

RAK5167 WisLink LPWAN Concentrator Datasheet

Overview

Product Description

The **RAK5167** is an LPWAN Concentrator Module with PCI Express M.2 Type 2280 form factor and Key B-M Dual Key IDs based on Semtech SX1303 and SX126X for Listen Before Talk feature, which enables easy integration into an existing router or other network equipment with LPWAN Gateway capabilities. It can be used in any embedded platform offering a free PCIe M.2 slot with a USB connection. Furthermore, the ZOE-M8Q GPS chip is integrated onboard.

This module is an exceptional, complete, and cost-efficient gateway solution offering up to 10 programmable parallel demodulation paths, 8 x 8 channel LoRa packet detectors, 8 x SF5-SF12 LoRa demodulators, and 8 x SF5-SF10 LoRa demodulators. It is capable of detecting an uninterrupted combination of packets at 8 different spreading factors and 10 channels with continuous demodulation of up to 16 packets. This product is best for smart metering fixed networks and Internet-of-Things (IoT) applications.

Product Features

- Designed based on **PCI Express M.2 Type 2280 form factor** and **Key B-M Dual Key IDs**
- **SX1303 baseband processor** emulates 8 x 8 channels LoRa packet detectors
- 8x SF5-SF12 LoRa demodulators
- 8x SF5-SF10 LoRa demodulators
- High-speed 125/250/500 kHz LoRa demodulator
- (G)FSK demodulator
- 3.3 V **PCI Express M.2**
- Compatible with Type 2280 Socket 2 Key B-M PCIe-based WWAN Module
- Tx power up to 27 dBm
- Rx sensitivity down to -139 dBm @ SF12, BW 125 kHz

- Supports **global license-free frequency band** (EU868, IN865, RU864, US915, AU915, KR920, AS923-1, AS923-2, AS923-3, AS923-4)
- Supports **USB** interfaces
- Listen Before Talk
- Fine Timestamp
- Built-in **ZOE-M8Q** GPS module

Specifications

Overview

The overview shows the top and back views of the RAK5167 board. It also presents the block diagram that discusses how the board works.

Board Overview

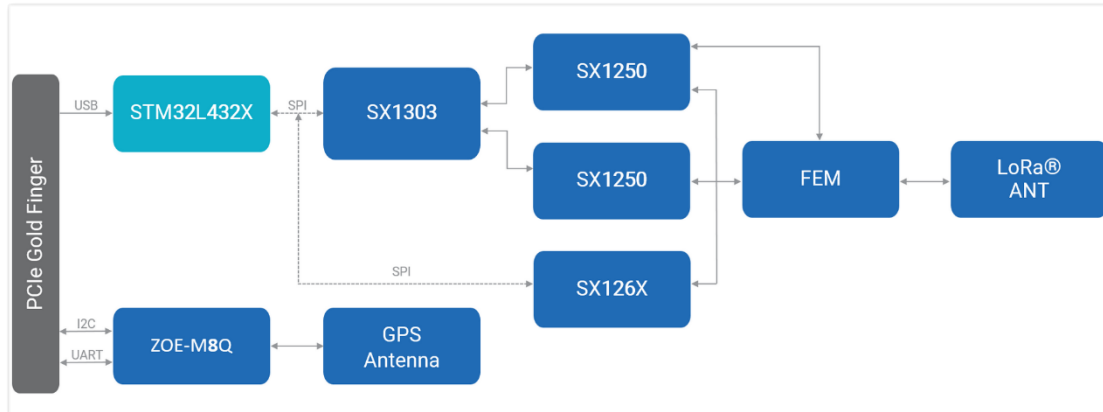
RAK5167 is a compact LPWAN Gateway Module, making it suitable for integration in systems where mass and size constraints are essential. It has been designed with the PCI Express M.2 Type 2280 form factor in mind, so it can easily become a part of products that comply with the standard, where they allow cards with a thickness of at least 3.7 mm.

The board has two MHF4 IPEX connectors for the LoRa and GNSS antennas and a standard 75-pin connector (M.2) with Key B-M Dual Key IDs.



Block Diagram

The RAK5167 concentrator is equipped with one SX1303 chip and two SX1250. The first chip is utilized for the RF signal and the core of the device, while the latter provides the related LoRa modem and processing functionalities. Additional signal conditioning circuitry is implemented for PCI Express M.2 compliance, and two MHF4 IPEX connectors are available for external antenna integration.



Hardware

The hardware is categorized into seven (7) parts. It discusses the interfacing, pinouts, and their corresponding functions and diagrams. It also covers the parameters and standard values of the board.

Interfaces

- **Power Supply** - The RAK5167 concentrator module must be supplied through the 3.3Vaux 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 SX1303 chip (for more information, see the [SX1303 Datasheet](#)).
- **USB Interface** - The USB interface mainly provides for the USB_D+, USB_D- pins of the system connector. The USB interface gives access to the configuration register of SX1303 via an MCU STM32L412KBU6. Only the slave side is implemented.
- **UART and I2C Interface** - RAK5167 integrates a ZOE-M8Q GPS module which has UART and I2C interface. The PINs on the golden finger provide a UART connection and an I2C connection, which allows direct access to the GPS module. The PPS signal is not only

connected to SX1303 internally but also connected to the golden finger which can be used by the host board.

- **GPS_PPS** - RAK5167 reserved the GPS_PPS input for received packets time-stamped and Fine timestamp.
- **MCU RESET** - RAK5167 USB card includes the RESET active-low input signal to reset the MCU. SX1303's RESET is controlled by MCU to reset the radio operations as specified by the SX1303 Specification.
- **Antenna RF Interface** - The module has two RF interfaces over a standard MHF4 IPEX connector with a characteristic impedance of 50 Ω . The RF port (J1) supports both Tx and Rx, providing the antenna interface for LoRa. The RF port (J2) provides the antenna interface for GPS.

Pin Definition

Pinout Diagram



Pinout Description

Type	Description
IO	Bidirectional
DI	Digital input
DO	Digital output
OC	Open collector

Type		Description		
OD		Open drain		
PI		Power input		
PO		Power output		
NC		No connection		
Pin No.	RAK5167 Pin	Type	Description	Remarks
1	NC (CONFIG_3=GND)		No connection by default	Reserved for CONFIG_3
2	3.3 V	PI	3.3 V _{DC} supply	
3	GND		Ground	
4	3.3 V	PI	3.3 V _{DC} supply	
5	GND		Ground	
6	NC		No connection	
7	USB_D+	IO	USB differential data (+)	Require differential impedance of 90 Ω
8	NC		No connection	
9	USB_D-	IO	USB differential data (-)	Require differential impedance of 90 Ω
10	NC		No connection	
11	GND		Ground	
			KEY-B Notch	
20	NC		No connection	
21	NC (CONFIG_0=GND)		No connection by default	Reserved for CONFIG_0
22	NC		No connection	

Pin No.	RAK5167 Pin	Type	Description	Remarks
23	NC		No connection	
24	NC		No connection	
25	NC		No connection	
26	NC		No connection	
27	GND		Ground	
28	NC		No connection	
29	NC		No connection	
30	NC (Optional: MCU_RESET)		No connection by default	Reserved for MCU_RESET
31	NC		No connection	
32	NC		No connection	
33	GND		Ground	
34	NC		No connection	
35	NC		No connection	
36	NC		No connection	
37	NC		No connection	
38	NC		No connection	
39	GND		Ground	
40	NC (Optional: I2C_SCL)		No connection by default	Reserved for connecting to GPS module ZOE-M8Q's I2C_SCL internally
41	NC		No connection	
42	NC (Optional: I2C_SDA)		No connection by default	Reserved for connecting to GPS module

Pin No.	RAK5167 Pin	Type	Description	Remarks
				ZOE-M8Q's I2C_SDA internally
43	NC		No connection	
44	NC		No connection	
45	GND		Ground	
46	GPS_RESET	DI	GSP module ZOE-M8Q reset input	Active low, leave open if not in use
47	NC		No connection	
48	NC (Optional: 1PPS)		No connection by default	Reserved for GPS module Time pulse output
49	NC		No connection	
50	MCU_RESET	DI	RESET signal for MCU of RAK5167	Active low
51	GND		Ground	
52	HOST_UART_RX	DO	HOST_UART_RX	Connect to GPS module ZOE-M8Q's UART_TX internally, leave open if not in use
53	NC		No connection	
54	HOST_UART_TX	DI	HOST_UART_TX	Connect to GPS module ZOE-M8Q's UART_RX internally,

Pin No.	RAK5167 Pin	Type	Description	Remarks
				leave open if not in use
55	NC		No connection	
56	NC (Optional: 1PPS)		No connection by default	Reserved for GPS module Time pulse output
57	GND		Ground	
58	NC		No connection	
			KEY-M Notch	
67	NC		No connection	
68	NC		No connection	
69	NC (CONFIG_1=GND)		No connection by default	Reserved for CONFIG_1
70	3.3 V	PI	3.3 V _{DC} supply	
71	GND		Ground	
72	3.3 V	PI	3.3 V _{DC} supply	
73	GND		Ground	
74	3.3 V	PI	3.3 V _{DC} supply	
75	NC (CONFIG_2=GND)		No connection by default	Reserved for CONFIG_2

LED Definition



RF Characteristics

Operating Frequencies

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

Region	Frequency (MHz)
Europe	EU868
North America	US915
Asia	AS923
Australia	AU915
Korea	KR920
India	IN865

Sensitivity Level

The following table gives the typically sensitivity level of the RAK5167 Concentrator Module.

Signal Bandwidth (kHz)	Spreading Factor	Sensitivity (dBm)
125	12	-139
125	7	-125
250	7	-123
500	12	-134
500	7	-120

Electrical Requirements

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
3V3	Module supply voltage	Input DC voltage at 3V3 pins	- 0.3 V	3.6 V
USB	USB D+/D- pins	Input DC voltage at USB interface pins	-	3.6 V
MCU_RESET	RAK5167 reset input	Input DC voltage at RESET input 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
Rho_ANT	Antenna ruggedness	Output RF load mismatch ruggedness at ANT1	-	10:1 VSWR
Tstg	Storage temperature		- 40° C	85° C

Warning :

The product is not protected against over voltage or reversed voltages. If necessary, voltage spikes exceeding the power supply voltage

specification, given in the 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 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.

Power Consumption

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

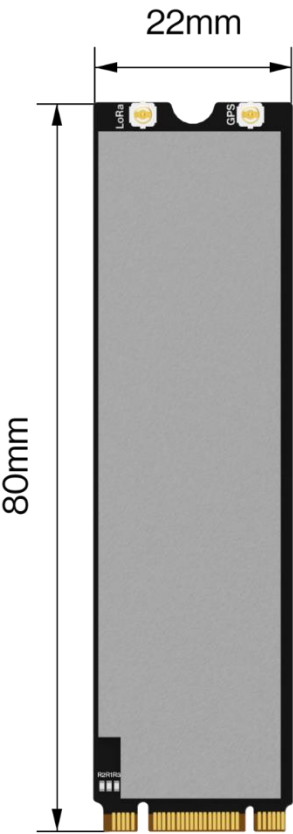
Power Supply Range

Input voltage at **3V3** must be above the normal operating range minimum limit to switch on the module.

Symbol	Parameter	Min	Typical	Max
3V3	Module supply operating input voltage	3 V	3.3 V	3.6 V

Mechanical Characteristics

The board weighs 8.2 grams, it is 22 mm wide and 80 mm tall. The dimensions of the module fall completely within the PCI Express M.2 Card Electromechanical Specification, except for the card's thickness (3.7 mm at its thickest).



Environmental Requirements

Operating Conditions

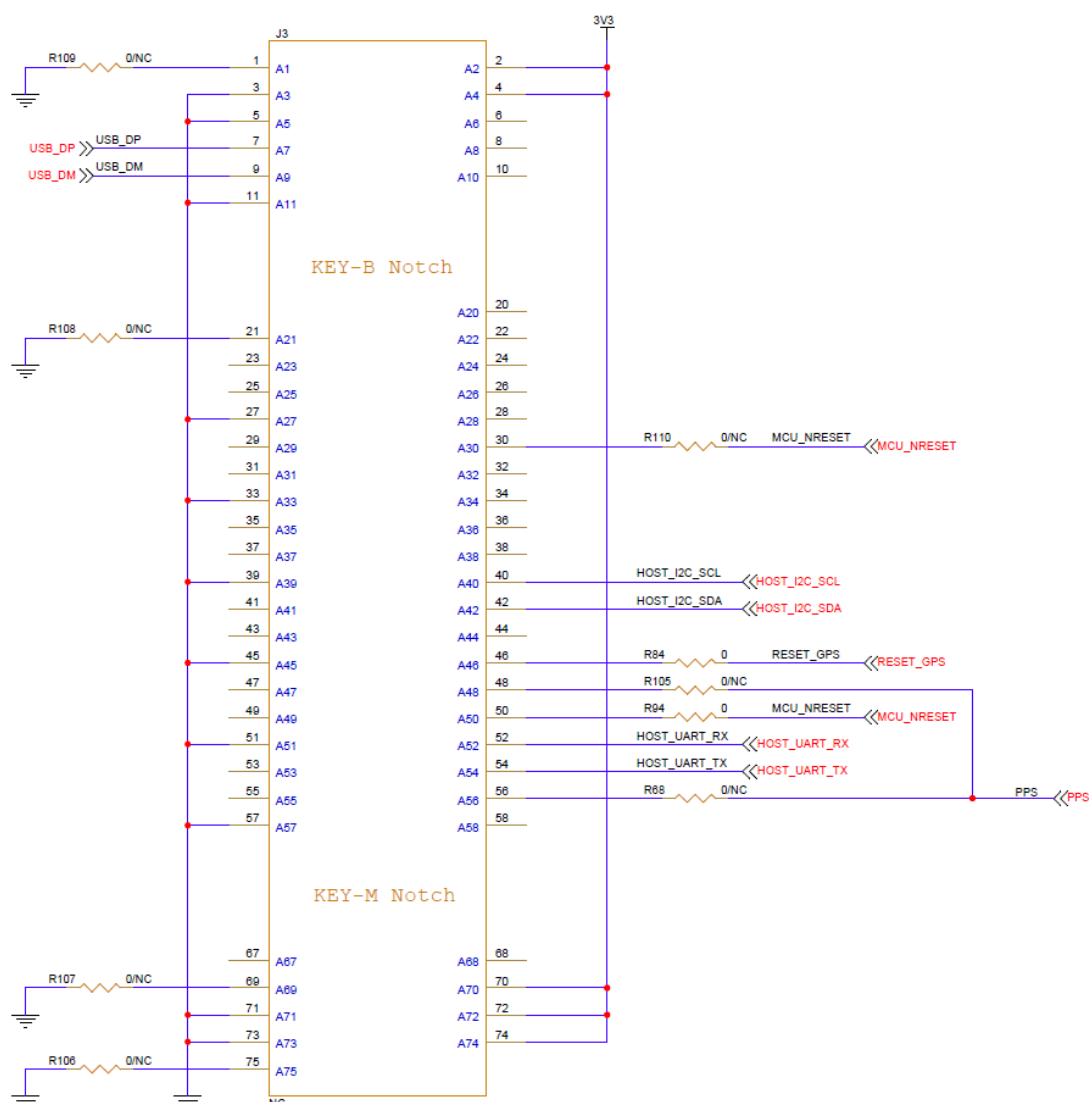
Parameter	Min	Typical	Max	Remarks
Normal operating temperature	-40° C	+25° C	+85° C	Normal operating temperature range (fully functional and meet 3GPP specifications)

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

RAK5167 M.2 concentrator module was designed by RAKWireless for SX1303. The USB interface can be used on the M.2 connector. **Figure 6** shows the minimum application schematic of the RAK5167. You should use at least 3.3 V / 1 A DC power, connect the USB interface to the main processor.



Models / Bundles

In general, the RAK5167's variation is defined as **RAK5167 - XYZ**, where **X**, **Y**, **Z** is the model variant. Take a look at the tables below to know the variants and their specification.

Symbol	Description	
X - Supported region	1 - US915; 2 - EU868	
Y - GPS Module	1 - GPS; 2 - No GPS	
Z - Additional features	0 - No additional features;	
Model	Frequency	GPS
RAK5167-110	US915	√
RAK5167-120	US915	
RAK5167-210	EU868	√
RAK5167-220	EU868	

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.

This equipment complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

- (1) This device may not cause harmful interference, and
 - (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.

2.2

This module has been assessed against the following FCC rule parts: CFR 47 FCC Part 15 C (15.247, DTS). It is applicable to the modular transmitter

2.3

This radio transmitter 2AF6B-5167 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.

The concrete contents to check are the following three points.

- 1) Maximum antenna gains are shown in item 2.7 below.
- 2) Should be installed so that the end user cannot modify the antenna
- 3) Feed line should be designed in 50ohm

Fine-tuning of return loss etc. can be performed using a matching network.

The antenna shall not be accessible for modification or change by the end user.

2.4

The module complies with FCC Part 15.247 and apply for Single module approval.

2.5

Trace antenna designs: Not applicable, the antenna connector for this module are integrated into the module.

2.6

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

2.7

The following antennas have been certified for use with this module.

Only antennas of the same type with equal or lower gain may also be used with this module.

Other types of antennas and/or higher gain antennas may require the additional authorization for operation. The installer should use unique antenna connector and 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. The manufacturer of module will inform installer to meet with the FCC part 15.203 in the warning part.

Antenna Specification list below:

Antenna	Model No.	Frequency (MHz)	Antenna Type	MAX Antenna Gain (dBi)
1	RAKARG15	923.3 – 927.5	Fiber Glass Antenna	8.0
2	RAKARG14	923.3 – 927.5	Fiber Glass Antenna	5.8
3	RAKARG19	923.3 – 927.5	Fiber Glass Antenna	5.1
4	RAKARJ14	923.3 – 927.5	Blade Antenna	2.3
5	RAKARJ16	923.3 – 927.5	Blade Antenna	2.3

Cable	Model No.	Frequency (MHz)	Cable Loss (dB)
1	RPSMA-C-J3/N-C-K316-1-1000m	923.3 – 927.5	-1
2	SLEingC100660088-C01	923.3 – 927.5	-0.63

2.8

Please notice that if the FCC identification number is not visible when the module is installed inside another device, then the outside of the device into which the module is installed must also display a label referring to the enclosed module. This exterior label can use wording such as “Contains FCC ID: 2AF6B-5167”; any similar wording that expresses the same meaning may be used.

2.9

Testing of the host product with all the transmitters installed – referred to as the composite investigation test- is recommended, to verify that the host product meets all the applicable FCC rules. The radio spectrum is to be investigated with all the transmitters in the final host product functioning to determine that no emissions exceed the highest limit permitted for any one individual transmitter as required by Section 2.947(f). The host manufacturer is responsible to ensure that when their product operates as intended it does not have any emissions present that are out of compliance that were not present when the transmitters were tested individually.

If the modular transmitter has been fully tested by the module grantee on the required number of channels, modulation types, and modes, it should not be necessary for the host installer to re-test all the available transmitter modes or settings. It is recommended that the host product manufacturer, installing the modular transmitter, perform some investigative measurements to confirm that the resulting composite system does not exceed the spurious emissions limits or band edge limits (e.g., where a different antenna may be causing additional emissions).

The testing should check for emissions that may occur due to the intermixing of emissions with the other transmitters, digital circuitry, or due to physical properties of the host product (enclosure). This investigation is especially important when integrating multiple modular transmitters where the certification is based on testing each of them in a stand-alone configuration.

2.10

Any company of the host device which install this modular should perform the test of radiated & conducted emission and spurious emission etc. according to FCC Part 15C: 15.247 and 15.209 & 15.207, 15B class B requirement, only if the test result comply with FCC part 15C: 15.247 and 15.209 & 15.207, 15B class B requirement. Then the host can be sold legally.

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.

2.11

The host manufacturer is recommended to use FCC KDB 996369 D04 Module Integration Guide recommending as "best practice" RF design engineering testing and evaluation in case non-linear interactions generate additional non-compliant limits due to module placement to host components or properties.

2.12

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.

Canada Statement

This device complies with Industry Canada's license-exempt RSSs. Operation is subject to the following two conditions:

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

Le présent appareil est conforme aux CNR d'Industrie 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'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Please notice that if the ISED certification number is not visible when the module is installed inside another device, then the outside of the device into which the module is installed must also display a label referring to the enclosed module. This exterior label can use wording such as the following: "Contains IC: 25908-5167" any similar wording that expresses the same meaning may be used.

l'appareil hôte doit porter une étiquette donnant le numéro de certification du module d'Industrie Canada, précédé des mots « Contient un module d'émission », du mot « IC: 25908-5167 » ou d'une formulation similaire exprimant le même sens, comme suit

The device meets the exemption from the routine evaluation limits in section 2.5 of RSS 102 and compliance with RSS-102 RF exposure, users can obtain Canadian information on RF exposure and compliance.
Le dispositif rencontre l'exemption des limites courantes d'évaluation dans la section 2.5 de RSS 102 et la conformité à l'exposition de RSS-102 RF, utilisateurs peut obtenir l'information canadienne sur l'exposition et la conformité de rf.

This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter. This equipment should be installed and operated with a minimum distance of 20 centimeters between the radiator and your body.

Cet émetteur ne doit pas être Co-placé ou ne fonctionnant en même temps qu'aucune autre antenne ou émetteur. Cet équipement devrait être installé et actionné avec une distance minimum de 20 centimètres entre le radiateur et votre corps.

This radio transmitter [IC: 25908-5167] 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.

The concrete contents to check are the following three points.

- 1) Maximum antenna gains are shown in following table.
- 2) Should be installed so that the end user cannot modify the antenna;
- 3) Feed line should be designed in 50ohm

Fine-tuning of return loss etc. can be performed using a matching network.

Le présent émetteur radio [IC: 25908-5167] a été approuvé par Innovation, Sciences et Développement économique Canada pour fonctionner avec les types d'antenne énumérés ci-dessous 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 strictement interdits pour l'exploitation de l'émetteur.

Le contenu concret à vérifier sont les trois points suivants.

- 1) Les gains maximaux d'antenne sont montrés dans le tableau suivant.
- 2) doivent être installés de façon que l'utilisateur final ne peut pas modifier l'antenne
- 3) La ligne d'alimentation doit être conçue en 50ohm

Le réglage précis de la perte de rendement, etc. peut être effectué en utilisant un réseau correspondant..

Antenna	Model No.	Frequency (MHz)	Antenna Type	MAX Antenna Gain (dBi)
1	RAKARG15	923.3 – 927.5	Fiber Glass Antenna	8.0
2	RAKARG14	923.3 – 927.5	Fiber Glass Antenna	5.8
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2	SLEingC100660088-C01	923.3 – 927.5	-0.63

Notice to OEM integrator

Must use the device only in host devices that meet the FCC/ISED RF exposure category of mobile, which means the device is installed and used at distances of at least 20cm from persons.

This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

The end user manual shall include FCC Part 15 /ISED RSS GEN compliance statements related to the transmitter as show in this manual(FCC/Canada statement).

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, ICES 003.

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

The use condition limitations extend to professional users, then instructions must state that this information also extends to the host manufacturer's instruction manual.

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

Must have on the host device a label showing Contains FCC ID: 2AF6B-5167 or IC: 25908-5167

l'hôte doit utiliser l'instrument uniquement dans des dispositifs qui répondent à la fcc / (catégorie d'exposition rf mobile, ce qui signifie le dispositif est installé et utilisé à une distance d'au moins 20 cm de personnes.

le manuel de l'utilisateur final doit inclure la partie 15 / (fac rss gen déclarations de conformité relatives à l'émetteur que de montrer dans ce manuel.

le fabricant est responsable de la conformité de l'hôte, le système d'accueil avec le module installé avec toutes les autres exigences applicables du système comme la partie 15 b, ices - 003.

accueillir le fabricant est fortement recommandé de confirmer la conformité avec les exigences de la fcc / (émetteur lorsque le module est installé dans l'hôte.

le dispositif d'accueil doivent avoir une étiquette indiquant contient FCC ID: 2AF6B-5167, IC: 25908-5167

Doit avoir sur l'appareil hôte une étiquette indiquant Contient l'ID FCC 2AF6B-5167 ou IC : 25908-5167 L'ID FCC et l'ID IC ne doivent pas être placés sur l'hôte en même temps et seuls les hôtes se rendant aux États-Unis peuvent utiliser l'ID FCC et seuls les hôtes se rendant au Canada peuvent utiliser l'ID IC.

Professional Installation Instructions

The device must be professionally installed. Installation must be controlled and requires special training.

The intended use is generally not for the general public. It is generally for industry/commercial use.

Instructions d'installation professionnelle

Le dispositif doit être installé par du personnel qualifié. L'installation est soumise à un contrôle rigoureux et nécessite une formation spécialisée.

Son utilisation prévue n'est généralement pas destinée au grand public, mais plutôt à un usage industriel ou commercial.