RAK833 LoRa Gateway

Mini PCIe modules with SPI and USB interface Datasheet V1.3

Contents

1. Functional description

1.1. Overview

The RAK833 is a family of LoRa concentrator cards with mini PCIe form factor based on SX1301, which enables an easy integration into an existing routers and others network equipment with Lora Gateway capabilities.

The card can be used in any embedded platform offering a free mini-PCIe slot with USB and SPI connectivity.

RAK833 are a complete and cost efficient LoRa gateway solution offering up to 10 programmable parallel demodulation paths. It targeted at smart metering fixed networks and Internet of Things applications with up to 500 nodes per km^2 in moderately interfered environment. 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. Product Parameters

Module	Frequency
Protocol	LoRaWAN 1.0.2
Lora Chipset	SX1301
Dual-Band	863-870MHz,915-923MHz
Frequency Range	EU 863-870MHz, US 902-928 MHz, AU 915-928MHz AS 923MHz South Korea 920-923MHz
Power Input	DC 3.3 ± 5%
Hardware Interface	Mini-PCIE
Software Interface	USB/SPI
Multichannel	8uplinks、1downlink
LEDs	2*LEDs for PA_EN and LNA_EN
USB	USB2.0, USB-to-SPI bridge FT2232H
Node Numbers	500 nodes/km^2
Range	Urban2~4km/Subur5~10km/Open Area>15km
Power Consumption	TX (max): 135 mA RX(all channels):260mA Ldle:71mA
RX Sensitivity	Up to -136. 5dBm@SF12, BW 125KHz
Max RF Output	Up to +25 dBm
Mean RF Output	Up to +23 dBm
Operation Temperature	-48 to +85° C
Size	50.95 x 30 x 4.5 mm (PCB)

Table 1: Module Parameters

1.3. Block diagram
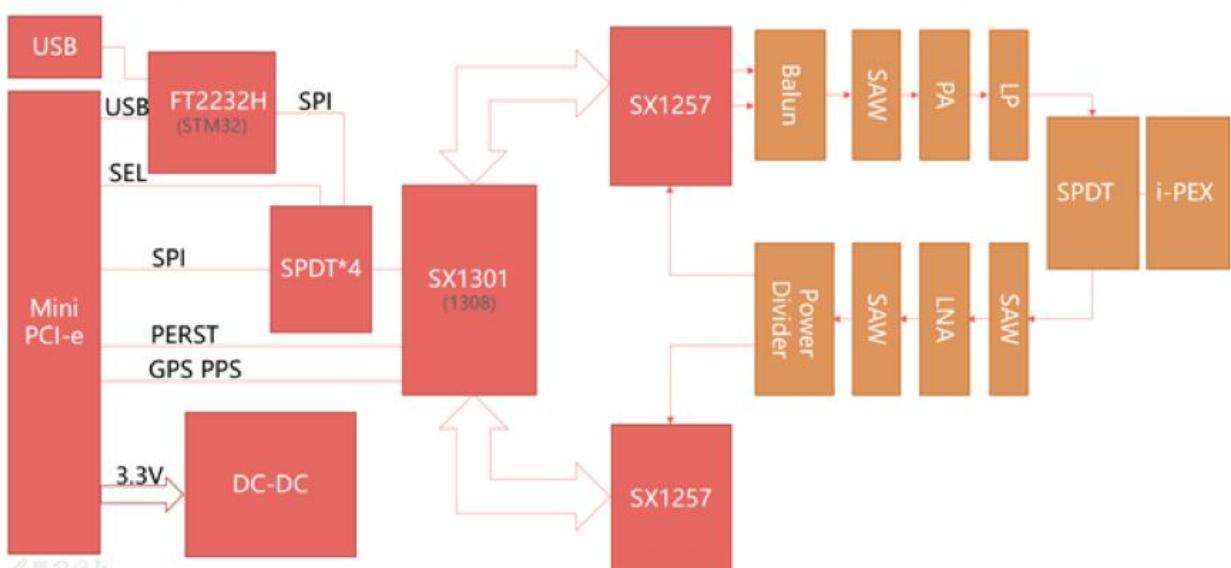
Figure 1: RAK833 series block diagram

As described in Figure 1, the RAK833 card integrates one SX1301 chip and two SX1255/7 and other chip for RF signal, which represents the core of the device, providing the related LoRa modem and processing functional lilies. Additional signal conditioning circuitry is implemented for PCI Express Mini Card compliance, and one U. FL connectors are available for external antennas integration.

1.4. Order NO.

Part Number	Description
RAK833-SPI/USB-915	USB and SPI, 902MHz-928 MHz
RAK833-SPI/USB-868	USB and SPI, 863MHz-870 MHz
RAK833-SPI-915	SPI, 902MHz-928 MHz
RAK833-SPI-868	SPI, 863MHz-870 MHz

Table 2: Module Number

2. Interfaces

2.1. Overview
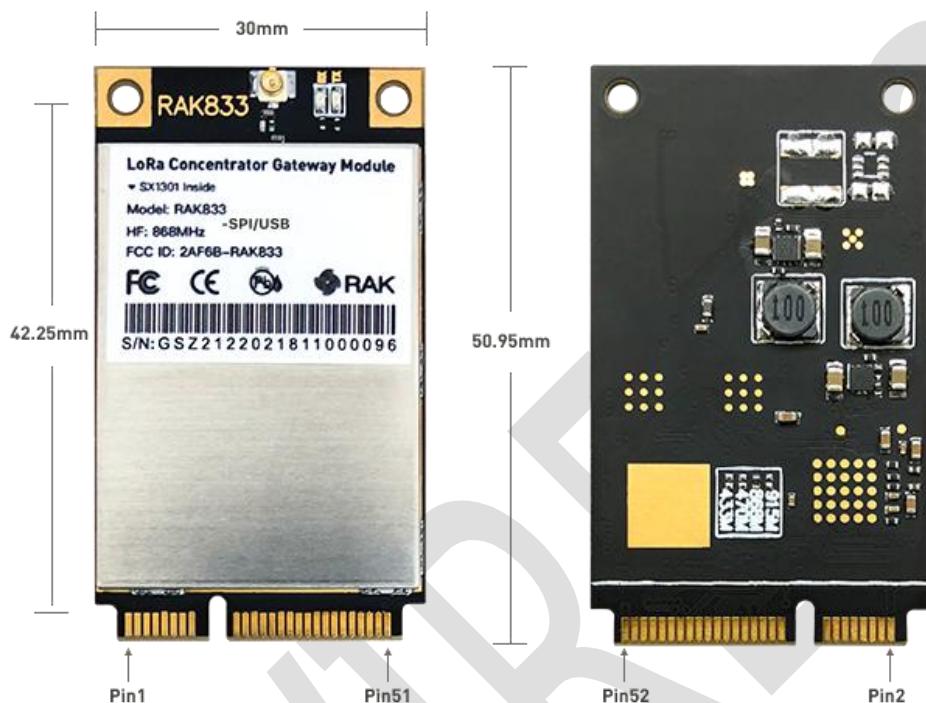
Figure 2: Module View

2.2. Interface
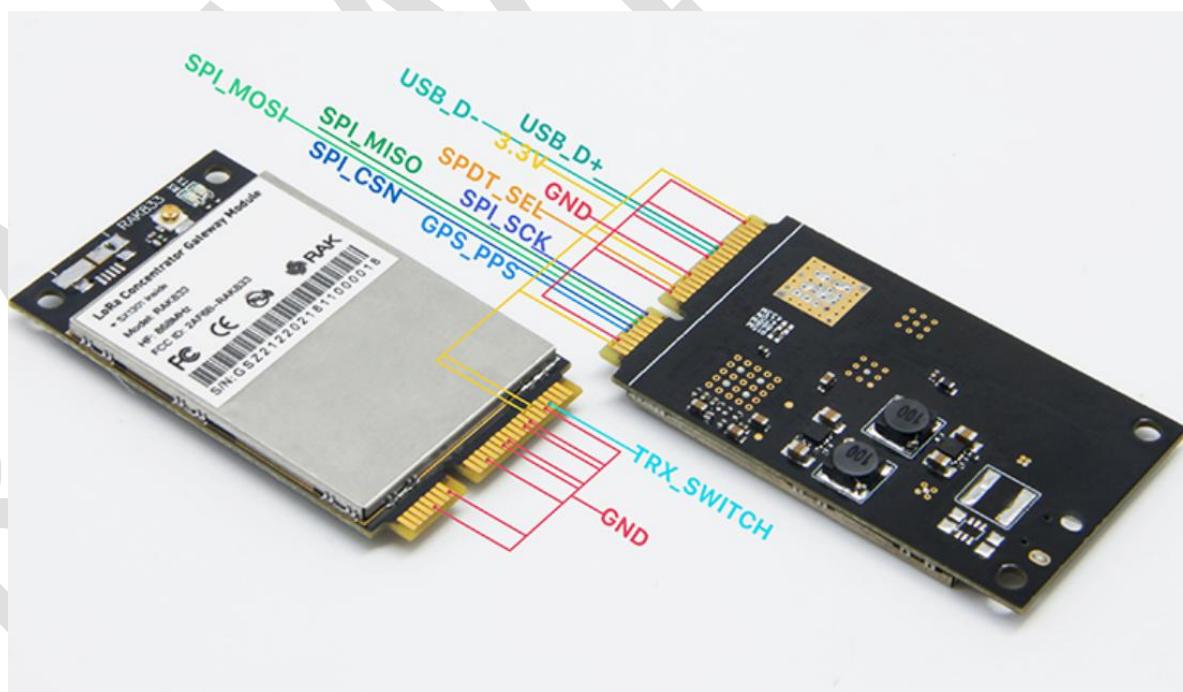
Figure 3: Module Interface

2.3. Pin definition with mini-PCIE

| No	Mini PCIEx PIN Rev. 2.0	RAK833 PIN	Power	I/O	Description	Remarks
1	WAKE#	NC		N/A		Internally not connected
2	3.3Vaux	3.3Vaux	3.3Vaux	N/A	RAK833 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	SPDT_SEL		N/A		Internal 10K ohm pull-up
18	GND	GND	GND	N/A	Ground	Connect to ground
19	GPS_PPS	GPS_PPS		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	RAK833 reset input	Active high(≥100ns) for SX1301
23	PERn0	NC		N/A		Internally not connected
24	3.3Vaux	3.3Vaux	3.3Vaux	I	RAK833 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
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-	90-ohm 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+	90-ohm 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	RAK833 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	RAK833 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	RAK833 supply input	Connect to 3.3 V

Table 3: Pin Definition

2.3.1. Module supply input

RAK833 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 (see SX1301 DS).

2.3.2. Antenna RF interfaces

The modules have one RF interfaces over a standard U. FL connectors (Hirose U. FL-R-SMT) with a characteristic impedance of 50. The RF port (ANT1) supports both Tx and Rx, providing the antenna interface.

2.3.3. SPI interface

A 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.

2.3.4. USB interface

Note: RAK833-SPI don't have this feature

RAK833 card can support the high speed USB to SPI by FT2232H, it includes a high-speed 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 FT2232H.

2.3.5. RESET

RAK833 card includes the RESET active-high input signal to reset the radio operations as specified by the SX1301 Specification.

2.3.6. SPDT_SEL

RAK833 card includes the SPDT_SEL input for selecting SPI or USB interface. SPDT_SEL="H", USB Port Enable, SPDT_SEL="L", SPI Port Enable. Internal Pull UP, Default USB Port.

2.3.7. GPS_PPS

RAK833 card includes the GPS_PPS input for received packets time-stamped.

3. Electrical specifications

⚠️   **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 (chapter 4.1) 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.

3.1. Absolute maximum rating

☞   Limiting values given below are in accordance with the Absolute Maximum Rating System (IEC 134).

Symbol	Description	Condition	Min.	Max.	Unit
3.3Vaux	Module supply voltage	Input DC voltage at 3.3Vaux pins	−0.3	3.6	V

USB	USB D+/D- pins	Input DC voltage at USB interface pins			3.6	V
SPDT_SEL	Port select	Input DC voltage at SPDT_SEL input pins	−0.3		3.6	V
RESET	RAK833 reset input	Input DC voltage at RESET input pin	−0.3		3.6	V
SPI	SPI interface	Input DC voltage at SPI interface pin	−0.3		3.6	V
GPS_PPS	GPS 1 pps input	Input DC voltage at GPS_PPS input pin	−0.3		3.6	V
Rho_ANT	Antenna ruggedness	Output RF load mismatch ruggedness at ANT1			10:1	VSWR
Tstg	Storage Temperature		−40		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.**

3.2. Maximum ESD

Parameter	Min	Typical	Max	Unit	Remarks
ESD sensitivity for all pins except ANT1			1000	V	Human Body Model according to JESD22-A114
ESD sensitivity for ANT1			1000	V	Human Body Model according to JESD22-A114
ESD immunity for ANT1			4000	V	Contact Discharge according to IEC 61000-4-2
			8000	V	Air Discharge according to IEC 61000-4-2

Table 5: Maximum ESD ratings

⚠ **RAK833 card are Electrostatic Sensitive Devices and require special precautions when handling. See section 7.2 for ESD handling instructions.**

3.3. Operating Conditions

☞ 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.**

3.3.1. Operating temperature range

Parameter	Min.	Typical	Max.	Unit	Remarks
Normal operating temperature	−20	+25	+65	°C	Normal operating temperature range (fully functional and meet 3GPP specifications)
Extended operating temperature	−40		+85	°C	Extended operating temperature range (RF performance may be affected outside normal operating range, though module is fully functional)

Table 6: Environmental conditions

3.3.2. Supply/power pins

Symbol	Parameter	Min.	Typical	Max.	Unit
3.3Vaux	Module supply operating input voltage[14]	3.00	3.30	3.60	V

Table 7: Input characteristics of Supply/Power pins

Input voltage at **3.3Vaux** must be above the normal operating range minimum limit to switch-on the module.

3.3.3. Current consumption

Mode	Condition	Min	Type	Max	Unit
Idle-Mode	All of the chip on the board enter idle mode or shutdown.	60	100		uA
Active-Mode (TX)	The power of TX channel is 23dBm and 3.3V supply.		TBD		mA
Active-Mode (RX)	TX disabled and shutdown PA.		TBD		mA

Table 8: Module 3.3Vaux supply current consumption

3.3.4. LoRa RF characteristics

The following table gives typically sensitivity level of the RAK833 card

Signal Bandwidth/[KHz]	Spreading Factor	Sensitivity/[dBm]
125	12	-136. 5
125	7	-124
250	12	-136
250	7	-123
500	12	-134
500	7	-120

Table 9: LoRa RF Characteristics

4. Mechanical specifications

RAK833 card are fully compliant to the 52-pin PCI Express Full-Mini Card Type F2 form factor, with top-side and bottom-side keep-out areas, with 50.95 mm nominal length, 30 mm nominal width and all the other dimensions as defined by the PCI Express Mini Card Electromechanical Specification [9] except for the card thickness (nominal value is 3.7 mm), as described in Figure 2. The weight of the RAK833 card is about 9.7 g.
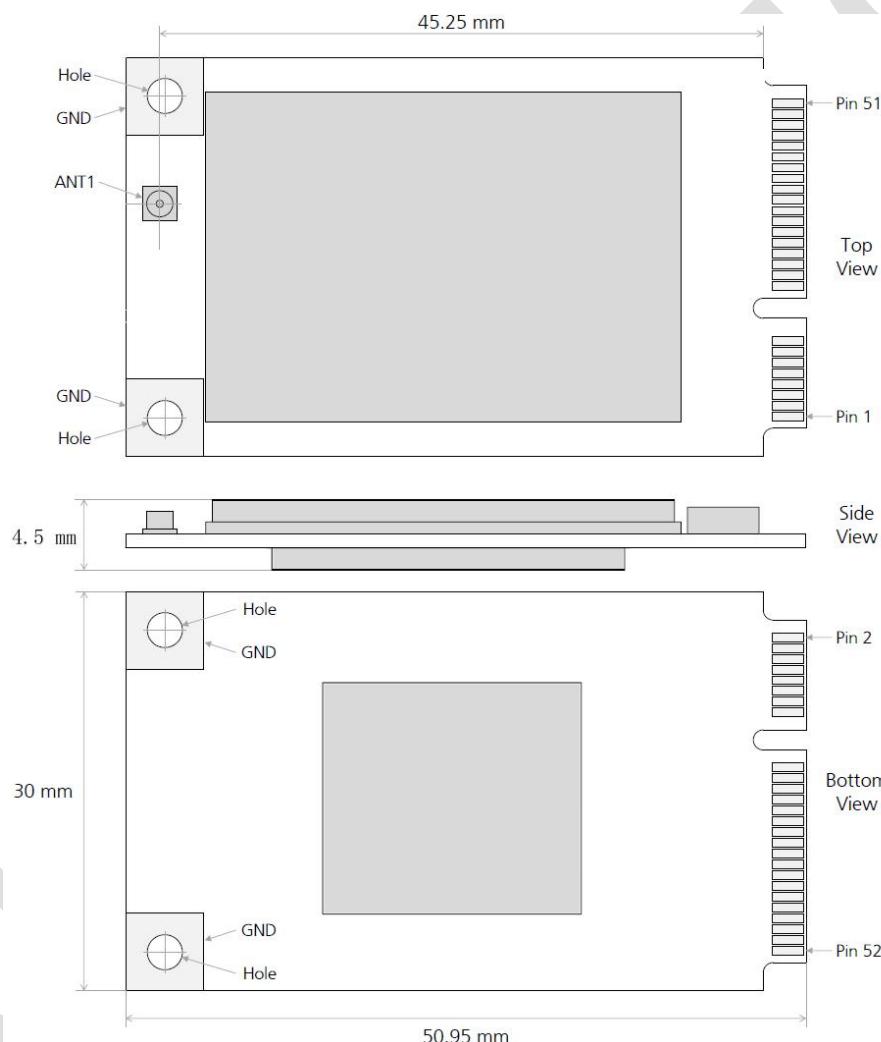

Figure 4: RAK833 card mechanical dimensions (top view, side view, bottom view)

☞ For further details regarding mechanical specifications see the *PCI Express Mini Card Electromechanical Specification* [9].

5. RAK833 Module schematic

RAK833 card refer Semtech's reference design of SX1301, add a 4 chancel SPDT to switch SPI of SX1301 to PCI edge connector or FT2232H which convert SPI to USB2.0 interface.

深圳市瑞科慧联科技有限公司
Shenzhen Rakwireless Technology Co., Ltd
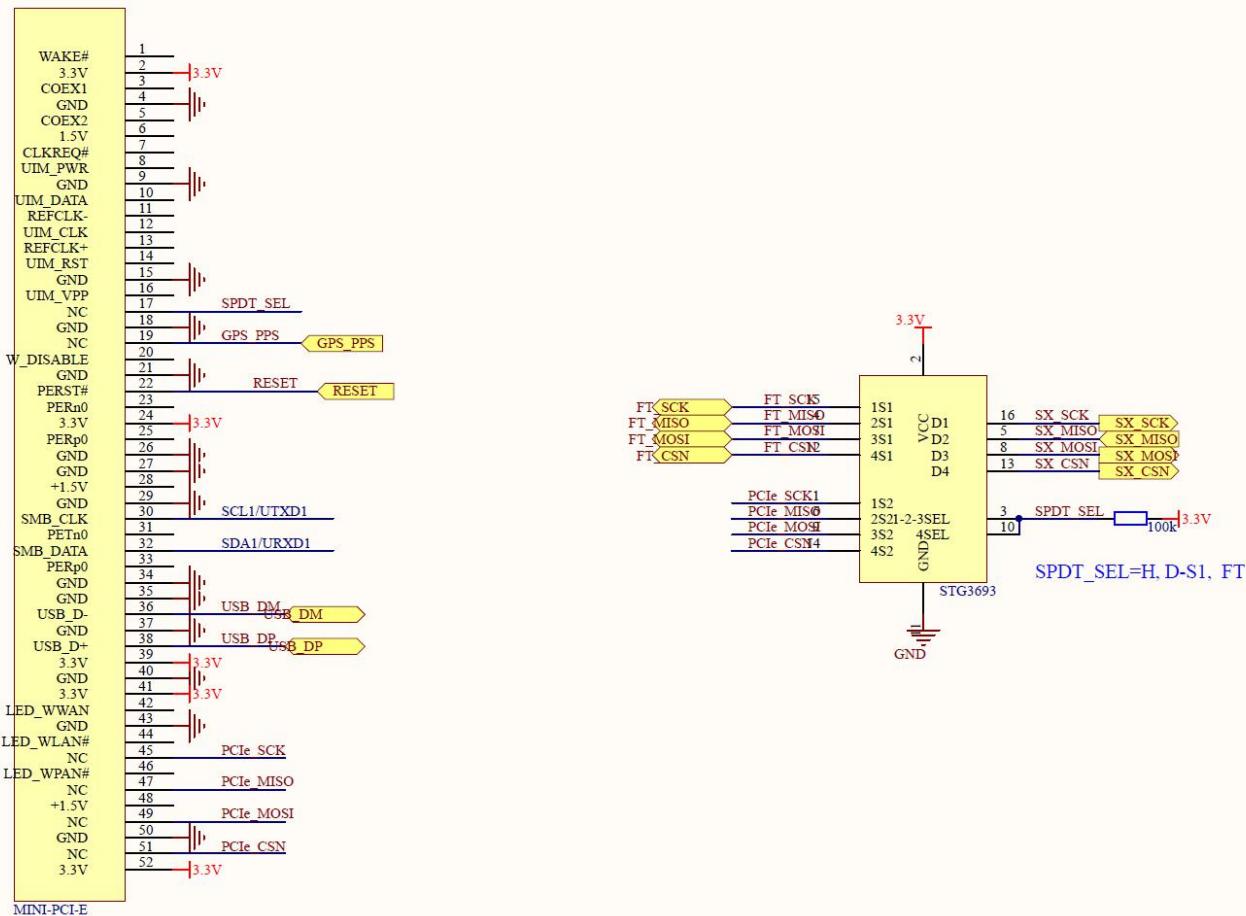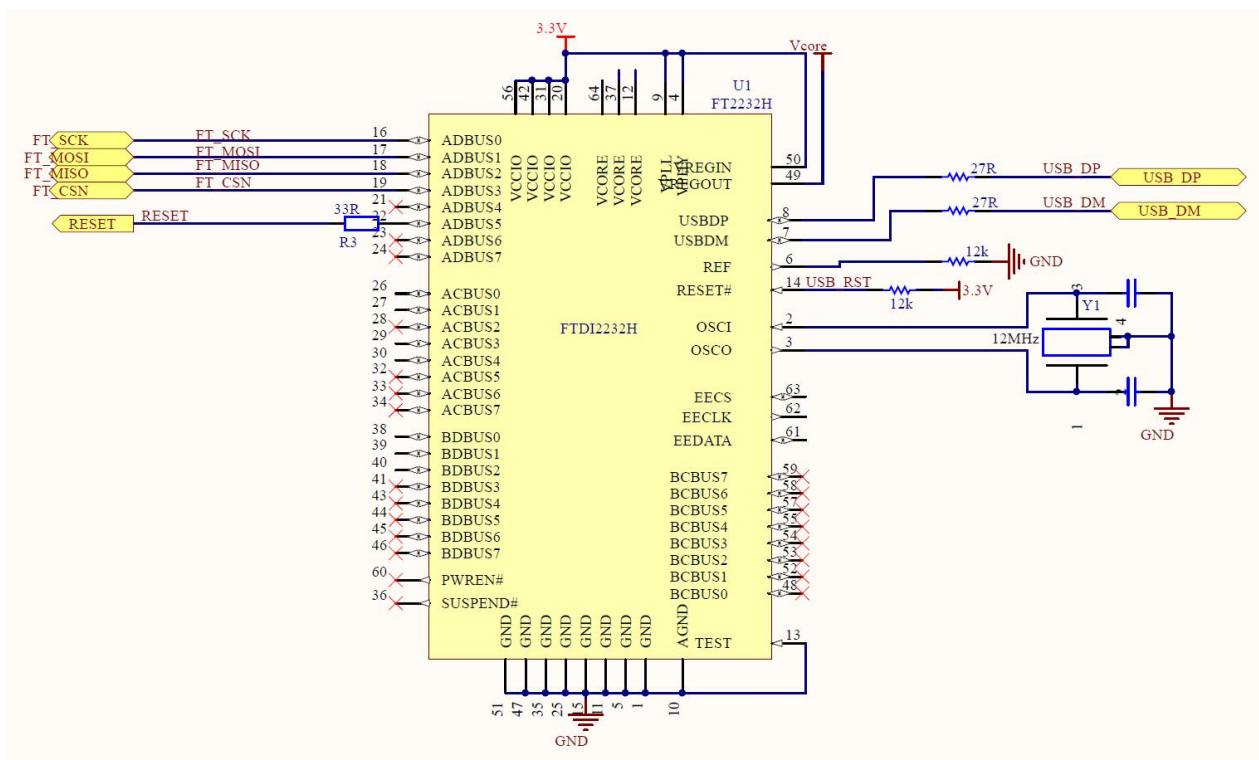
SX1301 Part:
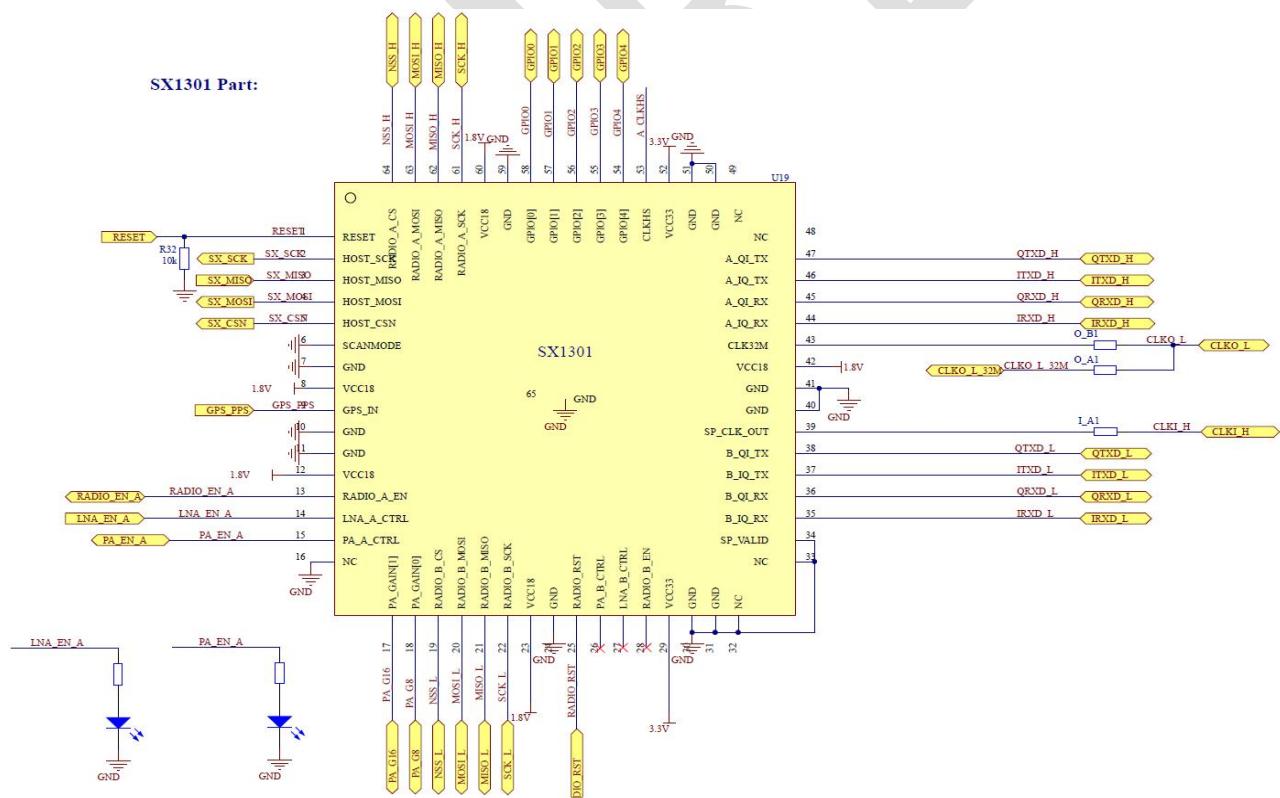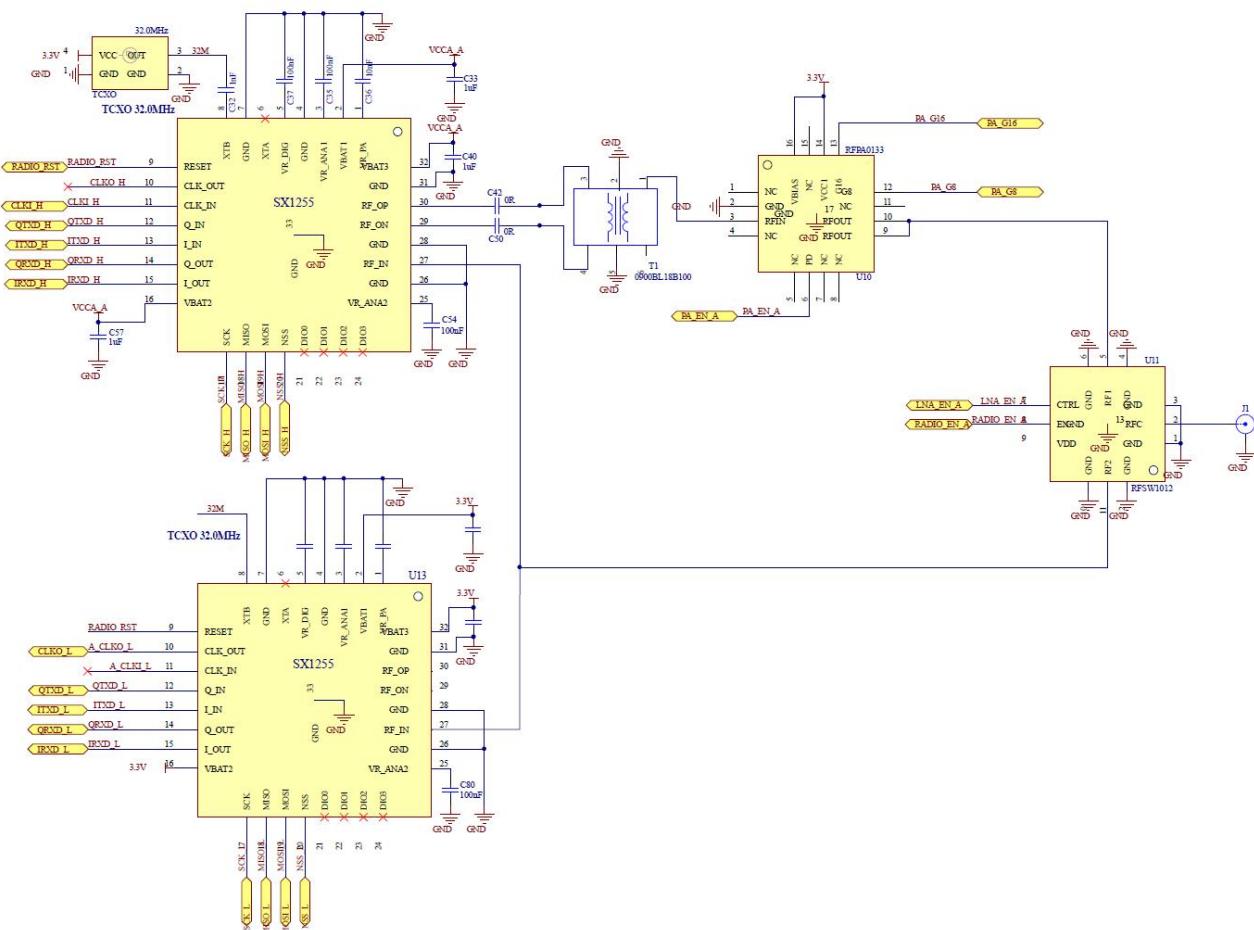
Figure 5: RAK833 card inner schematic.

For further details regarding schematic please refer "SX1301DVK_e286v02a_sch_layout" from Semtech.

6. Reference Application

Figure 4 shows the minimum application schematic of RAK833 card. Uses at lest 3.3V/1A DC power, connect SPI interface or USB interface to the main processor. If use SPI interface SPDT_SEL should be tied to GND otherwise just let this pin open.
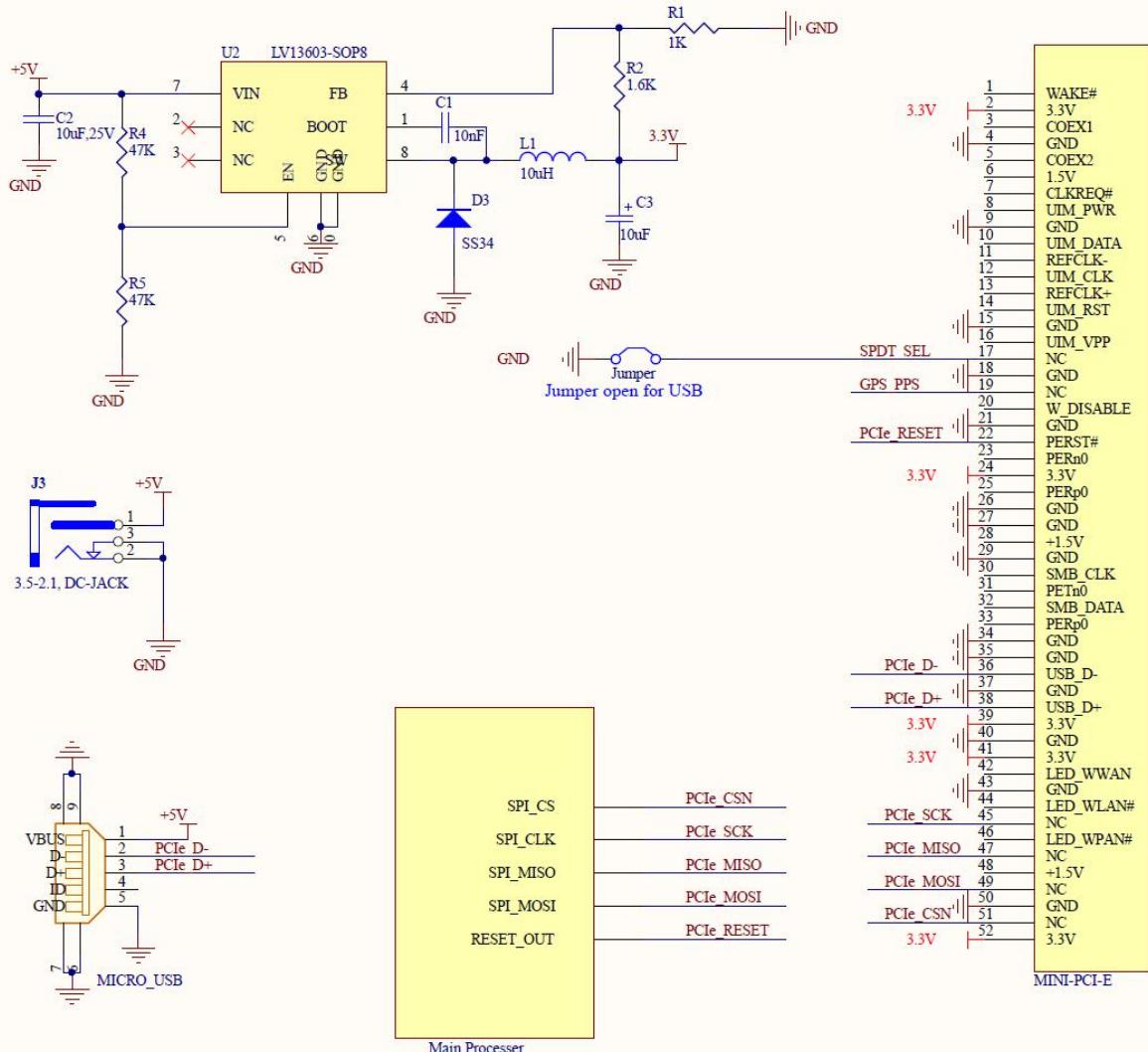

Figure 6: RAK833 card reference minimum schematic.

7. Contact

Shenzhen Business

E-Mail: ken.yu@rakwireless.com

Address: Room 506, Bldg. 3, Minqi Technology Park, No.65 Taoyuan Road,

Xili Block, Nanshan District, Shenzhen

Shenzhen Technical

E-Mail: steven.tang@rakwireless.com

Tel : 0755-86108311

Address: Room 506, Bldg. 3, Minqi Technology Park, No.65 Taoyuan Road,

Xili Block, Nanshan District, Shenzhen

8. Change Note

Version	Date	Change
V1.0	2018-01-11	Draft
V1.1	2018-03-11	Add module picture and fix some mistakes
V1.2	2018-05-11	Fix some description mistake for Part NO and parameters
V1.3	2018-06-19	Adjust the RF parameters and the content for reading.