



User Manual for

# WisLink-LoRa Concentrator Module

Mini PCI-e Edition

**RAK2247 SPI or USB**

Version V1.0 | December 2018



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## 1 Overview

### 1.1 Introduction

The RAK2247 is a LoRa concentrator module with the mini PCIe form factor based on SX1301, which enables an easy integration into an existing routers and others network equipment with LoRa Gateway capabilities. It can be used in any embedded platform offering a free mini-PCIe slot with SPI or USB connection.

RAK2247 is a complete and cost efficient LoRa gateway solution offering up to 10 programmable parallel demodulation paths. It targets at smart metering fixed networks and Internet of Things applications with up to 500 nodes per km<sup>2</sup> in moderately interfered environment. The modules have the industry standard PCI Express Mini Card form factor, which enables easy integration into an application board and is also ideal for manufacturing of small series.

The main features are listed below:

- Compatible with Mini PCI-e Edition specification with metal cooling fin.
- SX1301 base band processor emulates 49 x LoRa demodulators 10 parallel demodulation paths.
- 2 x SX125x Tx/Rx front-ends high/ low frequency.
- Build in FT2232H to convert SPI interface of SX1301 to USB2.0.
- Voltage of Mini PCI-e is 3.3v, compatible with 3G/LTE card of Mini PCI-e type.
- Supports US915 region.
- Supports optional SPI or USB interfaces.

### 1.2 Package Contents



RAK2247 board  
(1x)



LoRa Antenna of N-Type  
Male connector(1x)

Figure1 | Package Contents

## 2 LoRa Concentrator Module RAK2247

### 2.1 Overview



Figure2 | Module View

### 2.2 Block Diagram

The block diagram of RAK2247-SPI shown as below.

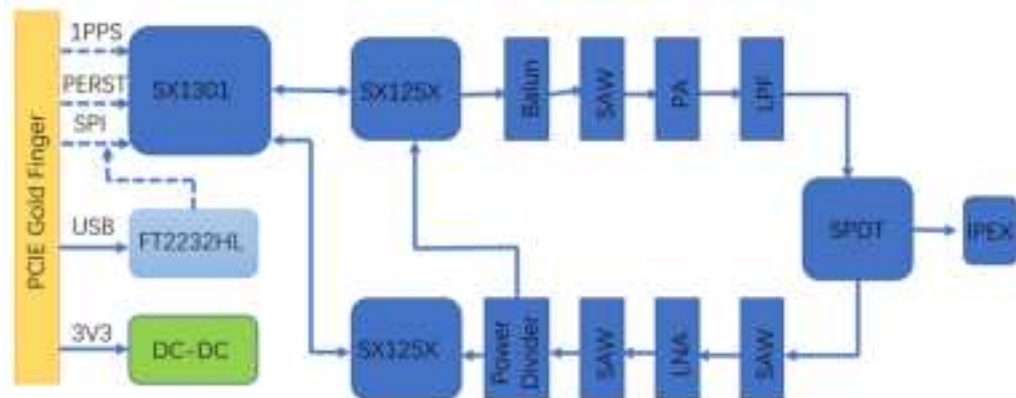


Figure3 | RAK2247-SPI block diagram

As described in Figure 3, the RAK2247 card integrates one SX1301 chip and two SX1255/7 and other chip for RF signal, which represents the core of the device, providing the related LoRa modem and processing functionalities. Additional signal conditioning circuitry is implemented for PCI Express Mini Card compliance, and one UFL connectors are available for external antennas integration.

## 2.3 Operating Frequencies

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

| Region        | Frequency ( MHz )  |
|---------------|--------------------|
| North America | US: 923.3-927.5Mhz |

Table 1 | Operating Frequencies

## 2.4 Pin Definition

| No | Mini PCIEx PIN Rev. 2.0 | RAK2247 PIN            | Power   | I/O | Description               | Remarks                  |
|----|-------------------------|------------------------|---------|-----|---------------------------|--------------------------|
| 1  | WAKE#                   | NC                     |         | N/A |                           | Internally not connected |
| 2  | 3.3Vaux                 | 3.3Vaux                | 3.3Vaux | N/A | RAK2247power supply input | Connect to 3.3 V         |
| 3  | COEX1                   | NC                     |         | N/A |                           | Internally not connected |
| 4  | GND                     | GND                    | GND     | N/A | Ground                    | Connect to Ground        |
| 5  | COEX2                   | NC                     |         | N/A |                           | Internally not connected |
| 6  | 1.5V                    | NC                     |         | N/A |                           | Internally not connected |
| 7  | CLKREQ#                 | NC                     |         | N/A |                           | Internally not connected |
| 8  | UIM_PWR                 | NC                     |         | N/A |                           | Internally not connected |
| 9  | GND                     | GND                    | GND     | N/A | Ground                    | Connect to ground        |
| 10 | UIM_DATA                | NC                     |         | N/A |                           | Internally not connected |
| 11 | REFCLK-                 | NC                     |         | N/A |                           | Internally not connected |
| 12 | UIM_CLK                 | NC                     |         | N/A |                           | Internally not connected |
| 13 | REFCLK+                 | NC                     |         | N/A |                           | Internally not connected |
| 14 | UIM_RESET               | NC                     |         | N/A |                           | Internally not connected |
| 15 | GND                     | GND                    | GND     | N/A | Ground                    | Connect to ground        |
| 16 | UIM_SPU                 | NC                     |         | N/A |                           | Internally not connected |
| 17 | UIM_IC_DM               | NC(5V optional For PA) |         | N/A |                           | Internally not connected |

|    |             |           |         |     |                     |  |
|----|-------------|-----------|---------|-----|---------------------|--|
| 18 | GND         | GND       | GND     | N/A | Ground              | Connect to ground  |
| 19 | Reserved    | 1PPS      |         | N/A |                     | Internal connection 1PPS for SX1301  |
| 20 | W_DISABLE1# | NC        |         | N/A |                     | Internally not connected   |
| 21 | GND         | GND       | GND     | N/A | Ground              | Connect to ground  |
| 22 | PERST#      | RESET     |         | I   | RAK2247 reset input | Active high ( $\geq 100\text{ns}$ ) for SX1301 reset.  |
| 23 | PERn0       | NC        |         | N/A |                     | Internally not connected   |
| 24 | 3.3Vaux     | 3.3Vaux   | 3.3Vaux | I   | RAK2247 supply      | Connect to 3.3 V   |
| 25 | PERp0       | NC        |         | N/A |                     | Internally not connected   |
| 26 | GND         | GND       | GND     | N/A | Ground              | Connect to ground  |
| 27 | GND         | GND       | GND     | N/A |                     | Connect to ground  |
| 28 | 1.5V        | NC        |         | N/A |                     | Internally not connected   |
| 29 | GND         | GND       | GND     | N/A | Ground              | Connect to ground  |
| 30 | SMB_CLK     | NC        |         | N/A |                     | Internally not connected   |
| 31 | PETn0       | NC        |         | N/A |                     | Internally not connected   |
| 32 | SMB_DATA    | NC        |         | N/A |                     | Internally not connected   |
| 33 | PETp0       | NC        |         | N/A |                     | Internally not connected   |
| 34 | GND         | GND       | GND     | N/A | Ground              | Connect to ground  |
| 35 | GND         | GND       | GND     | N/A | Ground              | Connect to ground  |
| 36 | USB_D-      | USB_D-    | USB     | I/O | USB Data Line D-    | 90-ohm nominal differential impedance.<br>Pull-up, pull-down and series resistors as required by USB 2.0 specifications are part of the USB pin driver and need not be |
| 37 | GND         | GND       | GND     | N/A | Ground              | Connect to ground  |
| 38 | USB_D+      | USB_D+    | USB     | I/O | USB Data Line D+    | 90-ohm nominal differential impedance.<br>Pull-up, pull-down and series resistors as required by USB 2.0 specifications are part of the USB pin driver and need not be |
| 39 | 3.3Vaux     | 3.3Vaux   | 3.3Vaux | I   | RAK2247 supply      | Connect to 3.3 V   |
| 40 | GND         | GND       | GND     | N/A | Ground              | Connect to ground  |
| 41 | 3.3Vaux     | 3.3Vaux   | 3.3Vaux | I   | RAK2247 supply      | Connect to 3.3 V   |
| 42 | LED_WWAN#   | NC        |         | N/A |                     | Internally not connected   |
| 43 | GND         | GND       | GND     | N/A | Ground              | Connect to ground  |
| 44 | LED_WLAN#   | NC        |         | N/A |                     | Internally not connected   |
| 45 | Reserved    | PCIe_SCK  |         | I/O | Host SPI CLK        | Max 10MHz clock  |
| 46 | LED_WPAN#   | NC        |         | N/A |                     | Internally not connected   |
| 47 | Reserved    | PCIe_MISO |         | I/O | Host SPI MISO       |  |
| 48 | 1.5V        | NC        |         | N/A |                     | Internally not connected   |
| 49 | Reserved    | PCIe_MOSI |         | I/O | Host SPI MOSI       |  |
| 50 | GND         | GND       | GND     | N/A | Ground              | Connect to ground  |
| 51 | W_DISABLE2# | PCIe_CSN  |         | I/O | Host SPI CS         |  |

|    |         |         |         |   |                |                  |
|----|---------|---------|---------|---|----------------|------------------|
| 52 | 3.3Vaux | 3.3Vaux | 3.3Vaux | I | RAK2247 supply | Connect to 3.3 V |
|----|---------|---------|---------|---|----------------|------------------|

Table 2 | Pin Definition

## 2.5 Power Supply

RAK2247 card must be supplied through the 3.3Vaux pins by a DC power supply. The voltage must be stable, because during this operation the current drawn from 3.3Vaux can vary significantly, based on the power consumption profile of the SX1301 chip (see SX1301 DS).

## 2.6 SPI Interface

A SPI interface is provided on the PCIe\_SCK, PCIe\_MISO, PCIe\_MOSI, PCIe\_CSN pins of the system connector. The SPI interface gives access to the configuration register of SX1301 via a synchronous full-duplex protocol. Only the slave side is implemented.

## 2.7 USB Interface

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Note: RAK2247-SPI version don't have this interface.

RAK2247 card can support the high speed USB to SPI by FT2232HL, it includes a high-speed USB 2.0 compliant interface with maximum 480 Mb/s data rate, representing the interface for any communication with an external host application processor. The module itself acts as a USB device and can be connected to any USB host equipped with compatible drivers. For more information, please refer to the data sheet of FT2232HL.

## 2.8 1PPS

RAK2247 card includes the 1PPS input for received packets time-stamped.

## 2.9 RESET

RAK2247 card includes the RESET active-high input signal to reset the radio operations as specified by the SX1301 Specification.

## 2.10 Antenna RF Interface

The modules have one RF interfaces over a standard UFL connectors (Hirose U. FL-R-SMT) with a characteristic impedance of 50OHM. The RF port (J1) supports both Tx and Rx, providing the antenna interface.

## 2.11 Electrical Characteristics

Stressing the device above one or more of the ratings listed in the Absolute Maximum Rating section may cause permanent damage. These are stress ratings only. Operating the module at these or at any conditions other than those specified in the Operating Conditions sections of the specification should be avoided.

Exposure to Absolute Maximum Rating conditions for extended periods may affect device reliability. The operating condition range define those limit within which the functionality of the device is guaranteed.

Where application information is given, it is advisory only and does not form part of the specification.

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### 2.11.1 Absolute Maximum Rating

Limiting values given below are in accordance with the Absolute Maximum Rating System (IEC 134).

| Symbol   | Description           | Condition                                  | Min.  | Max.     |
|----------|-----------------------|--|-------|----------|
| 3.3Vaux  | Module supply voltage | Input DC voltage at 3.3Vaux pins           | −0.3V | 3.6V     |
| USB      | USB D+/D- pins        | Input DC voltage at USB interface pins     |       | 3.6V     |
| SPDT_SEL | Port select           | Input DC voltage at SPDT_SEL input pins    | −0.3V | 3.6V     |
| RESET    | RAK2247 reset input   | Input DC voltage at RESET input pin        | −0.3V | 3.6V     |
| SPI      | SPI interface         | Input DC voltage at SPI interface pin      | −0.3V | 3.6V     |
| GPS_PPS  | GPS 1 pps input       | Input DC voltage at GPS_PPS input pin      | −0.3V | 3.6V     |
| Rho_ANT  | Antenna ruggedness    | Output RF load mismatch ruggedness at ANT1 |       | 10:1VSWR |
| Tstg     | Storage Temperature   |  | −40°C | 85°C     |

Table 3 | Absolute maximum ratings

The product is not protected against overvoltage or reversed voltages. If necessary, voltage spikes exceeding the power supply voltage specification, given in table above, must be limited to values within the specified boundaries by using appropriate protection devices.



### 2.11.2 Maximum ESD

| Parameter                                | Min | Typical | Max   | Remarks                                      |
|--|-----|---------|-------|--|
| ESD sensitivity for all pins except ANT1 |     |         | 1000V | Human Body Model according to JESD22-A114    |
| ESD sensitivity for ANT1                 |     |         | 1000V | Human Body Model according to JESD22-A114    |
| ESD immunity for ANT1                    |     |         | 4000V | Contact Discharge according to IEC 61000-4-2 |
|  |     |         | 8000V | Air Discharge according to IEC 61000-4-2     |

Table 4 | Maximum ESD ratings

Note: RAK2247 card are Electrostatic Sensitive Devices and require special precautions when handling.

### 2.11.3 Operating Conditions

Input voltage at 3.3Vaux must be above the normal operating range minimum limit to switch-on the module.

| Symbol  | Parameter   | Min.  | Typical | Max.  |
|---------|---|-------|---------|-------|
| 3.3Vaux | Module supply operating input voltage <sup>14</sup> | 3.00V | 3.30V   | 3.60V |

Table 5 | PowerSupply Range

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### 2.11.4 Power Consumption

| Mode             | Condition   | Min | Type  | Max |
|------------------|---|-----|-------|-----|
| Idle-Mode        | All of the chip on the board enter idle mode or shutdown. |     | 68uA  |     |
| Active-Mode(TX)  | TX enabled and RX disabled.                               |     | 440mA |     |
| Active-Mode(RX ) | TX disabled and RX enabled.                               |     | 470mA |     |

Table 6 |Module 3.3Vaux supply current consumption

### 2.11.5 RF Characteristics

The following table gives typically sensitivity level of the RAK2247 card.

| Signal Bandwidth/[KHz] | Spreading Factor | Sensitivity/[dBm] |
|------------------------|------------------|-------------------|
| 500                    | 12               | -134              |
| 500                    | 7                | -120              |

Table 7 |LoRa RF Characteristics

## 2.12 Mechanical Dimensions

RAK2247 card are fully compliant to the 52-pin PCI Express Full-Mini Card Type F2 form factor, with top-side and bottom-side keep-out areas, with 50.95 mm nominal length, 30 mm nominal width and all the other dimensions as defined by the PCI Express Mini Card Electromechanical Specification [9] except for the card thickness (nominal value is 3.7 mm), as described in the next figure.

The weight of the RAK2247 card is about 9.7 g.KHz

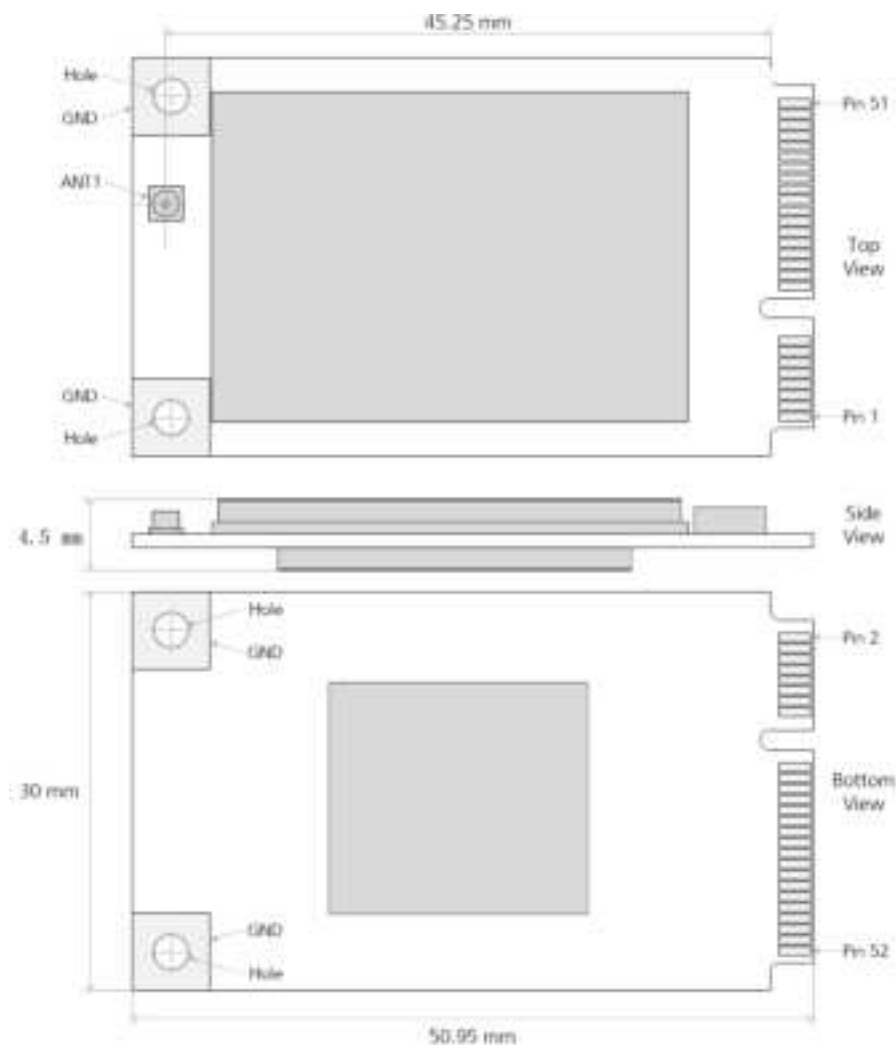


Figure 4| RAK2247 card mechanical dimensions (top view, side view, bottom view)

For further details regarding mechanical specifications see the PCI Express Mini Card Electromechanical Specification.

## 3 LoRa Antenna

### 3.1 Overview



Figure 5|LoRa Antenna Overview

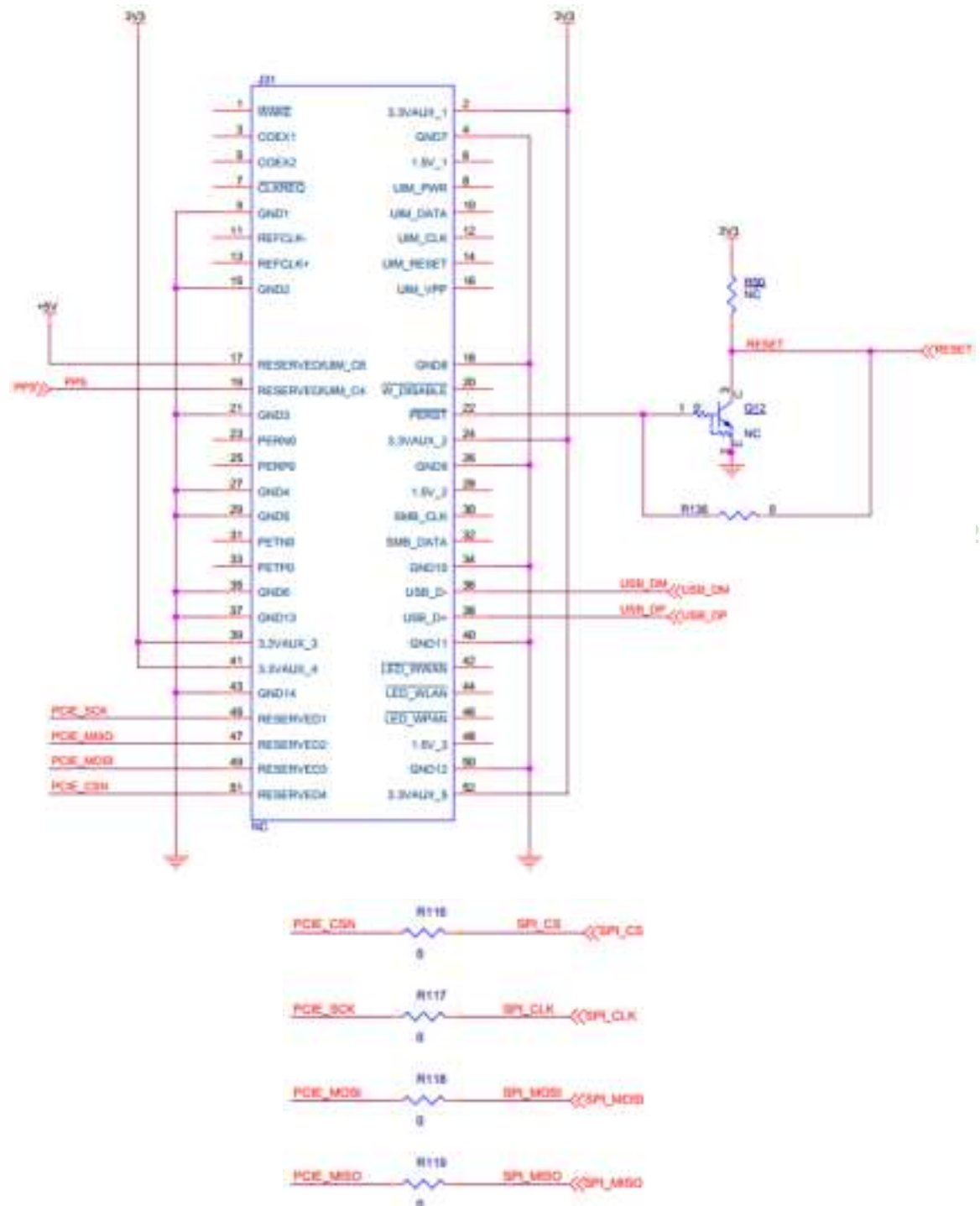
### 3.2 Antenna Parameter

| Items                             | Specifications                 |
|-----------------------------------|--------------------------------|
| VSWR(Voltage Standard Wave Radio) | 1:1.5                          |
| Gain                              | 5.8 dBi                        |
| WorkingTemperature&Humidity       | T:-35 °C ~ +80 °C, H: 0% ~ 95% |
| StorageTemperature&Humidity       | T:-40 °C ~ +85 °C, H: 0% ~ 95% |

Table 8| LoRa Antenna Parameter

## 4 SchematicsReference

RAK2247 card refer to Semtech's reference design of SX1301, the SPI interface or USB interface, which convert SPI to USB2.0 by FT232H, can be used on PCIE connector.



## 5 Warning

**FCC Warning:** This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions.

- (1) This device may not cause harmful interference;
- (2) This device must accept any interference received, including interference that may cause undesired operation.

Any Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment. When the module is installed in the host device, the FCC ID label must be visible through a window on the final device or it must be visible when an access panel, door or cover is easily removed. If not, a second label must be placed on the outside of the final device that contains the following text: —Contains FCC ID: 2AF6B-RAK2247.

Maximum antenna gain allowed for use with this device is 5.8 dBi.

This module complies with FCC radiation exposure limits set forth for an uncontrolled environment .This equipment should be installed and operated with minimum distance 20 cm between the radiator& your body.

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### **Manufacture name and address:**

Shenzhen Rakwireless Technology Co., Ltd.

Room 506, Bldg B, New Compark, Pingshan First Road, Taoyuan Street, XiLi town, Nanshan District, Shenzhen, China

### **Integration instructions for host product manufacturers according to KDB 996369 D03OEM**

#### **Manual v01**

#### **2.2 List of applicable FCC rules**

The modular complies with Part 15.247 of the FCC Rules.

#### **2.3 Specific operational use conditions**

This module is stand-alone modular. If the end product will involve the Multiple simultaneously transmitting condition or different operational conditions for a stand-alone modular transmitter in a host, host manufacturer have to consult with module manufacturer for the installation method in end system.

#### **2.4 Limited module procedures**

Not applicable

2.5 Trace antenna designs

Not applicable

2.6 RF exposure considerations

To maintain compliance with FCC's RF Exposure guidelines, This equipment should be installed and operated with minimum distance of 20cm from your body.

2.7 Antennas

This radio transmitter FCC ID: **2AF6B-RAK2247** has been approved by Federal Communications Commission to operate with the antenna types listed below, with the maximum permissible gain indicated. Antenna types not included in this list that have a gain greater than the maximum gain indicated for any type listed are strictly prohibited for use with this device.

| Antenna Description | Antenna Type | Modulation Type  | Impedance (Ω) | Maximum antenna gain(dBi) |
|---------------------|--------------|------------------|---------------|---------------------------|
| Lora Antenna        | Monopole     | Chirp Modulation | 50            | 5.8dBi                    |

2.8 Label and compliance information

The final end product must be labeled in a visible area with the following" Contains

FCC ID: **2AF6B-RAK2247**"

2.9 Information on test modes and additional testing requirements

Host manufacturer is strongly recommended to confirm compliance with FCC requirements for the transmitter when the module is installed in the host.

2.10 Additional testing, Part 15 Subpart B disclaimer

Host manufacturer is responsible for compliance of the host system with module installed with all other applicable requirements for the system such as Part 15 B

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## 6 Revision History

| Revision | Description     | Date       |
|----------|-----------------|------------|
| 1.0      | Initial version | 2018-12-21 |

Table 9 | Revision History

## 7 Document Summary

**Document Name:** WisLink-LoRa RAK2247 User Manual  
**Release Date:** December2018  
**Revision Number:** V1.0

| Prepared by | Checked by: | Approved by: |
|-------------|-------------|--------------|
| Penn        | Jeff        |              |

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