure 6: Gateway registration form

Figure 7: Gateway ID on a bottom label

Note: The Gateway ID field (text string format) must be lower case and has limitations on what characters can be used. The Gateway ID must be unique among all gateways on the TTN server, not just this account.

Figure 8: Gateway ID restrictions
Note: Because we use the TTN Forwarder, do not mark the Legacy Packet Forwarder.

Figure 9: Packet forwarder selection

4. Enter a unique description for the gateway (Figure 10).

Figure 10: Description

5. Select the appropriate frequency plan from the drop-down menu (Figure 11). This is based on the region in which the gateway is operating.

Figure 11: Frequency plan selection
6. Select the appropriate router from the drop-down menu (Figure 12).

![Figure 12: Router selection](image)

The router selection is based on the physical location of the gateway. Selecting the correct router reduces latency.

7. (Optional) Set the location of the gateway.

**Note:** This gateway location step is optional; however, setting the location helps determine which gateway was used to forward the LoRaWAN packets if the sensors are visible to multiple gateways.

a. To set a location in the map area, double-click the desired location in the map area to place the marker (Figure 13).

![Figure 13: Marker location](image)

b. Click on the location where the gateway antenna will be placed.
c. Register the gateway with TTN.
d. Once the gateway is registered with TTN, go to the Gateway Overview page. There is a Gateway Key assigned to the gateway that needs to be entered in the Gateway Key field located on the gateway's web interface (see Figure 22 for additional information) when setting up the TTN Forwarder.
Figure 14: Gateway key

**Note:** For the TTN servers to authorize the gateway and to establish a connection, the gateway ID and gateway key in the TTN account must be copied exactly into the gateway’s web configuration page.

We recommend that you turn off the automatic updates in the Gateway settings (Figure 15).

Figure 15: Automatic updates off
5 CONNECT THE GATEWAY

To use the gateway, you must power it up and access the web interface via the Ethernet port. To do this, follow these steps:

1. Follow the label on the box and connect the three antennas. Refer to Antenna Configuration for additional information.
2. Connect the power supply (see #2 in Figure 16).
3. Connect the gateway to your router (#3 in Figure 16) using the Ethernet cable (#1 in Figure 16).

Your gateway is now connected and ready.

*Figure 16: Connecting the gateway*

**Antenna Configuration**

To configure the antenna properly, do the following:

1. Attach the two shorter antennas to the 2.4/5.5 GHz (Wi-Fi) ports.
2. Attach the third and longer antenna to the 868 MHz/900 MHz (LoRa) port.

*Figure 17: Antenna configuration*
6  LOG INTO THE GATEWAY

6.1  Logging into Gateway Web Interface

To log into the gateway web interface, follow the steps from the RG1xx User Guide’s Log into the Gateway section. This guide is accessible from the website’s RG1xx product page on the Documentation tab.

![Gateway interface login screen](image)

**Figure 18: Gateway interface login screen**

**Note:** For this guide, we assume the LAN and Wi-Fi connections are successfully set up and the user login credentials are updated. We recommend that you update the credentials as soon as possible to minimize a potential security risk. Update these credentials on the Settings page.

6.2  Updating Gateway Firmware

To configure the TTN forwarder, the RG1xx gateway must be updated with the latest firmware. Update the firmware by clicking **Settings > Update Firmware**.

![Updating gateway firmware](image)

**Figure 19: Updating gateway firmware**

Enter the following URL: https://connectivity-firmware.s3.amazonaws.com/rg1xx-lora-gateway/firmware/latest/fw.txt

**Note:** You need GA2 FW or greater in order for this to function.

Once the gateway is finished updating the firmware, follow the on-screen instructions to reboot the device. This requires a login using your updated profile credentials.
Note: If the gateway firmware is updated after the TTN Packet Forwarder is already set up, you must set the TTN pre-sets (Figure 20). The default Forwarder setting is automatically set after an update and needs to be changed.

6.3 LoRa Packet Forwarding Set Up

Before you set up the packet forwarder, we recommend that you set the Things Network – US default settings (located in Presets accessible from the left column) for a gateway operating in the U.S. at 915 MHz. These presets configure the forwarder and the channel plan on the gateway.

The gateway connection status should change to true once the Preset is applied.

To set up the TTN packet forwarder, follow these steps:

1. Select Forwarder (Figure 21).
2. Select TTN Forwarder from the Mode drop-down menu.
3. Enter the Gateway ID which can be found by the Gateway ID in the left column or on the gateway label (see Figure 7 for additional information).
4. Enter the generated TTN gateway key.
5. Click Update. A confirmation note appears in the left column (Figure 22).
7 Adding Devices to the Gateway in TTN

7.1 Creating an Application

Now that the gateway is connected to the TTN network and gateway web interface, the next step is to add an application. The TTN server uses applications to create groups of devices.

Gateways are associated with user accounts but not applications. All gateways connected to TTN servers forward all LoRaWAN data traffic to the TTN message router. The TTN network server filters LoRa traffic by application ID so that data is routed to the correct user/application and users are only able to access data from devices registered to their account.

To add an application, follow these steps:

1. Click Applications located on the Console page (Figure 24).

   ![Figure 24: TTN console screen (Applications)]
2. Click **add application** *(Figure 25)*. 

![Figure 25: Click add application](image)

3. Enter an application ID and description. Note the application ID; it is used to set up the node-RED interface *(Figure 48)*.

   **Note:** The Application ID field (text string format) has limitations on what characters can be used and can only be named once.

   ![Figure 27: Application ID restrictions](image)
Note: The Application EUI field is auto-generated by the TTN network. This is required when setting up Laird RS1xx devices that are associated to this application ID (Figure 28).

Figure 28: Device overview screen

4. Enter the Handler Registration. This is the same as the router selection in the previous Gateway registration (see Figure 12 for more information).

7.2 Adding a Device to the Application

To add a RS1xx device to the Application ID recently established, follow these steps:

1. Click Register Device under Devices in the application overview page (Figure 29).

Figure 29: Register device form
2. Enter the **Device ID**. This ID must be unique on the user’s account.

   We recommend using the convention dev (for device), followed by the Sentrius Sensor Dev EUI. For instance, if the Sentrius Sensor device has a Dev EUI of 0025ca0000000000f then the Device ID is dev-0025ca0000000000f.

   **Note:** The Sensor Dev EUI can be found on the bottom of the sensor. This field is lower-case sensitive.

   ![Figure 30: Sensor Dev EUI](image)

3. Enter the Device EUI. This is the Sensor Dev EUI on the label. To ensure uniqueness, the sensors extended MAC address is used.

   The App key field is auto-generated by the TTN network.

   The App EUI field was previously auto-generated by the TTN network when the application ID was created (Figure 26). The application EUI is associated with the application ID and used by the TTN servers to associate the device with the application ID.

4. Register the device.
7.3 Updating Device Settings (Dev EUI_App EUI_App Key)

Each registered device is associated with an application EUI and application key pair. The device must be updated with the newly-generated app EUI and app key. The application EUI is generated for an application ID and is used to route traffic. The application key is unique per device and is used during activation to generate the LoRa session keys. You may have multiple applications with devices registered to each application. Applications are defined by the application EUI/ID.

The application EUI and application key for a device can be found in the list of registered devices on the TTN Applications page.

To update the settings for the registered device, follow these steps:

1. Click the registered device on the Applications page (Figure 31).

![Figure 31: Registered device](image)

2. Click the device to be updated (Figure 32).

![Figure 32: Device list](image)
Figure 33: Application EUI and App Key

To update the App EUI and App key on each registered device, the Sentrius mobile phone app must be installed on an iOS or Android device and used to modify these LoRa configuration settings on the RS1xx Sensor. Reference the Mobile Application section of the Sentrius RS1xx User Guide for details on installing the phone application and updating these LoRa configurations. This guide is available from the Sentrius RS1xx product page of the Laird website on the Documentation tab.

Once the device is updated, it attempts to connect to the TTN server via the LoRa Gateway. When it has connected, the status on the TTN Device Overview page changes from *Never Seen* to a green connected Status. This is confirmation that the device is communicating with the TTN servers through a registered gateway.
8 NODE-RED SETUP

node-RED is a flow-based programming environment which is used to wire devices models, APIs, and online services together. Flow-based programming is a way of describing an application’s behavior as a network of nodes. Each node receives data, does something with that data, and then passes the data onward. This network of nodes is set up using the node-RED palette web interface.

node-RED uses node.js to host the flow-based programming palette and to create a user web interface. Reference https://nodered.org/ for more information on the node-RED tool.

8.1 Install node.js Package Manager and node.js

Install the node.js package manager (NPM) and node.js locally on your PC by going to the node.js website: https://nodejs.org/en/. Both node.js and the NPM are installed in the same install (Figure 35). We recommend that you install the latest version.

Note: This guide is based off working versions of Node-Red: Version 0.17.5 and Node.js: Version 8.9.1

Figure 34: Device Connection Status

Note: The channel mask should be set to sub-band 2. This is set as a default value in the sensor, however if this is not set change the value.
8.2 Install JSON Files

Before running the install, you must save the JSON config and flow file in the same directory from which node-RED is run. In Windows, this is typically in your USER file location on the C: drive (e.g. C:\Users\User_Name\nodered-demo). Placing the files in this USER file location ensures that the correct privileges are assigned to these files; otherwise there may be issues during the install of node-RED packages.

Download the JSON files off the website – https://connectivity.lairdtech.com/wireless-modules/lorawan-solutions/sentrius-rs1xx-lora-enabled-sensors

![JSON file example]

Figure 35: node.js and node.js package manager installation

**Note:** If there are errors encountered while running the latest version of the installer, use the Recommended for Most Users version of node.js.
8.3 Installing node-RED

Once the nodered-demo folder is saved in the User folder within the C drive (or other folder with appropriate permissions), you can install node-RED using a terminal window. In Windows 10, press **Shift** and right-click on the mouse while in the nodered-demo folder. This brings up the PowerShell Window option. Depending on the Windows version, a Command Prompt or a PowerShell Window will appear. (Figure 37).

![Opening command prompt screen](image)

Type the `npm install -g node-red` command to install node-RED using the Node.js Package Manager (NPM). Reference the node-RED website for information on alternate ways to install node-RED: https://nodered.org/docs/getting-started/installation.

![node-Red install command prompt screen](image)

![Successful node-Red install](image)
node-Red is now installed on your PC.

8.4 Updating RS1xx-Demo-Config File

To populate the Device ID drop-down menu on the node-RED app user interface with the devices registered within the TTN servers, you must edit the rs1xx-demo-config.json file. This file is read by the node-RED flow during the start-up of the user web interface.

**Note:** JSON is an object representation in a human readable text format. Any text editor can be used to modify the file. We recommend Notepad++ ([https://notepad-plus-plus.org/](https://notepad-plus-plus.org/)). Install the latest version.

![Figure 40: List of Devices from TTN](image)

**Note:** Reference the Device List in the Registered Device section from the appropriate Applications ID page to see a list of available devices to list in the drop-down menu (see Figure 32 for additional information).

![Figure 41: rs1xx-demo-config.json Editor](image)
When you’re done editing, save the file.

**Note:** The content of the file is an array of device IDs plus a variable to either display the temperature readings in Celsius or Fahrenheit. The file is in JSON format and the JSON object must look like this: 

```json
{ "dev_ids": [ "<enter a device id here>" ], "degreesFahrenheit":false }.
```

For every device you want to add to the list, replace: “<enter a device id here>” with a device ID. The file must be named `rs1xx-demo-config.json`. The following is an example of a valid config file content:

```json
{ "dev_ids": [ "dev-0025ca0000000002", "dev-0025ca0000000004" ], "degreesFahrenheit":false }.
```

Even if there is only one device, the array format (square brackets) is used.

To change the temperature readings from Celsius to Fahrenheit, set the variable from false to true or vice versa depending on the what is desired. False is the Default Setting.

### 8.5 Installing node-RED-Dashboard

To install the node-RED-dashboard, enter the command `npm install -g node-red-dashboard`.

![node-RED Dashboard](image)

**Figure 42: node-RED Dashboard**

The dashboard module adds a set of nodes to the node-RED palette that provides a quick and effortless way to create a live data dashboard.

### 8.6 Running node-RED with Default Settings

In the prompt screen, enter the following command:

```
node-red sentrius-rs1xx-demo.json.
```

node-RED generates the dashboard based on the Flow file: `sentrius-rs1xx-demo.json`.

To close node-RED, press **CTRL-C**.

![node-red-sentrius-rs1xx-demo.js](image)

**Figure 43: node-red-sentrius-rs1xx-demo.js**
Open a Chrome web browser to the address: http://localhost:1880. This launches the node-RED Integrated Development Environment (IDE).

![Default Node-RED Dashboard](image)

**Figure 44: Default Node-RED Dashboard**

### 8.7 Establishing MQTT Broker Connections

When you run the node-RED application for the first time, notice that the MQTT client links are disconnected, as indicated by the red disconnected symbol below them.

![Broken MQTT broker links](image)

**Figure 45: Broken MQTT broker links**

To establish an MQTT connection with the TTN Server, you must set the MQTT Broker configuration. The Broker configuration is the information required to connect to an MQTT Broker using the node-RED flow. The connection allows the nodes to receive sensor device data from the TTN servers and display the information in the dashboard.
To modify the nodes, follow these steps:

1. From the “Hamburger Menu” in the top right corner, click **Configure Nodes**.

2. Double-click the MQTT Broker configuration. This brings up the customizable settings for this node (Figure 47).

3. Click the **Security Tab**. You can find the user name and password on the TTN network.

4. From **Applications** under the **Console** page, click the **Applications ID** under which the devices are registered. The user name is the **Application ID** and the password is the **Access Key Default Key** at the bottom of the page.

5. Click **Update** to save parameters.
Figure 48: User name and password

**Note**: When entering the user name, copy the Applications ID from the TTN network *exactly*.

6. Click **Deploy** to update the node-RED application on the local node-RED server.

**Note**: Whenever a change is made to the flow, you must click on the **Deploy** button to save the changes to the server. If customizing the Flow, utilize the palette which contains a list of possible nodes located on the left-hand side of the screen.

Once the MQTT client configuration is set and a MQTT connection is established, the communication links display a connected status. Note that all the MQTT nodes on the flow share the same MQTT connection under-the-hood.

Figure 49: Good connection status
8.8 Loading node-RED User Interface

To view the node-RED user interface, open a Chrome web browser and enter the URL: http://localhost:1880/ui.

![Node-RED User Interface](image)

*Figure 50: node-RED user interface*

**Note:** To display the User Interface, run the node-RED flow example by entering: `node-red sentrius-rs1xx-demo.json` on the command line in a terminal window (Figure 43). This starts a local host web server which provides the user interface web page and establishes the MQTT connection to the TTN server.

To pick a different device in the drop-down menu, click the Device ID.
Figure 51: Device ID Drop-Down Menu

Note: Please contact a Laird sales representative if you need help setting up your application to work with the TTN servers and the customizable node-RED user interface.
APPENDIX

Problems? Issues with connecting your gateway to the network? Learn more about viable solutions to your issues from previous encounters below in our Troubleshooting Tips Guide.

9.1 Troubleshooting Tips for Sentrius Gateway Connections

9.1.1 LoRaWAN Network Ports Open?

- For the gateway to get access to the necessary LoRaWAN data servers, these Network Ports must have an opened TCP socket:
  - discovery.the.thingsnetwork.org: Port 1900 HTTP/2
  - router.us.thethings.network: Port 1901 HTTP/2
- The most frequent problem encountered when running this demo is that the required IP ports are not open or have traffic restrictions in place on these ports.

9.2 Troubleshooting Tips for The Things Network (TTN) Connections

9.2.1 Common Issues

- Most connection problems are due to inaccuracies between what LoRa Configuration settings (Dev EUI, App EUI, and App Key) are loaded in the RS1xx device and the settings on the TTN server. Make sure the RS1xx settings are accurate and match what is displayed in the TTN network.

9.2.2 Device Network Time

- The RS1xx must be provided with network time as part of the activation process for the device to begin sending data. The node-Red application sends network time to the sensor if it is running when the sensor joins the network.
  - If the node-Red application is not running, the RS1xx device joins the network (activation), but does not begin sending data. If the sensor is activated but has not received network time, going to the data view (on the TTN device page) shows that the device received one or more activations but no uplink or downlink data.

Note: Selecting Uplink, downlink, activation, ack and error filters is possible by click on the option above the data table on the device data view.

Figure 52: Device network time
9.2.3  Connection Issues Between Registered Devices and the Things Network Servers

- Go to the TTN console and then Applications > <my Application ID> > Devices <my Device ID> >. You should see the following window.

![Device Overview](image)

**Figure 53: Device overview**

- The status value is how long ago the sensor was last seen by the TTN servers. If the last seen value is never, the device never established a connection with TTN. The problem is usually that any of the following do not match the server: the App EUI, the Device EUI, or the Application Key. If the status is x number of time ago, and the App EUI, Device EUI, and Application Key have not changed, then the problem is likely elsewhere.
  - Carefully check the three keys (Device EUI/App EUI/App Key) on the Sensor device utilizing the Sensor Phone App. The Sentrius RS1xx guide available from the [Sentrius RS1xx product page](https://connectivity.lairdtech.com/wireless-modules/lorawan-solutions) of the Laird website can help with explaining how to use the phone app.
  - You may need to Refresh the Page to see the Status change.
- Make sure the Activation Method is set to Over-the-Air-Activation (OTAA)
- The App Key is unique for each Sentrius Device and is used to derive the session keys. The App Key is not shown in the Phone App for security reasons.
  - The App Key must be reprogrammed, it cannot be verified with the phone app. If the other two values match the TTN server then the problem is often the App Key. Before reprogramming the App Key, it may be worth power cycling the sensor, wait 15 seconds and check the device web page on TTN to see if the Status have changed from never.
  - If the status still has not changed, the next step is to reprogram the App Key. The App Key is a long string that must match exactly. It may be helpful to email or otherwise copy it to the phone and paste it into the Sentrius application.
9.3 Troubleshooting Tips for node_RED (MQTT Broker Links) Connections

9.3.1 MQTT Network Port Open?

- For the devices to connect to the Things Network Servers and communicate with the MQTT Broker Links in the node-RED dashboard, the Network Port needs to have an opened TCP socket:
  - `us-west.thethings.network` (us-west portion of URL can vary depending on the TTN server being used): **Port 1883 MQTT**
- The most frequent problem Users encounter when running this demo, is that the required IP ports are not open or have traffic restrictions in place on these ports.

9.3.2 Device IDs Correct on User Web Interface?

- The available Device IDs are read from the file `rs1xx-demo-config.json` at startup. Make sure that this config file is in the same directory as the `sentrius-rs1xx-demo.json` flow file and that node-RED is started from this directory with the command: `node-red sentrius-rs1xx-demo.json` If your Device ID is not shown in the dropdown menu double check the config file.

9.3.3 MQTT Broker Nodes Connection

- The three MQTT nodes (Device Subscription, Activations Subscription and Downlink) should show a connected status. These all use the same configuration node (MQTT Broker)
  - Access the Hamburger Menu > Configuration Nodes > MQTT-Broker. (Figure 48). Make sure the username is the **TTN Application ID** and the password is the **Application Default Access key**.
- MQTT troubleshooting can be done with one of the free MQTT applications such as MQTT-SPY.
- Debug nodes are shown in green on the flow. A Debug node is active when the tab on the right has a green dot in the center. The output of active debug nodes is shown in the debug window. The debug window in node-RED can be enabled by clicking on the debug tab in the right-hand pane of the flow editor. When active, debug node 1 will show all device data sent from the TTN server for the Application ID (set in the Configuration Node). Debug node 2 will display data.
  - Below shows a properly connected Terminal Window running node-RED with the predefined Flow settings.

![Figure 54: Properly-connected terminal window](image)