RAK5148 WisLink LPWAN 2.4 GHz Concentrator Module Datasheet

Overview

Description

RAK5148 is a 2.4 GHz LPWAN concentrator module with a mini-PCIe form factor based on Semtech SX1280, which enables easy integration into an existing router or other network equipment with LPWAN gateway capabilities. It can be used on any embedded platform offering a free mini-PCIe slot with an SPI/USB connection. Furthermore, a ZOE-M8Q GPS chip is integrated onboard.

Features

- Designed based on a **mini-PCIe form factor**
- 3+1 SX1280 (3 for receive, 1 for transmit)
- 3.3 V **Mini PCI-e**, compatible with **3G/LTE card** of mini-PCIe type
- Tx power up to 27 dBm, Rx sensitivity down to -132 dBm @ SF12, BW 203 kHz
- Supports optional **SPI/USB** interfaces
- Fine Timestamp
- Built-in **ZOE-M8Q** GPS module (optional)

Specifications

Overview

The overview shows the top and back views of the RAK5148 board. It also presents the block diagram that discusses how the board works.

Board Overview

RAK5148 is a compact LPWAN Gateway Module suitable for integration in systems where mass and size constraints are essential. It is designed with the PCI Express Mini Card form factor in mind, so it can easily become a part of products that comply with the standard, which allows for cards with a thickness of at least 5.5 mm.

The board has two UFL interfaces for the LoRa and GNSS antennas and a standard 52-pin connector (mPCIe).
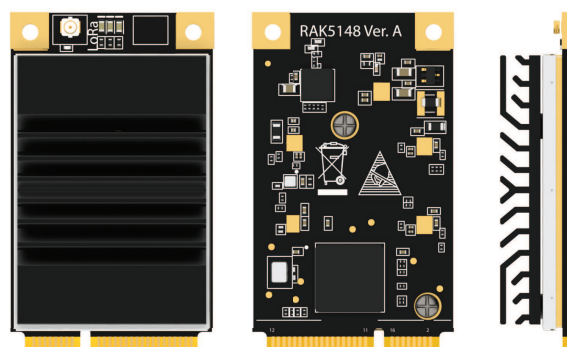

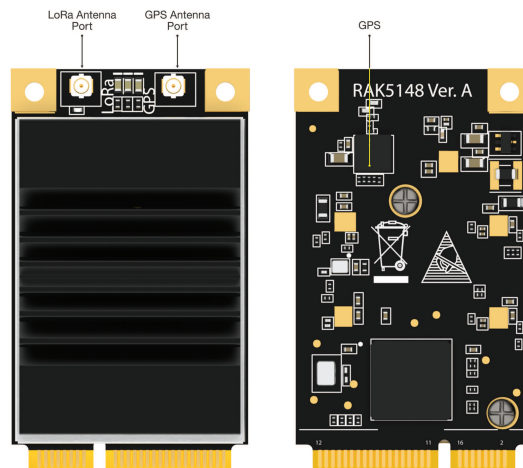
Figure 1: RAK5148 Board Overview

Figure 2: RAK5148 Antennas

Block Diagram

The RAK5148 Concentrator is equipped with four (4) SX1280 chips. Three of them work as 2.4 GHz LoRa receivers (3 channels), and one works as a transmitter.
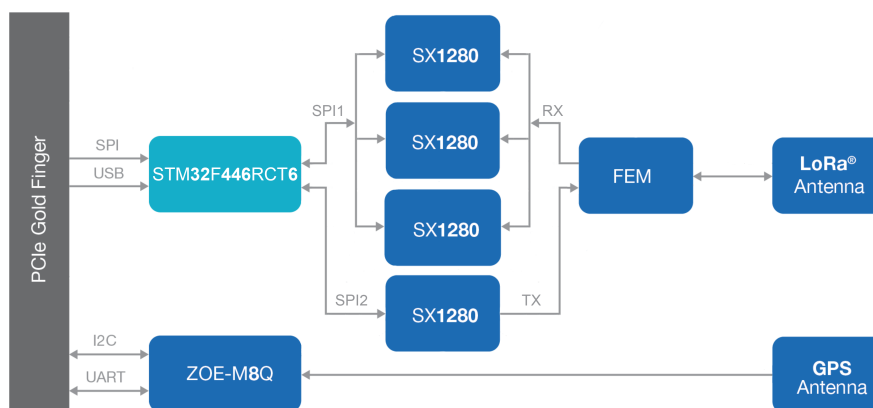

Figure 3: RAK5148 Block Diagram

Hardware

The hardware is categorized into seven parts. It discusses the interface, pinouts, and their corresponding functions and diagrams. It also covers the parameters and standard values of the board.

Interfaces

- **Power Supply** - The RAK5148 concentrator module must be supplied through the 3.3 V_{aux} pins by a DC power supply. The voltage needs to be stable since the current drawn can vary significantly during operation based on the power consumption profile of the SX1280 chip.

- **SPI Interface** - SPI interface mainly provides for the `Host_SCK`, `Host_MISO`, `Host_MOSI`, and `Host_CSN` pins of the system connector. The SPI interface gives access to the configuration register of the SX1280 via an MCU STM32F446RCT6. Only the slave side is implemented.
- **USB Interface** - The USB interface mainly provides for the `USB_D+` and `USB_D-` pins of the system connector. The USB interface gives access to the configuration register of the SX1280 via an MCU STM32F446RCT6. Only the slave side is implemented.
- **UART and I2C Interface** - RAK5148 integrates a ZOE-M8Q GPS module, which has a UART and I2C interface. The PINs on the golden finger provide a UART connection and an I2C connection, which allow direct access to the GPS module. The PPS signal is not only connected to STM32F446RCT6 internally but also connected to the golden finger which can be used by the host board.
- **GPS_PPS** - RAK5148 includes the `GPS_PPS` input for received packets time-stamped and fine-timestamped.
- **RESET** - RAK5148 USB and SPI cards' RESET is controlled by the MCU.
- **Antenna RF Interface** - The module has one RF interface over a standard UFL connector (Hirose U. FL-R-SMT) with a characteristic impedance of 50 Ω. The RF port supports both Tx and Rx, providing the antenna interface.

Pin Definition

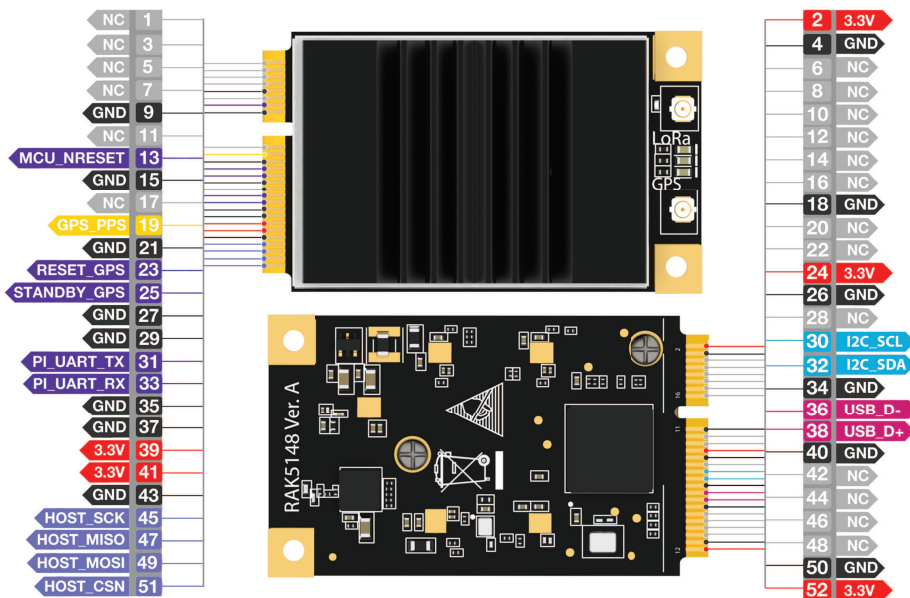**Figure 4:** RAK5148 Pinouts

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

Pin No.	mPCie Pin Rev.2.0	RAK5148 Pin	Type	Description	Remarks
1	WAKE#	NC		No connection	
2	3.3 V$_{aux}$	3V3	PI	3.3 V$_{DC}$ supply	
3	COEX1	NC		No connection	
4	GND	GND		Ground	
5	COEX2	NC		No connection	Reserved for future applications
6	1.5 V	NC		No connection	Connect to the SX1280's GPIO(6) internaly
7	CLKREQ#	NC		No connection	Reserved for future applications
8	UIM_PWR	NC		No connection	
9	GND	GND		Ground	
10	UIM_DATA	NC		No connection	
11	REFCLK-	NC		No connection	Reserved for future application
12	UIM_CLK	NC		No connection	
13	REFCLK+	MCU_NRESET	DI	RESET signal for MCU of RAK5148	Active low
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 in use
20	W_DISABLE#	NC		No connection	
21	GND	GND		Ground	
22	PERST#	NC		No connection	

Pin No.	mPCie Pin Rev.2.0	RAK5148 Pin	Type	Description	Remarks
23	PERn0	RESET_GPS	DI	GSP module ZOE-M8Q reset input	Active low, leave open if not in use
24	3.3 V_{aux}	3v3	PI	3.3 V_{DC} supply	
25	PERp0	STANDBY_GPS	DI	GPS module ZOE-M8Q external interrupt input	Active low, leave open if not in use
26	GND	GND		Ground	
27	GND	GND		Ground	
28	1.5 V	NC		No connection	
29	GND	GND		Ground	
30	SMB_CLK	I2C_SCL	IO	HOST SCL	Connect to temperature sensor and GPS module ZOE-M8Q's SCL internally Leave open if not in use
31	PETn0	PI_UART_TX	DI	HOST UART_TX	Connect to GPS module ZOE-M8Q's UART_RX internally Leave open if not in use
32	SMB_DATA	I2C_SDA	IO	HOST SDA	Connect to temperature sensor and GPS module ZOE-M8Q's SDA internally Leave open if not in use
33	PETp0	PI_UART_RX	DO	HOST UART_RX	Connect to GPS module ZOE-M8Q's UART_TX internally Leave open if not in use
34	GND	GND		Ground	
35	GND	GND		Ground	
36	USB_D-	USB_DM	IO	USB differential data (-)	Require differential impedance of 90 Ω
37	GND	GND		Ground	
38	USB_D+	USB_DP	IO	USB differential data (+)	Require differential impedance of 90 Ω
39	3.3 V_{aux}	3V3	PI	3.3 V_{DC} supply	

Pin No.	mPCie Pin Rev.2.0	RAK5148 Pin	Type	Description	Remarks
40	GND	GND		Ground	
41	3.3 V_{aux}	3V3	Pi	3.3 V_{DC} supply	
42	LED_WWAN#	NC		No connection	
43	GND	GND		Ground	
44	LED_WLAN#	NC		No connection	
45	RESERVED	HOST_SCK	IO	Host SPI SCK	
46	LED_WPAN#	NC		No connection	
47	RESERVED	HOST_MISO	IO	Host SPI MISO	
48	1.5 V	NC		No connection	
49	RESERVED	HOST_MOSI	IO	Host SPI MOSI	
50	GND	GND		Ground	
51	RESERVED	HOST_CSN	IO	Host SPI CSN	
52	3.3 V_{aux}	3V3	PI	3.3 V_{DC} supply	

RF Characteristics

The following table gives the typical Tx Power and Sensitivity Level of the RAK5148 Concentrator Module.

Parameters	Typical	Condition
Tx Power	Max: 27 dBm	-
Receiver Sensitivity	-132 dBm -110 dBm	SF12 BW 203 kHz SF7 BW 1625 kHz

Electrical Requirements

> ⚠️ **WARNING**
>
> 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 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 defines those limits 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.

Absolute Maximum Rating

The limiting values given below are following the Absolute Maximum Rating System (IEC 134).

Symbol	Description	Condition	Min	Max
3.3 V_{aux}	Module supply voltage	Input DC voltage at 3.3 V_{aux} pins	-0.3 V	3.6 V
USB	USB D+/D- pins	Input DC voltage at USB interface pins		3.6 V
MCU_RESET	RAK5148 reset input	Input DC voltage at RESET input pin	-0.3 V	3.6 V
SPI	SPI interface	Input DC voltage at SPI interface pin	-0.3 V	3.6 V
GPS_PPS	GPS 1 PPS input	Input DC voltage at GPS_PPS input pin	-0.3 V	3.6 V
HO_ANT	Antenna ruggedness	Output RF load mismatch ruggedness at ANT1		10:1 VSWR

> ⚠️ **WARNING**
>
> 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.

Maximum ESD

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

> 📝 **NOTE**
>
> Although this module is designed to be as robust as possible, electrostatic discharge (ESD) can damage the module. This module must always be protected 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.

Power Consumption

Mode	Condition	Min	Typical	Max
Active Mode(TX)	The power of the TX channel is 27 dBm and 3.3 V supply	-	-	810 mA
Active Mode(RX)	TX disabled and RX enabled	-	-	179 mA

Power Supply Range

Input voltage at **3.3 V$_{aux}$** must be above the normal operating range minimum limit to switch on the module.

Symbol	Parameter	Min	Typical	Max
3.3 V$_{aux}$	Module supply operating input voltage	3 V	3.3 V	3.6 V

Mechanical Characteristics

The board is 30 mm wide and 50.96 mm tall. The dimensions of the module fall completely within the **PCI Express Mini Card Electromechanical Specification**, except for the card's thickness (11.5 mm at its thickest including the heatsink).
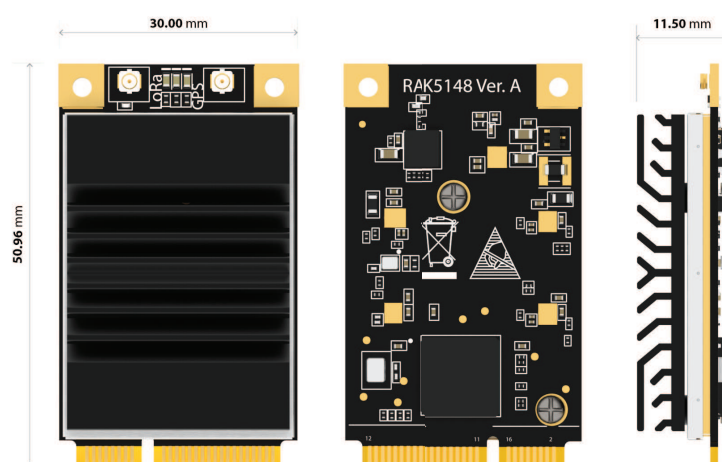

Figure 5: RAK5148 Mechanical Dimension

Environmental Requirements

Parameter	Min	Typical	Max	Remarks
Normal operating temperature	-40° C	+25° C	+85° C	Normal operating temperature range (fully functional and meet 3GPP specifications)

> 📝 **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.

Schematic Diagram

RAK5148 Concentrator Module refers to the Semtech reference design for SX1280. **Figure 6** shows the minimum application schematic of the RAK5148. You should use at least 3.3 V / 1 A DC power and connect the USB interface to the main processor.
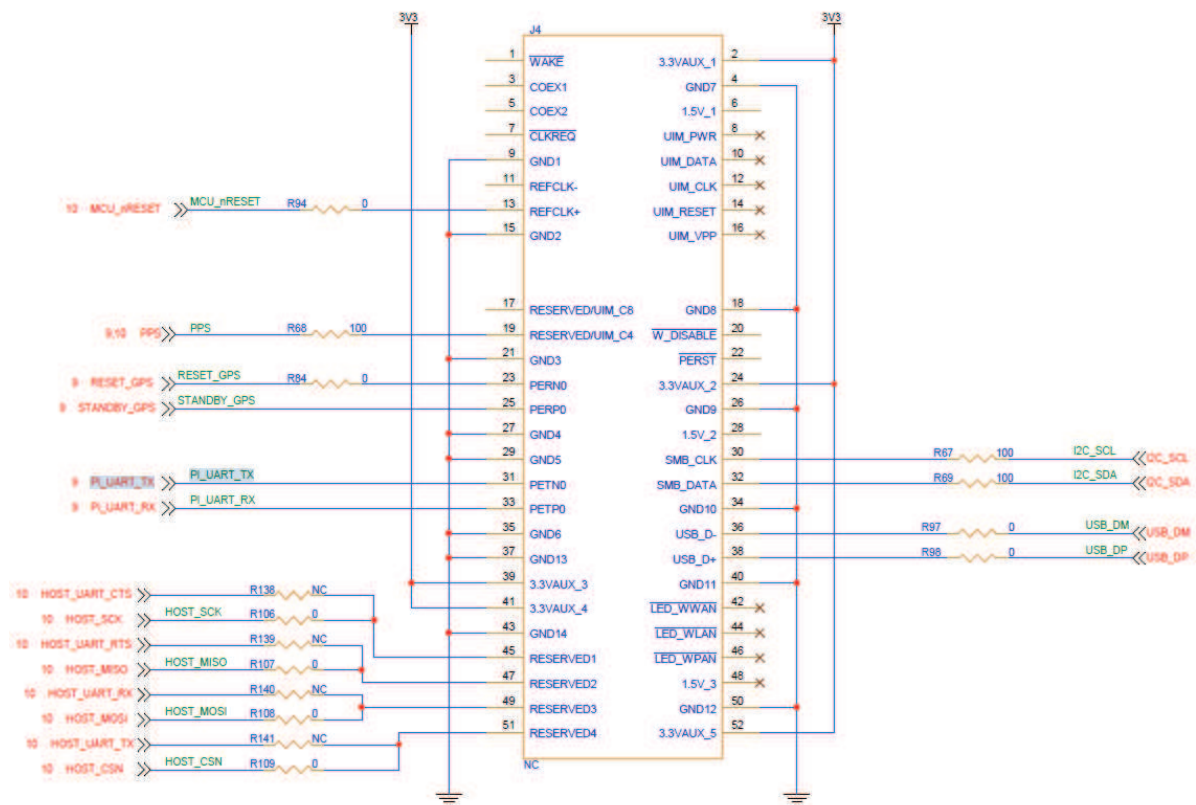
Figure 6: RAK5148 Schematic Diagram

Models/Bundles

In general, the RAK5148's variation is the defined as **RAK5148 - XY**, where **X, Y, Z is the model variant**. Refer to the following tables to know the variants and their specification.

Symbol	Description
X - Interface type	1 - SPI 2 - USB
Y - Additional features	1 - No additional features 2 - GPS
Z - MCU RESET with or without	1 - With MCU RESET 2 - Without MCU RESET

Model	USB	SPI	GPS	MCU_RESET
RAK5148-111		√		√
RAK5148-112		√		
RAK5148-121		√	√	√
RAK5148-122		√	√	
RAK5148-211	√			√
RAK5148-212	√			√
RAK5148-221	√		√	
RAK5148-222	√		√	

Last Updated: 3/17/2023, 12:45:56 PM

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 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 equipment complies with FCC & Industry Canada exposure limits set forth for an uncontrolled environment.
2. 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-RAK5148

3. 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 circuity), 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 FCC & Industry Canada exposure limits set forth for an uncontrolled environment, this Transmitter must be installed to provide a separation distance of at least 20 cm from all persons.

L'équipement est conforme aux limites d'exposition établies par fac et Industrie Canada pour les environnements non contrôlés, Cet émetteur doit être installé pour fournir une distance de séparation d'au moins 20 cm de toute personne.

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-RAK5148

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-RAK5148

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-RAK5148, Contains IC: 25908-RAK5148" shall be placed on the outside of final host system.

Labelling
— This radio transmitter [25908-RAK5148] 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-RAK5148] 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

Antenna#	Model	Antenna Gain	Manufacturer	Antenna Type
#1	RAKARX21	6dBi	Shenzhen RAKwireless Technology Co., Ltd.	External Rod Antenna
#2	RAKARW02	8dBi	Shenzhen RAKwireless Technology Co., Ltd.	External Omni Antenna