

User Manual for

WisLink-LoRa Concentrator Module

Mini-PCIe Edition

RAK2247 SPI/USB

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1 Overview

1.1 Introduction

RAK2247 is a LoRa concentrator module with mini-PCIe form factor based on SX1301. This enables easy integration to existing routers and other network equipment with LoRa Gateway capabilities, and can be used in any embedded platform offering mini-PCIe slot with SPI or USB connection.

This module is a complete and cost efficient LoRa gateway solution offering up to 10 programmable parallel demodulation paths. 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. 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.

1.2 Main Features

- Compatible with Mini PCI-e Edition specification with heat sink.
- SX1301 base band processor emulates 49 x LoRa demodulators, 10 parallel demodulation paths. It supports 8 uplinks channel and 1 downlink channel.
- 2 x SX125x Tx/Rx front-ends high/low frequency.
- Built-in FT2232H to convert SPI interface of SX1301 to USB 2.0.
- Voltage of Mini PCI-e is 3.3 V, compatible with 3G/LTE card of Mini PCI-e type.
- Tx power up to 25 dBm, Rx sensitivity down to -139 dBm @ SF12, BW 125 kHz.
- Supports latest LoRaWAN 1.0.2 protocol.
- Supports global license-free frequency band (EU433, CN470, EU868, US915, AS923, AU915, KR920, IN865 and AS920).
- Supports optional SPI or USB interfaces.

1.3 Package Contents



RAK2247 board
(1x)



iPEX LoRa Antenna
(1x)

Figure 1 | Package Contents

2 WisLink LoRa Module RAK2247

2.1 Overview

The module which is the mini-PCIe edition as shown below. The outer dimension of the RAK2247 is 50.95 x 30.0 x 10.4mm (nominal value). The board with 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. And the thickness 10.4mm includes the 8mm heat sink.

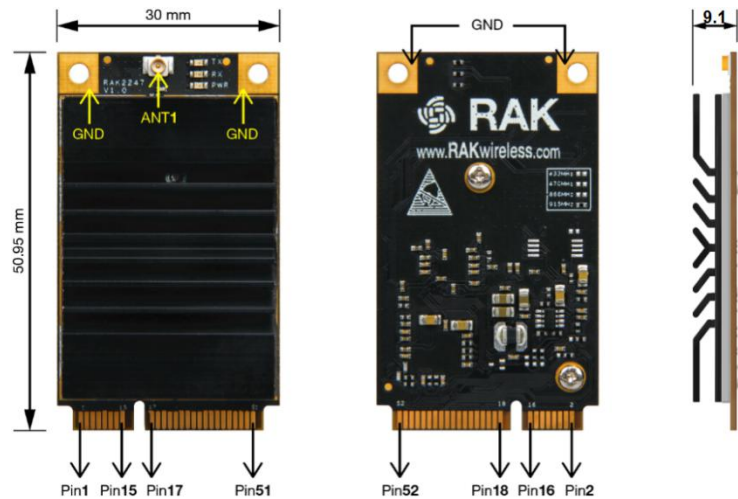


Figure 2 | Module Overview

2.2 Block Diagram

RAK2247 card integrates one SX1301 chip and two SX125X. The other chip is for RF signal, which represents 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 one UFL connectors are available for external antennas integration.

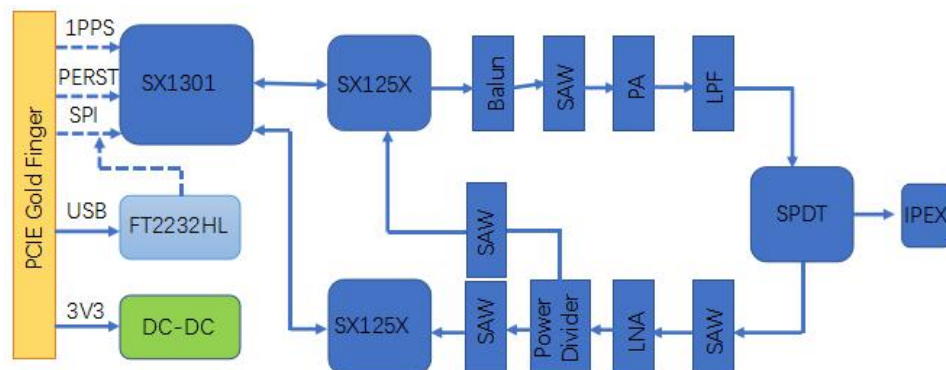


Figure 3 | RAK2247 Block Diagram

2.3 Mini-PCle Interface

RAK2247 is compliant to 52-pin PCI Express Full-Mini Card Type F2 form factor, with top-side and bottom-side keep-out areas. The pin configuration is defined below:

Item	Pin(s)
GND	4, 9, 15, 18, 21, 26, 27, 29, 34, 35, 37, 40, 43, 50
3.3V	2, 24, 39, 41, 52
1PPS	19
RESET	22
USB_D-	36
USB_D+	38
SPI_SCK	45
SPI_MISO	47
SPI_MOSI	49
SPI_CSN	51

Table 1 | Mini-PCle Pins

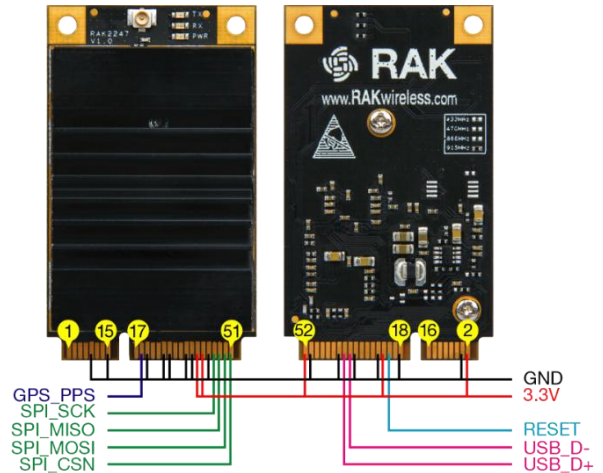


Figure 4 | Mini-PCle Interface

2.4 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	EU433, EU868
China	CN470
North America	US915
Asia	AS923, AS920
Australia	AU915
Korea	KR920
Indian	IN865

Table 2 | Operating Frequencies



2.5 Pin Definition

Pin #	Mini PCIe 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	RAK2247 power 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	GPS_PPS	1PPS		N/A		Internal connection GPS_PPS 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 input	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

Continued on next page...



...Continuation.

Pin #	Mini PCIe PIN Rev. 2.0	RAK2247 PIN	Power	I/O	Description	Remarks
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-	90Ω nominal differential impedance. 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 provided externally.
37	GND	GND	GND		N/A	Ground Connect to ground
38	USB_D+	USB_D+	USB	I/O	USB Data Line D+	90Ω nominal differential impedance. 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 provided externally.
39	3.3Vaux	3.3Vaux	3.3Vaux	I	RAK2247 supply input	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 input	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 input	Connect to 3.3 V

Table 3 | Pin Definitions

2.6 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 (please refer to SX1301 DataSheet).

2.7 SPI Interface

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.

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

2.8 USB Interface

RAK2247 card can support the high speed USB to SPI by FT2232HL, 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. For more information, please refer to the data sheet of FT2232HL.

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

2.9 GPS_PPS

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

2.10 RESET

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

2.11 LEDs

3 x Green LED for indicating the status of PWR, TX, RX.

2.12 Antenna RF Interface

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

2.13 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.

2.13.1 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
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		10:1 VSWR
Tstg	Storage Temperature		-40°C	85°C

Table 4 | 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.

2.13.2 Maximum ESD

The table below lists the 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 5 | Maximum ESD Ratings

Note: RAK2247 card is an Electrostatic Sensitive Device and require special precautions when handling.

2.13.3 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 (fully functional and meet 3GPP specifications)

Table 6 | 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 V	3.3 V	3.6 V

Table 7 | Power Supply Range

2.13.4 Power Consumption

Mode	Condition	Min	Type	Max
Idle-Mode	All of the chip on the board enter idle mode or shutdown.		68 uA	
Active-Mode(TX)	The power of TX channel is 25dBm and 3.3V supply.		440 mA	
Active-Mode(RX)	TX disabled and RX enabled.		470 mA	

Table 8 | Power Consumption

2.13.5 RF Characteristics

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

Signal Bandwidth / [KHz]	Spreading Factor	Sensitivity / [dBm]
125	12	-139
125	7	-125
250	12	-136
250	7	-123
500	12	-134
500	7	-120

Table 9 | LoRa RF Characteristics

3 Schematics Reference

RAK2247 card refers to Semtech's reference design of SX1301. The SPI interface or USB interface converts SPI to USB2.0 by FT2232H and can be used on PCIE connector.

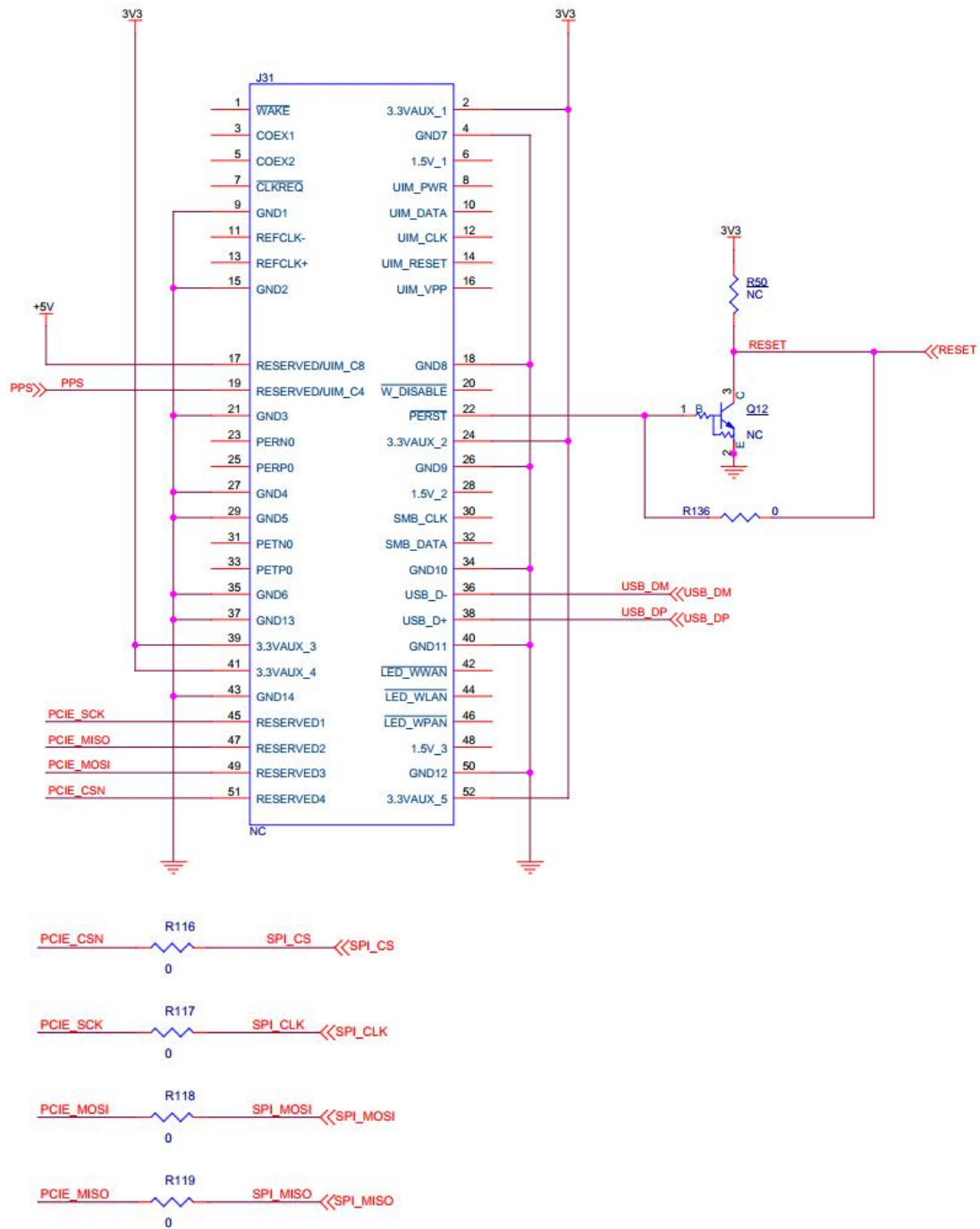


Figure 5 | Schematic Diagram Reference

The next figure shows the minimum application schematic of RAK2247 card. You should use it at least 3.3V / 1A DC power, connect SPI interface or USB interface to the main processor.

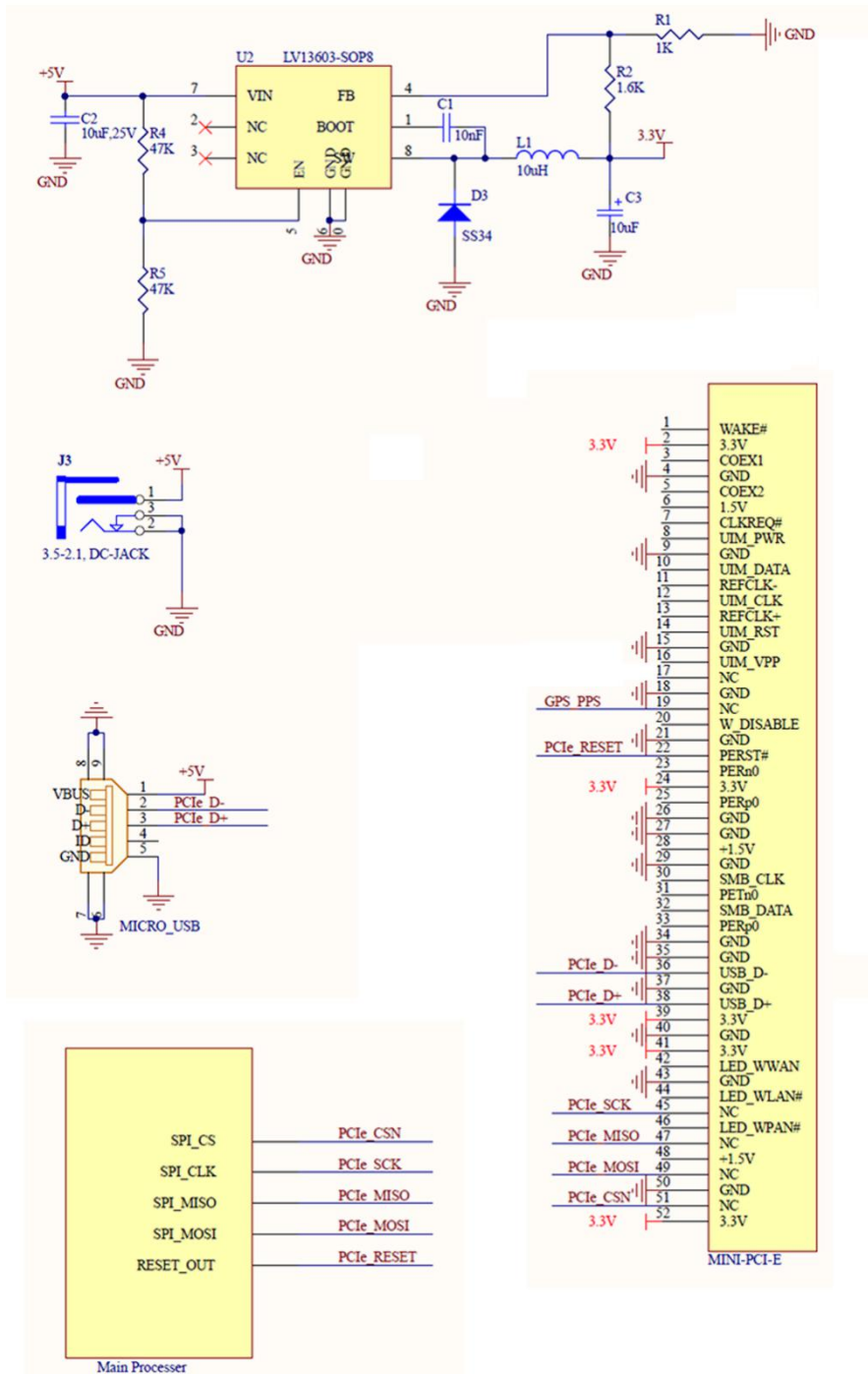


Figure 6 | RAK2247 Card Minimum Schematic Reference

4 Contact Information

Please contact us if you need technical support or want to know more information.

Support center: <https://forum.rakwireless.com/>

Email us: info@rakwireless.com

5 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

6 Document Summary

Prepared by	Checked by:	Approved by:
Jeff & Penn	Jeff	



About RAKwireless:

RAKwireless is the pioneer in providing innovative and diverse cellular and LoRa connectivity solutions for IoT edge devices. It's easy and modular design can be used in different IoT applications and accelerate time-to-market turnover.

For more information, please visit RAKwireless website at www.rakwireless.com.