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1 Overview

1.1 Introduction

The RAK5205 LoRa tracker board is built on SX1276 LoRaWAN modem with low power microcontroller STM32L1, integrated the GPS module. It is a feature-packed sensor board that provides various interfaces for featured applications development.

This is the best sensor board available in the market, ideal as a quick prototyping tool for Internet-of-Things and LoRaWAN Network integration. It is perfect for IoT applications such as asset tracking, smart vehicle management and location-based services. Most importantly, application development environments such as the CooCox IDE and Kiel are all supported, users can quickly develop own applications.

The main features are listed below:

- With SX1276 LoRa long range and L76-L GPS modems which allow to enable the GPS low power mode.
- Integrated the ultra-low power microcontroller ARM Cortex-M3 STM32L1.
- Built-in environmental sensor BME680 (gas, pressure, humidity, temperature) and 3-axis MEMS sensor LIS3DH (accelerometer).
- SMA/IPEX antenna optional for LoRa and GPS.
- Supports latest LoRaWAN 1.0.2 protocol, activation by OTAA/ABP.
- Supports programmable bit rate up to 300kbps.
- Supports rechargeable battery through micro USB or 5V solar charging ports.
- Supports sleep mode, the power consumption down to 16μA.
- Supports I2C, GPIOs, UART and ADC interfaces.

1.2 Package Contents

RAK5205 board (1x)
LoRa Modem Antenna (1x)
GPS Antenna (1x)
Micro USB cable (1x)
2 WisTrio LoRa Tracker RAK5205

2.1 Overview

The picture below shows the top view and external interfaces of the RAK5205 LoRa tracker board.

The dimension and underside of the board is shown below. Sensor ICs are also labeled for your reference.
2.2 Functional Diagram

The block diagram below shows internal architecture and external interfaces:

![Functional Diagram](image)

2.3 Interfaces

It is built around RAK811 module and compatible with 96Boards. It provides the following interfaces, headers, jumpers, button and connectors:

- Micro USB
- 30-pin 96Boards Headers (UART, RESET, GPIOs, I2C, ADC)
- 2-pin USB Boot jumper
- 3-pin UART RX jumper
- 2-pin Battery female interface
- 2-pin Solar Panel female interface
- LEDs
- Reset Button

It has two SMA/IPEX Antenna connectors:

- GPS antenna
- LoRa antenna
2.4 **Operating Frequencies**

The board supports all LoRaWAN frequency channels as below. Which is easy to configure while building the firmware from the source code.

<table>
<thead>
<tr>
<th>Region</th>
<th>Frequency (MHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Europe</td>
<td>EU433 EU868</td>
</tr>
<tr>
<td>China</td>
<td>CN470</td>
</tr>
<tr>
<td>North America</td>
<td>US915</td>
</tr>
<tr>
<td>Asia</td>
<td>AS923</td>
</tr>
<tr>
<td>Australia</td>
<td>AU915</td>
</tr>
<tr>
<td>Korea</td>
<td>KR920</td>
</tr>
<tr>
<td>Indian</td>
<td>IN865</td>
</tr>
</tbody>
</table>

*Table 1 | Operating Frequencies*

2.5 **Board Pin Out**

Here are the six connectors for RAK5205 tracker board: P1, P2, J11, J12, J22 and J25.

2.5.1 **P1**

(Pin1 connected to VBATT, Pin2 connected to GND) Li-ion battery connector.

2.5.2 **P2**

(Pin1 connected to VBUS, Pin2 connected to GND) Solar cell interface.

2.5.3 **J11**

Pin1 is connected to VBUS. Pin2 is connected to VBIN. Without a battery connection, the J11 needs to be short-circuited with a jumper. Instead, the J11 needs to be kept open.

2.5.4 **J12**

Pin1 is connected to BOOT0. Pin2 is connected to VDD. Enter flash mode through jumper short circuit and open into normal mode.
2.5.5 **J22**

30 pins, follow the 96Board’s pin definition.

<table>
<thead>
<tr>
<th>Pin</th>
<th>Pin Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>NC</td>
<td>NC</td>
</tr>
<tr>
<td>3</td>
<td>UART1_TX</td>
<td>UART1_TX</td>
</tr>
<tr>
<td>4</td>
<td>NC</td>
<td>NC</td>
</tr>
<tr>
<td>5</td>
<td>UART1_RX1</td>
<td>UART1_RX1 (need to connect RX pin and RX1 pin of J25 via jumper if user wants to use this UART interface).</td>
</tr>
<tr>
<td>6-8</td>
<td>NC</td>
<td>NC</td>
</tr>
<tr>
<td>9-10</td>
<td>GND</td>
<td>GND</td>
</tr>
<tr>
<td>11</td>
<td>VCCin</td>
<td>5Vout</td>
</tr>
<tr>
<td>12</td>
<td>VCC_3V3</td>
<td>3V3 OUT</td>
</tr>
<tr>
<td>13</td>
<td>PA8</td>
<td>GPIO Pin</td>
</tr>
<tr>
<td>14</td>
<td>PB3</td>
<td>GPIO Pin</td>
</tr>
<tr>
<td>15</td>
<td>NC</td>
<td>NC</td>
</tr>
<tr>
<td>16</td>
<td>PB5</td>
<td>GPIO Pin</td>
</tr>
<tr>
<td>17</td>
<td>SWD_TMS</td>
<td>GPIO Pin / R21, R22 pull-up 10K resistor can be used as JTAG interface</td>
</tr>
<tr>
<td>18</td>
<td>SWD_CLK</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>LED1_PA12</td>
<td>GPIO Pin</td>
</tr>
<tr>
<td>20</td>
<td>LED2_PB4</td>
<td>GPIO Pin</td>
</tr>
<tr>
<td>21</td>
<td>NC</td>
<td>NC</td>
</tr>
<tr>
<td>22</td>
<td>SCL</td>
<td>I2C</td>
</tr>
<tr>
<td>23</td>
<td>NC</td>
<td>NC</td>
</tr>
<tr>
<td>24</td>
<td>SDA</td>
<td>I2C</td>
</tr>
<tr>
<td>25</td>
<td>NC</td>
<td>NC</td>
</tr>
<tr>
<td>26</td>
<td>PB12</td>
<td>ADC Interface</td>
</tr>
<tr>
<td>27-28</td>
<td>NC</td>
<td>NC</td>
</tr>
<tr>
<td>29</td>
<td>RST</td>
<td>Reset Pin</td>
</tr>
<tr>
<td>30</td>
<td>NC</td>
<td>NC</td>
</tr>
</tbody>
</table>

*Table 2 | Pin Descriptions*

2.5.6 **J25**

(RX1, RX, RXCP) J22 and USB UART share. If you use the UART of J22, you need to connect Rx and RX1 pins. If you use USB UART, you need to connect Rx and RXCP pins.
2.6 **Micro-B USB Interface**

A Standard Micro-B USB compliant with USB 2.0 standard specification is used to provide an interface to connect to a PC for control of the board and firmware upgrade. The Micro-B USB pin definition is shown below:

<table>
<thead>
<tr>
<th>Pin</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>USB_VBUS (+5V)</td>
</tr>
<tr>
<td>2</td>
<td>USB_DM</td>
</tr>
<tr>
<td>3</td>
<td>USB_DP</td>
</tr>
<tr>
<td>4</td>
<td>NC</td>
</tr>
<tr>
<td>5</td>
<td>GND</td>
</tr>
</tbody>
</table>

*Table 3 | Micro-B USB Pin Descriptions*

2.7 **LEDs**

Three LEDs are used to indicate operating status, here are their functions:

- **Green LED**: **STATUS** – Defined by user.
- **Blue LED**: **STATUS** – Defined by user.
- **Red LED**: **Charging Status** – indicates the Li-ion Battery is charging.

2.8 **RESET Push Button**

Reset Push Button is used to reset the RAK811 module. To reset the module push the Reset Button for 1 second.

2.9 **Working Mode**

The board supports to enable the GPS low power mode, it has a 3-axis MEMS Sensor LIS3DH, which can detect the user’s motion status, when the device is stationary, it will enter the low power sleep mode, reducing the overall power consumption and increase battery life. The power consumption as shown in the following table.

<table>
<thead>
<tr>
<th>Mode</th>
<th>Power consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sleep mode</td>
<td>14.5μA (Min)</td>
</tr>
<tr>
<td>Normal mode</td>
<td>174mA (Max) @ 20dBm and GPS enable</td>
</tr>
</tbody>
</table>

*Table 4 | Power consumption*
2.10 Power Requirements

The RAK5205 LoRa tracker board has an operating voltage of 3.7V. It can be powered by micro USB with 5V Max.

![Image 5](Powered by Micro USB)

The board can also be powered by a 3.7V Li-ion battery. You can connect a 5V solar panel charger to recharge the Li-ion battery.

![Image 6](Charging with 5V Solar)
2.11 **Environmental Requirements**

The table below lists the operation and storage temperature requirements:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Min.</th>
<th>Typical</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation Temp. Range</td>
<td>-35 °C</td>
<td>+25 °C</td>
<td>+60 °C</td>
</tr>
<tr>
<td>Extended Temp. Range</td>
<td>-40 °C</td>
<td></td>
<td>+80 °C</td>
</tr>
<tr>
<td>Storage Temp. Range</td>
<td>-40 °C</td>
<td></td>
<td>+80 °C</td>
</tr>
</tbody>
</table>

*Table 5 | Electrical Characteristics*

2.12 **Mechanical Dimensions**

Here is the detailed dimension of RAK5205 LoRa tracker:
3 LoRa Antenna

3.1 Overview

The LoRa antenna and interfaces are shown below.

![Image 8 | LoRa Antenna and SMA interface]

Here is the IPEX LoRa Antenna interface:

![Image 9 | LoRa IPEX interface]

3.2 LoRa Antenna Dimension

The SMA antenna’s mechanical dimension is shown below:

![Image 10 | LoRa Antenna Dimension]

3.3 LoRa Antenna Parameter

<table>
<thead>
<tr>
<th>Items</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>VSWR (Voltage Standard Wave Radio)</td>
<td>1:1.5</td>
</tr>
<tr>
<td>Gain</td>
<td>2.0dbm</td>
</tr>
<tr>
<td>Working Temperature &amp; Humidity</td>
<td>T: -35 °C ~ +80 °C, H: 0% ~ 95%</td>
</tr>
<tr>
<td>Storage Temperature &amp; Humidity</td>
<td>T: -40 °C ~ +85 °C, H: 0% ~ 95%</td>
</tr>
</tbody>
</table>

*Table 6 | LoRa Antenna Parameter*
4. **GPS Antenna**

4.1 **Overview**

The GPS antenna and interfaces for RAK5205 tracker board is shown below.

![Image 11 | GPS Antenna and SMA interface](image11)

Here is the IPEX GPS Antenna interface:

![Image 12 | GPS IPEX interface](image12)

4.2 **GPS Antenna Dimensions**

![Image 13 | GPS Antenna Dimensions](image13)

4.3 **GPS Environmental Requirements**

The antenna environmental requirements are listed in the table below:

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Temperature</th>
<th>Humidity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Working</td>
<td>-35 °C ~ +80 °C</td>
<td>0% ~ 95%</td>
</tr>
<tr>
<td>Storage</td>
<td>-40 °C ~ +85 °C</td>
<td>0% ~ 95%</td>
</tr>
</tbody>
</table>

*Table 7 | GPS Environmental Requirements*
4.4 GPS Antenna Parameter

Antenna specifications are listed in the table below:

<table>
<thead>
<tr>
<th>Item</th>
<th>Specifications</th>
<th>PET</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range of Receiving Frequency</td>
<td>1575.42 ± 1.1</td>
<td>± 2.5</td>
</tr>
<tr>
<td>Center Frequency (MHz) w/ 30mm2 GND plane</td>
<td>1575.42</td>
<td>± 3.0</td>
</tr>
<tr>
<td>Bandwidth (MHz) (Return Loss ≤ -10dB)</td>
<td>≥ 10</td>
<td>± 0.5</td>
</tr>
<tr>
<td>VSWR (in Center Frequency)</td>
<td>≤ 2.0</td>
<td>± 0.5</td>
</tr>
<tr>
<td>Gain (Zenith) (dBi Typ) w/ 70mm2 GND Plane</td>
<td>4.5</td>
<td>± 0.5</td>
</tr>
<tr>
<td>Axial Ratio (dB) w/ 70mm2 GND Plane</td>
<td>3.0</td>
<td>± 0.2</td>
</tr>
<tr>
<td>Polarization</td>
<td>Right-Handed Circular</td>
<td>-</td>
</tr>
<tr>
<td>Impedance (Ω)</td>
<td>50</td>
<td>-</td>
</tr>
<tr>
<td>Frequency Temperature Coefficient (ppm/°C)</td>
<td>0 ± 10</td>
<td>-</td>
</tr>
</tbody>
</table>

*Table 8| GPS Antenna Parameter*

Amplifier Specifications are listed in the table below:

<table>
<thead>
<tr>
<th>Item</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency Range</td>
<td>1575.42 MHz</td>
</tr>
<tr>
<td>Gain</td>
<td>27 dB</td>
</tr>
<tr>
<td>VSWR</td>
<td>≤ 2.0 V</td>
</tr>
<tr>
<td>Noise Coefficient</td>
<td>≤ 2.0 dBm</td>
</tr>
<tr>
<td>DC Voltage</td>
<td>3 ~ 5 V</td>
</tr>
<tr>
<td>DC Current</td>
<td>5 ± 2 mA</td>
</tr>
</tbody>
</table>

*Table 9| Amplifier Specifications*

Environmental test performance specifications are listed below:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Amplifier Gain</td>
<td>27dB ± 2.0</td>
<td>27dB ± 2.0</td>
<td>27dB ± 2.0</td>
</tr>
<tr>
<td>VSWR</td>
<td>≤ 2.0</td>
<td>≤ 2.0</td>
<td>≤ 2.0</td>
</tr>
<tr>
<td>Noise Coefficient</td>
<td>≤ 2.0</td>
<td>≤ 2.0</td>
<td>≤ 2.0</td>
</tr>
</tbody>
</table>

1. High temperature test: soap in temperature (85° C) and humidity (95%) chamber for 24-hour and return to normal temperature (at least for 1-hour) without visual shape change.
2. Low temperature test: soap in temperature (-40° C) chamber for 24-hour and return to normal temperature (at least for 1-hour) without visual shape change.

*Table 10| Environmental Test Performance*
5 Schematics

The Component schematics diagram of the RAK5205 are shown below:
6 Usage and Examples

We are going to use CooCox IDE to view and build the firmware. Download the source code from the provided GIT repository. All the necessary software should be installed earlier.

6.1 Source Code

All application source codes are available on GIT repository. You can either download the source zip from the GIT repository or you can also clone. The source code link is: https://github.com/RAKWireless/RAK811_LoRaNode

6.2 Required Software

To start with developing the application over the RAK5205 LoRa tracker board you may need to download the following software. All the software provided below are based on Windows operating system.

6.2.1 USB Driver

WisTrio-LoRa-RAK5205/Tools/CP210x_Windows_Drivers.zip

6.2.2 CooCox IDE

WisTrio-LoRa-RAK5205/Tools/CoIDE_V2Beta_20170117.exe

6.2.3 Flash Loader

WisTrio-LoRa-RAK5205/Tools/Flash_Loader_Demonstrator.zip

6.2.4 Tool Chain

WisTrio-LoRa-RAK5205/Tools/gcc-arm-none-eabi-5_4-2016q3-20160926-win32.exe
6.3 Importing Source Code

Download it from the GIT URL indicated in Source Code Section of this manual.

![Image of a Git repository interface with options to clone or download]

**Screenshot 1** | Download Source code from Github

Extract the downloaded ZIP file and run CooCox CoIDE. Open project from the menu.

![Image of CooCox CoIDE interface with options for New Project, Open Project, etc.]

**Screenshot 2** | Open Project in CooCox CoIDE

After opening the project, you will see the following project structure in CooCox CoIDE:

![Image of the project directory structure]

**Screenshot 3** | Project Directory

*Continue to next page*
Build the current project with the target frequency band of 868MHz for example:

The following window will appear together with the build status.

To find the build executable file, click the LoRaMacClassA folder as shown below. Follow the path to the bin directory where you can find the executable files.
6.4 Uploading Firmware

6.4.1 Install the “CP210x_windows_Drivers” driver
Connect the board to the computer via a Micro USB cable and you'll find the COM port for RAK5205 LoRa tracker in the device manager.

6.4.2 Install the Flash Loader Demonstrator
It is recommended to use Flash Loader Demonstrator to upgrade the RAK5205 LoRa tracker board to the latest version.

6.4.3 Connect the BOOT jumper
The bootpin of the board needs to be raised to 3.3V when upgrading, so you need to connect the BOOT0 and VDD pin of J12 by using a jumper. Also, make sure that the RX pin of J25 is connected to the RXCP pin.

6.4.4 Upgrade the firmware
Select the COM Port for the board, the Baud Rate is “115200”, as shown in the following figure.
Reconnect the RAK5205 or press the reset button if prompted.

Select “STM32L1_Cat2-128K” then click “Next”.

Continue to next page…
Select “Download to device” then navigate to location of bin file. Click “Next” when finished. This will start the download process:

After finishing the download, close the Demonstrator program, disconnect the RAK5205 and remove the jumper of J12.
7 Contact Information

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8 Revision History

<table>
<thead>
<tr>
<th>Revision</th>
<th>Description</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Initial version</td>
<td>2018-09-10</td>
</tr>
<tr>
<td>1.1</td>
<td>Improved Layout and content</td>
<td>2018-11-06</td>
</tr>
<tr>
<td>1.2</td>
<td>Modify the picture and the context</td>
<td>2018-11-10</td>
</tr>
<tr>
<td>1.3</td>
<td>Add the IPEX Antenna interface picture</td>
<td>2018-11-14</td>
</tr>
</tbody>
</table>

Table 11 | Revision History

9 Document Summary

Document Name: WisTrio LoRa Tracker RAK5205 User Manual
Product Name: RAK5205
Release Date: November 2018
Revision Number: V1.3

Prepared by | Checked by: | Approved by:
-------------|-------------|-------------|
Hairui & Penn | Steven | |

About RAKwireless:

RAKwireless is the pioneer in providing innovative and diverse cellular and LoRa connectivity solutions for IoT edge devices. It’s easy and modular design can be used in different IoT applications and accelerate time-to-market turnover. For more information, please visit RAKwireless website at www.rakwireless.com.

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