

Specification for

LoRa Concentrator Module

RAK2287X

Version V1.2 | February 2020

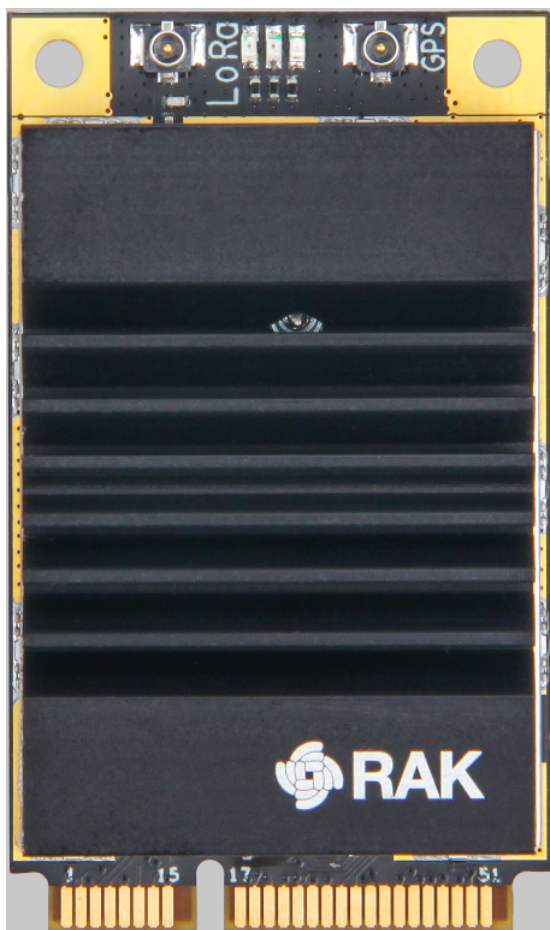


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1 Overview

1.1 Introduction

RAK2287X is a LoRa concentrator card with mini-PCIe form factor based on SX1302, which enables an easy integration into an existing router or other 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. Furthermore, ZOE-M8Q GPS chip is integrated on board.

RAK2287X is a complete and cost efficient LoRa gateway solution offering up to 10 programmable parallel demodulation paths which are 8xSF5-SF12 LoRa demodulators, 8xSF5-SF10 LoRa demodulators, 125 /250 / 500 kHz LoRa demodulator and (G)FSK demodulator. It can detect at any time, any packet in a combination of 8 different spreading factors(SF5 to SF12) and 10 channels, and demodulate up to 16 packets at any time. It targets smart metering fixed networks and Internet-of-Things (IoT) applications, covering up to 500 nodes per square kilometer in an environment with moderate interference. Another feature is the integration of Ublox GPS module which expands applications.

1.2 Main Features

- Compatible with Mini PCI-e Edition specification with heat sink.
- SX1302 base band processor emulates 8 x8 channel LoRa packet detectors, 8 x SF5-SF12 LoRa demodulators, 8 x SF5-SF10 LoRa demodulators, one 125 /250 / 500 kHz high-speed LoRa demodulator and one (G)FSK demodulator .
- Built-in STM32L412K to convert SPI interface of SX1302 to USB2.0.
- Voltage of Mini PCI-e is 3.3 V, compatible with 3G/LTE card of Mini PCI-e type.
- Tx power up to 27dBm, Rx sensitivity down to -139dBm@SF12, BW 125 kHz.
- Supports latest LoRaWAN 1.0.2 protocol.
- Supports global license-free frequency band (EU868, US915, AS923, AU915, KR920, IN865 and AS920).
- Supports optional SPI or USB interfaces.
- Built-in ZOE-M8Q GPS module

Note: The above parameters such as frequency band/BW/Tx power etc. changes in difference region to compliance with the local regulatory requirements, contact Rakwireless for detail.

1.3 Package Contents

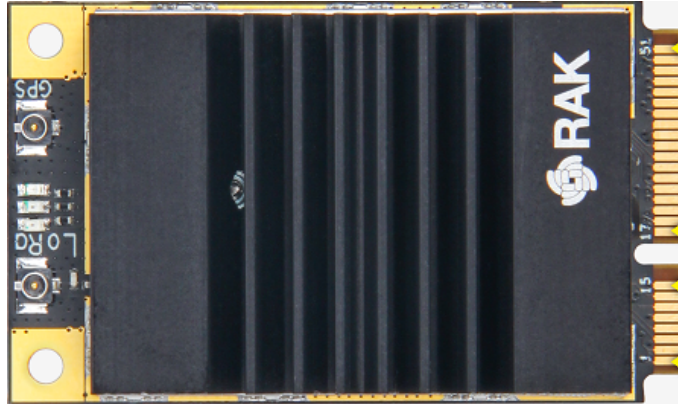


Figure 1 | RAK2287Xboard

2 WisLink LoRa Module RAK2287X

Overview

The board only weighs 9.7 grams, its length is 50.95 mm while its width is 30 mm. The board width, top-side and bottom-side keep-out areas and all other dimension is defined by [PCI Express Mini Card Electromechanical Specification](#) except for the card thickness (nominal value of 3.7 mm).

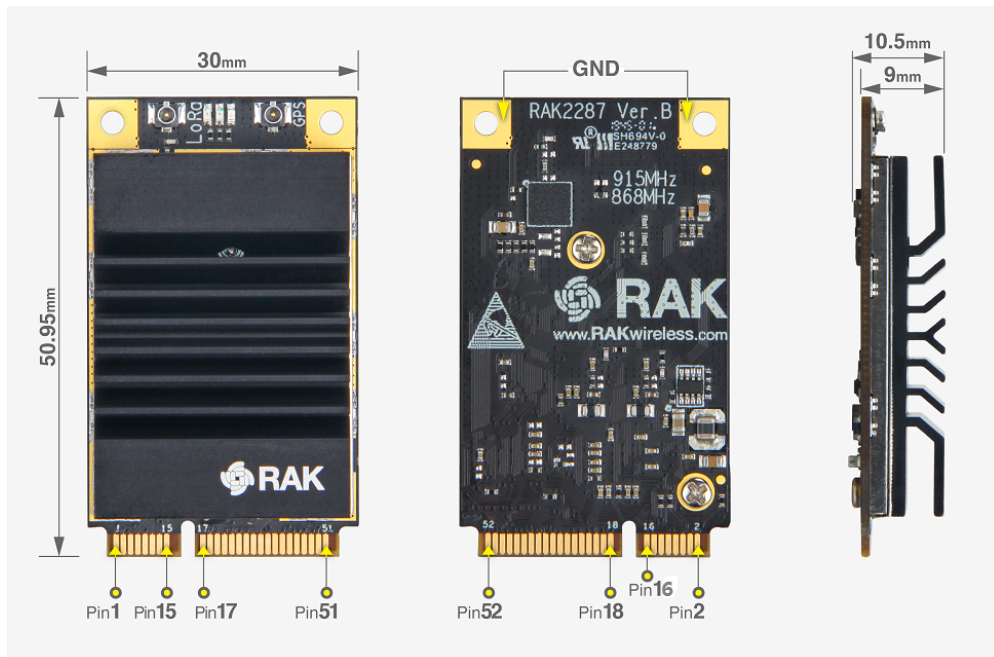


Figure 2 | Module Overview

2.2 Block Diagram

RAK2287X card integrates one ZOE-M8Q, one SX1302 chip and two SX1250 chips which represent the core of the device. This provides the related LoRa modem and processing functionalities. Additional signal conditioning circuitry is implemented for PCI Express Mini Card compliance, and two UFL connectors are available for external antennas integration.

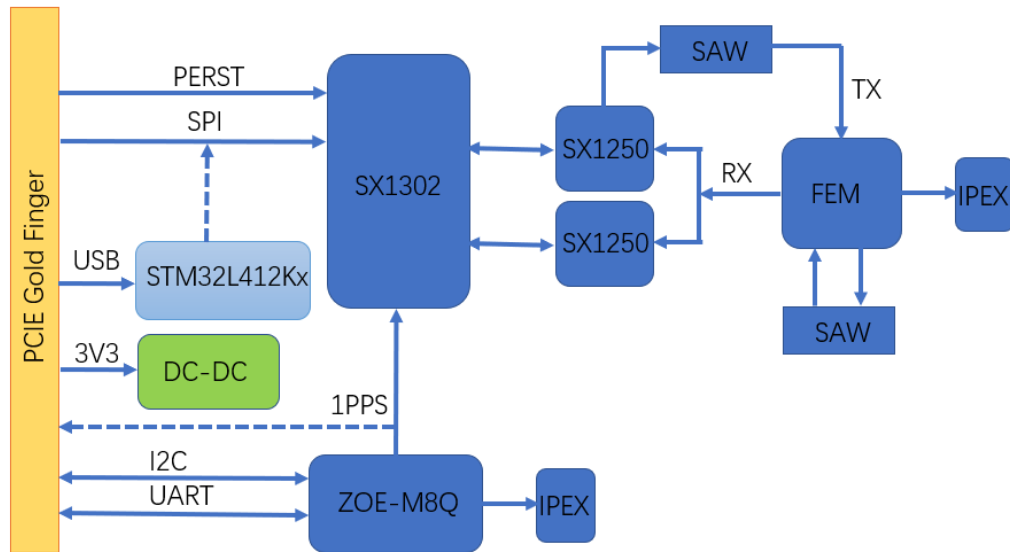


Figure 3 | RAK2287Block Diagram

2.3 Operating Frequencies

The board supports the following LoRaWAN frequency channels, allowing easy configuration while building the firmware from the source code.

Region	Freq. (MHz)
Europe	EU868
North America	US915
Asia	AS923, AS920
Australia	AU915
Korea	KR920
Indian	IN865

Table 1 | Operating Frequencies

Note: The above frequency band parameters changes in difference region to compliance with the local regulatory requirements, contract Rakwireless for detail.

2.4 Pin Definition

The following tables show the pin definition and description of RAK2287X on the 52-pin application.

Type	Description
IO	Bidirectional
DI	Digital input
DO	Digital output
OC	Open collector
OD	Open drain
PI	Power input
PO	Power output
NC	No Connection

Table 2 | Definition of I/O Parameters

Pin #	Mini PCIe PIN Rev. 2.0	RAK2287X PIN		Description	Remarks
1	WAKE#	SX1261_BUSY	DO	No Connection by default	Reserved for future applications.
2	3.3Vaux	3V3	PI	3.3V DC supply	
3	COEX1	SX1261_DIO1	IO	No Connection by default	Reserved for future applications.
4	GND	GND		Ground	
5	COEX2	SX1261_DIO2	IO	No Connection by default	Reserved for future applications.
6	1.5V	GPIO(6)	IO		Connect to SX1302's GPIO[6].
7	CLKREQ#	SX1261_NSS	DI	No Connection by default	Reserved for future applications.
8	UIM_PWR	NC		No Connection	
9	GND	GND		Ground	
10	UIM_DATA	NC		No Connection	
11	REFCLK-	SX1261_NRESET	DI	No Connection by default	Reserved for future applications.
12	UIM_CLK	NC		No Connection	
13	REFCLK+	MCU_NRESET	DI	No Connection by default	Reserved for future applications.
14	UIM_RESET	NC		No Connection	
15	GND	GND		Ground	



16	UIM_VPP	NC		No Connection	
17	RESERVED	NC		No Connection	
18	GND	GND		Ground	
19	RESERVED	PPS	DO	Time pulse output	Leave open if not used.
20	W_DISABLE#	NC		No Connection	
21	GND	GND		Ground	
22	PERST#	SX1302_RESET	DI	SX1302 reset input	Active high, $\geq 100\text{ns}$ for SX1302 reset.
23	PERn0	RESET_GPS	DI	GPS module ZOE-M8Q reset inputs	Active low, Leave open if not used.
24	3.3Vaux	3V3	PI	3.3V DC supply	
25	PERp0	STANDBY_GPS	DI	GPS module ZOE-M8Q external interrupt input	Active low, Leave open if not used.
26	GND	GND		Ground	
27	GND	GND		Ground	
28	1.5V	NC		No Connection	
29	GND	GND		Ground	
30	SMB_CLK	I2C_SCL	IO	HOST SCL	Connect to GPS module ZOE-M8Q's SCL internally. Leave open if not used.
31	PETn0	PI_UART_TX	DI	HOST UART_TX	Connect to GPS module ZOE-M8Q's UART_RX internally. Leave open if not used.
32	SMB_DATA	I2C_SDA	IO	HOST SDA	Connect to GPS module ZOE-M8Q's SDA internally. Leave open if not used.
33	PETp0	PI_UART_RX	DO	HOST UART_RX	Connect to GPS module ZOE-M8Q's UART_TX internally. Leave open if not used.
34	GND	GND		Ground	
35	GND	GND		Ground	
36	USB_D-	USB_DM	IO	USB differential data (-)	Require differential impedance of 90Ω.
37	GND	GND		Ground	
38	USB_D+	USB_DP	IO	USB differential data (+)	Require differential impedance of 90Ω.
39	3.3Vaux	3V3	PI	3.3V DC supply	
40	GND	GND		Ground	
41	3.3Vaux	3V3	PI	3.3V DC supply	
42	LED_WWAN#	NC		No Connection	
43	GND	GND		Ground	
44	LED_WLAN#	NC		No Connection	

45	RESERVED	HOST_SCK	I/O	Host SPI CLK
46	LED_WPAN#	NC		No Connection
47	RESERVED	HOST_MISO	I/O	Host SPI MISO
48	1.5V	NC		No Connection
49	RESERVED	HOST_MOSI	I/O	Host SPI MOSI
50	GND	GND		Ground
51	RESERVED	HOST_CSN	I/O	Host SPI CS
52	3.3Vaux	3V3	PI	3.3V DC supply

Table 4 | Pin Definitions

2.5 Power Supply

RAK2287X card must be supplied through the 3.3Vaux pins by a DC power supply and the voltage must be stable.

2.6 SPI Interface

SPI interface is provided on the Host_SCK, Host_MISO, Host_MOSI, Host_CSN pins of the system connector. The SPI interface gives access to the configuration register of SX1302 via a synchronous full-duplex protocol. Only the slave side is implemented.

2.7 USB Interface

RAK2287X card can support the high speed USB to SPI by STM32L412Kx, it includes a 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.

Note: RAK2287-SPI version don't have this interface.

2.8 UART and I2C interface

RAK2287X integrates ZOE-M8Q GPS module which has UART and I2C interface. The PINs on golden finger provide an UART connection and an I2C connection, which

allows direct access to the GPS module. The PPS signal is not only connected to SX1302 internally, but also connected to golden finger which can be used by host board.

2.9 **RESET**

RAK2287X card includes the RESET active-high input signal to reset the radio operations as specified by the SX1302 Specification.

2.10 **Antenna RF Interface**

The modules have two RF interfaces over standard UFL connector (Hirose U. FL-R-SMT) with the characteristic impedance of 50Ω. Port (J1) is the LoRa antenna interface and Port (J2) is the GPS 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.

2.12 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
RESET	SX1302 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
PPS	GPS pps output	Output DC voltage at PPS output pin	-0.3V	3.6V
Rho_ANT	Antenna ruggedness	Output RF load mismatch ruggedness at ANT1		10:1VSW R
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.

2.13 Maximum ESD

The table below lists the maximum ESD.

Parameter	Min	Typical	Max	Remarks
ESD_HBM			1000V	Charged Device Model JESD22-C101 CLASS III
ESD_CDM			300V	Charged Device Model JESD22-C101 CLASS III

Table 4 | Maximum ESD Ratings

ESD HANDLING: Although this module is designed to be as robust as possible, electrostatic discharge (ESD) can damage this module. This module must be protected at all times from ESD when handling or transporting. Static charges may easily produce potentials of several kilovolts on the human body or equipment, which can discharge without detection. Industry-standard ESD handling precautions should be used at all times.

2.14 Operating Conditions

The table below lists the operation temperature range.

Parameter	Min.	Typical	Max.	Remarks
Normal operating temperature	-40°C	+25°C	+85°C	Normal operating temperature range

Table 5 | Operation Temperature Range

Note: unless otherwise indicated, all operating condition specifications are at an ambient temperature of 25 ° C. Operation beyond the operating conditions is not recommended and extended exposure beyond them may affect device reliability.

The table below lists the power supply range.

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 ¹⁴	3.0 V	3.3 V	3.6 V

Table 6 | PowerSupply Range

2.15 Power Consumption

Mode	Condition	Min	AVG	Max
Active-Mode(TX)	The power of TX channel is 27dBm and 3.3V supply.	511mA	512mA	513mA
Active-Mode(RX)	TX disabled and RX enabled.	70mA	81.6 mA	101 mA

Table 7 | Power Consumption

2.16 RF Characteristics

The following table gives typically sensitivity level of the RAK2287Xcard.

Signal Bandwidth/[KHz]	Spreading Factor	Sensitivity /[dBm]
125	12	-139
125	7	-125
250	7	-123
500	12	-133
500	7	-120

Table 8 | LoRa RF Characteristics

Note: The above parameters changes in difference region to compliance with the local regulatory requirements, contract Rakwireless for detail.

3 Schematics Reference

RAK2287X card refers to Semtech's reference design of SX1302. The SPI interface or USB interface converts SPI to USB2.0 by STM32L412Kx, and can be used on PCIE connector. The next figure shows the minimum application schematic of RAK2287X card. You should use it at least 3.3V/1A DC power, connect SPI interface or USB interface to the main processor.

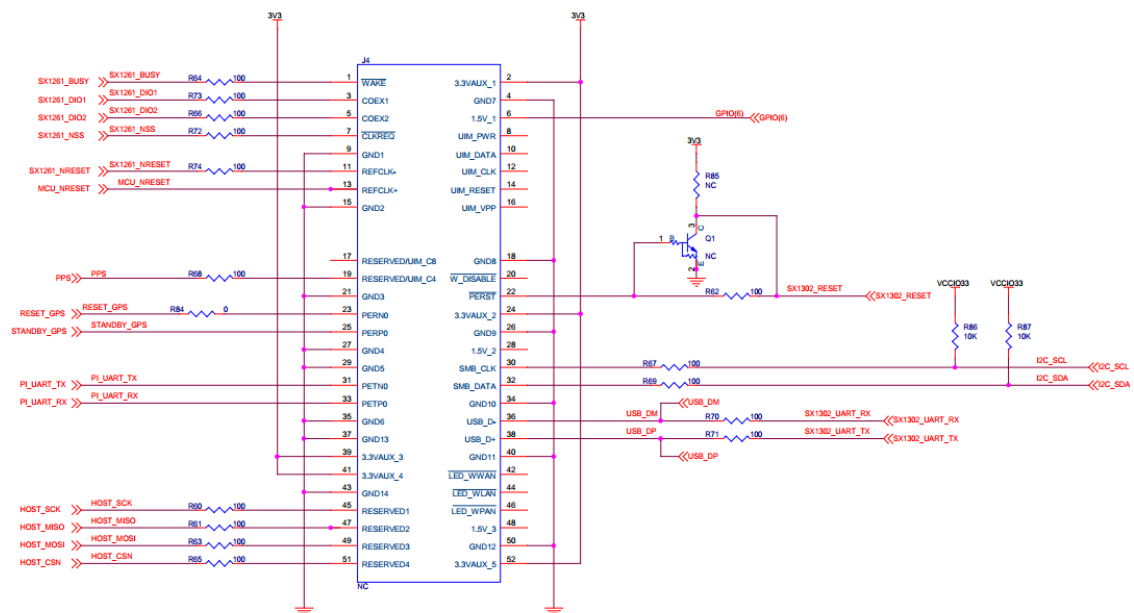


Figure 4 | RAK2287Card Minimum Schematic Reference

4 Contact Information

Document Center: <https://doc.rakwireless.com/>

Resource Downloads: <https://downloads.rakwireless.com.cn/cn/>

Forum Supports: <https://forum.rakwireless.com/>

Email: info@rakwireless.com

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.

FCC Statement:

"This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.

—Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.

—Consult the dealer or an experienced radio/TV technician for help."

INTEGRATION INSTRUCTIONS

1. This module has been tested and found to comply with the FCC Part15.247 for Modular Approval.

2. This Modular Approval is limited to OEM installation for mobile and fixed applications only. The antenna installation and operating configurations of this transmitter, including any applicable source-based time- averaging duty factor, antenna gain and cable loss must satisfy MPE categorical Exclusion Requirements of 2.1091. This modular should be installed and operated with minimum distance 20 cm between the radiator& your body.

3. The U.FL connector antenna has been approved for the modular. The maximum antenna gain is 3dBi. For situations where the host manufacturer is responsible for an external connector, the integration instructions shall inform the installer that a unique antenna connector must be used on the Part 15 authorized transmitters used in the host product.

4. 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-RAK2287X.

5. The Shenzhen Rakwireless Technology Co., Ltd. uses various test mode programs for test set up which operate separate from production firmware. Host integrators should contact Shenzhen Rakwireless Technology Co., Ltd. for assistance with test modes needed for module/host compliance test requirements.

6. The Shenzhen Rakwireless Technology Co., Ltd. modular transmitter is only FCC authorized for the FCC Part15.247 listed on the grant, and that the host product manufacturer is responsible for compliance to any other FCC rules that apply to the host not covered by the modular transmitter grant of certification. If the grantee markets their product as being Part 15 Subpart B compliant (when it also contains unintentional-radiator digital circuitry), then the grantee shall provide a notice stating that the final host product still requires Part 15 Subpart B compliance testing with the modular transmitter installed.

ISED Warning:

This device contains licence-exempt transmitter(s)/receiver(s) that comply with Innovation, Science and Economic Development Canada's licence-exempt RSS(s). Operation is subject to the following two conditions:

1. This device may not cause interference.
2. This device must accept any interference, including interference that may cause undesired operation of the device.

L'émetteur/récepteur exempt de licence contenu dans le présent appareil est conforme aux CNR d'Innovation, Sciences et Développement économique Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes :

1. L'appareil ne doit pas produire de brouillage;
2. L'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

This equipment complies with ISED radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance 20cm between the radiator & your body. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter located or operating in conjunction with any other antenna or transmitter.

Cet équipement est conforme avec les limites d'exposition à la radiation de l'ISED émises dans un environnement contrôlé. Cet équipement devrait être installé et fonctionnel avec un minimum de distance entre le radiateur et votre corps d'au moins 20 cm. Ce transmetteur ne doit pas être co-situé près d'une autre antenne ou en conjonction avec un autre transmetteur.

The host product shall be properly labelled to identify the modules within the host product. The ISED certification label of a module shall be clearly visible at all times when installed in the host product; otherwise, the host product must be labelled to display the ISED certification number for the module, preceded by the word "contains" or similar wording expressing the same meaning, as follows:

Contains IC: 25908-RAK2287X

Le numéro d'homologation d'ISDE, le NIVM, le NMP et le NIVL ne doivent pas nécessairement être adjacents.

Le numéro d'homologation se compose d'un numéro de compagnie (NC), attribué par le Bureau d'homologation et de services techniques d'ISDE, suivi du numéro de produit unique (NPU) attribué par le requérant. Le numéro d'homologation doit apparaître comme suit : IC: 25908-RAK2287X

Conformity Assessment of the Radio Module to the RED

This radio module is for professional installation only. When installing this radio module permanently into a host product to create a new radio equipment device; the manufacturer responsible for placing the final radio product on the market in the EU must assess if the combination of this radio module and the host product complies with the essential requirements of the RE Directive 2014/53/EU.

The final radio product will need to be fully assessed to Article 3.1a of the RED, for product safety

With regard to RF exposure for Article 3.1a of the RED, the manufacturer of the final radio product will need to assess if the compliance assessment of the original radio equipment/module remains relevant to the final radio product, or if further action is necessary. This equipment can transmit more than 20mW output power, if the final radio equipment is used at the distance 20cm from a person or domesticated animal as the radio module was assessed, then the final radio product assessment could conclude that the final radio product is compliant with the RF exposure requirements without additional actions. If a closer distance is used, then the final radio product assessment could not automatically conclude that the final radio product is compliant with the RF exposure requirements without additional actions; and further assessment is necessary.

The final radio product will need to be fully assessed to Article 3.1b of the RED, for EMC.

EMC testing of the radio module will have been performed on some sort of temporary host or test jig; but now the module is in a new host product and the EMC performance of the final radio product must be assessed. Most likely the host product will have its own EMC assessment for other functions, which should be performed with the radio module installed; and inclusion of the radio module into the host product will also require an assessment, such as to the relevant applicable part of EN 301 489, on the final radio product.

In theory, radio transmitter or receiver measurements made as conducted measurements at a radio module antenna port may be considered applicable to the radio performance of the final radio product. However, in this example, the radio module does not have an antenna port. The radio module has a pin which leads through a PCB trace to an antenna on the host product. If the manufacturer of the final radio product wishes to use conducted power, conducted emissions or receiver performance measurements from the radio module to show compliance of the final radio product, then they will need to exactly follow the detailed instructions from the radio module manufacturer; including input voltage, driver software, environmental conditions, antenna trace layout design construction and material, circuit board layout design construction and material, nearby circuitry, etc. In reality, it is expected that manufacturers of final radio products will need to test the output power, conducted spurious emissions and receiver performance requirements on the final radio product; and not take the results of those test cases from the radio module test reports. Radiated test cases will also need to be performed on the final radio product.

For CE:

The device belongs to receiver category 2.
Operating frequency range: 863-870MHz
Maximum output power: 13.98dBm

Manufacture name and address:

Shenzhen Rakwireless Technology Co., Ltd.
Room 506, Bldg B, New Compark, Pingshan First Road, Taoyuan Street, Nanshan District, Shenzhen

Labelling

The proposed FCC IC label format is to be placed on the module. If it is not visible when the module is installed into the system,

“Contains FCC ID: 2AF6B-RAK2287X, Contains IC: 25908- RAK2287X” shall be placed on the outside of final host system.

Labelling

— This radio transmitter [25908- RAK2287X] has been approved by Innovation, Science and Economic Development Canada 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.

— Le présent émetteur radio [25908- RAK2287X] a été approuvé par Innovation, Sciences et Développement économique Canada pour fonctionner avec les types d'antenne énumérés cidessous et ayant un gain admissible maximal. Les types d'antenne non inclus dans cette liste, et dont le gain est supérieur au gain maximal indiqué pour tout type figurant sur la liste, sont trictement interdits pour l'exploitation de l'émetteur.

Antenna info

Model	Manufacturer	Antenna Gain	Antenna Type	Connector Type
RAKARG15	Shenzhen RAKwireless Technology Co., Ltd	8dBi	Fiber Glass Antenna	N-type male connector
RAKARG14		5.8dBi	Fiber Glass Antenna	N-type male connector
RAKARJ14		2.3 dBi	Dipole Antenna	RPSMA connector

6 Revision History

Revision	Description	Date
1.0	Initial version	2018-12-21
1.1	Modify the figures, add the source code chapter	2019-01-02
1.2	Rectify mistakes	2020-02-26

7 Document Summary

Prepared by	Checked by:	Approved by:
Penn	Jeff	



About RAKwireless:

RAKwireless is a pioneer in providing innovative and diverse Cellular and LoRaWAN connectivity solutions for both Edge and Gateway IoT devices. We believe that through easy to use and modular designs we can accelerate the time to market for various IoT Applications in order to optimize system deployment in both Developer and Commercial settings.