

RAK5166 WisLink LPWAN Concentrator Datasheet

Overview

Product Description

The **RAK5166** is an LPWAN Concentrator Module with PCI Express M.2 Type 3042 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 3042 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
- Gigh-speed 125/250/500 kHz LoRa demodulator
- (G)FSK demodulator
- **3.3 V PCI Express M.2**
- Compatible with Type 3042 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, AS923-1/2/3/4)
- 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 RAK5166 board. It also presents the block diagram that discusses how the board works.

Board Overview

RAK5166 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 3042 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.

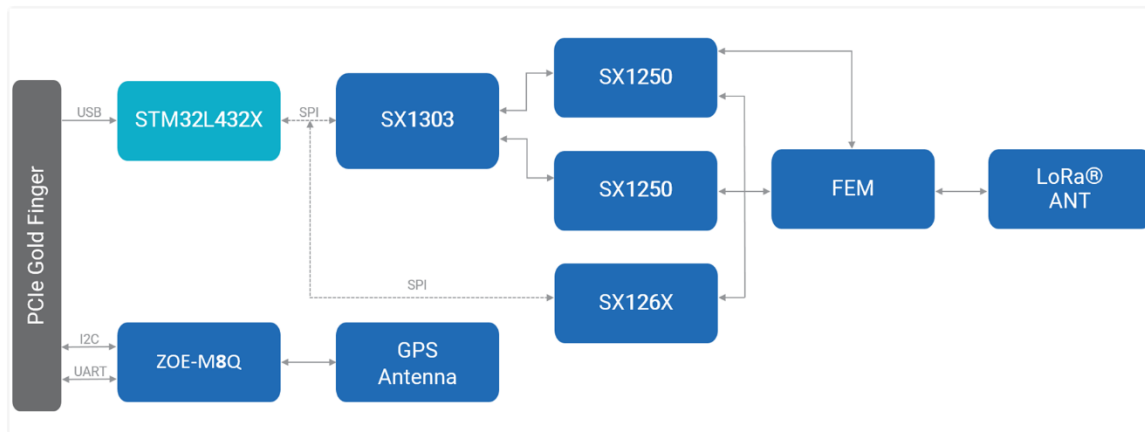
The board has two MHF4 IPEX connectors for the LoRa and GNSS antennas and a standard 75-pin connector (M.2) with Key B-M Dual Key IDs.



Block Diagram

The RAK5166 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

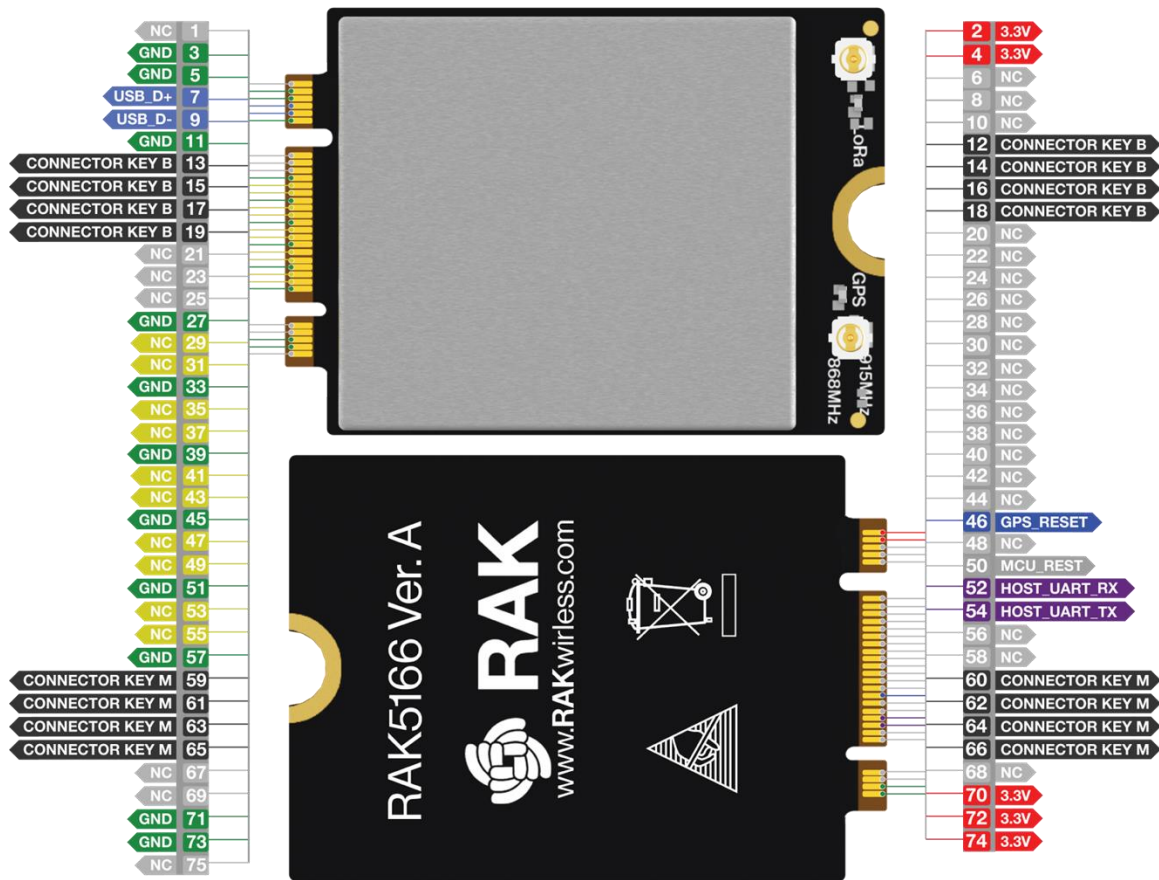
The hardware is categorized into seven (7) parts. It discusses the interfacing, pinouts, and their corresponding functions and diagrams. It also covers the parameters and standard values of the board.

Interfaces

- Power Supply** - The RAK5166 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** - RAK5166 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** - RAK5166 reserved the GPS_PPS input for received packets time-stamped and Fine timestamp.
- MCU RESET** - RAK5166 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
OD	Open drain
PI	Power input
PO	Power output
NC	No connection

Pin No.	RAK5166 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

Pin No.	RAK5166 Pin	Type	Description	Remarks
22	NC		No connection	
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	

Pin No.	RAK5166 Pin	Type	Description	Remarks
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 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 RAK5166	Active low

Pin No.	RAK5166 Pin	Type	Description	Remarks
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, 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		No connection	Reserved for

Pin No.	RAK5166 Pin	Type	Description	Remarks
	(CONFIG_1=GND)		by default	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

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 typically sensitivity level of the RAK5166 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	RAK5166 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

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

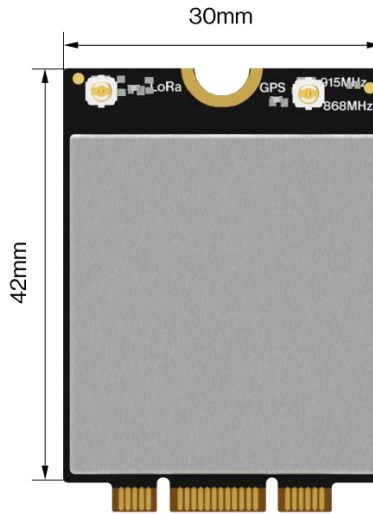
Power Supply Range

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 5.9 grams, and it is 30 mm wide and 42 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

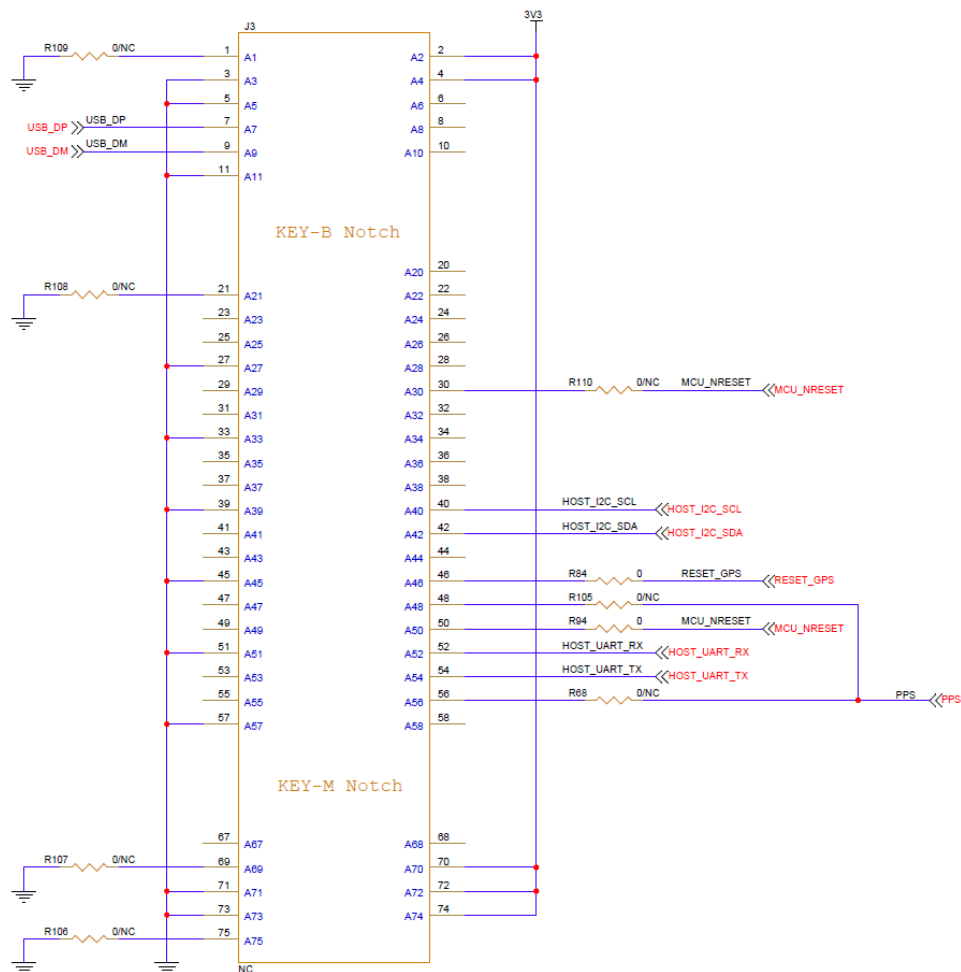
Parameter	Min	Typical	Max	Remarks
Normal operating temperature	-40° C	+25° C	+85° C	Normal operating temperature range (fully functional and meet 3GPP specifications)

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

RAK5166 M.2 concentrator module was designed by RAKWireless for SX1303. The USB interface can be used on the M.2 connector. **Figure 5** shows the minimum application schematic of the RAK5166. You should use at least 3.3 V / 1 A DC power, and connect the USB interface to the main processor.



Models / Bundles

In general, the RAK5166's variation is defined as **RAK5166 - XYZ**, where **X**, **Y**, **Z** are the model variants. 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
RAK5166-110	US915	√
RAK5166-120	US915	
RAK5166-210	EU868	√
RAK5166-220	EU868	