

RAK833LoRa Gateway

MiniPCle modules with SPI and USB interface Datasheet V1.3



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Contents

| | |
|---|-----------|
| Contents..... | 2 |
| 1. Functional description | 4 |
| 1.1. Overview | 4 |
| 1.2. Product Parameters..... | 4 |
| 1.3. Order NO..... | 5 |
| 2. Interfaces..... | 5 |
| 2.1. Overview | 5 |
| 2.2. Interface..... | 6 |
| 2.3. Pin definition with mini-PCIE | 6 |
| 2.3.1. Module supply input | 7 |
| 2.3.2. Antenna RF interfaces | 8 |
| 2.3.3. SPI interface | 8 |
| 2.3.4. USB interface | 8 |
| 2.3.5. RESET | 8 |
| 2.3.6. SPDT_SEL | 8 |
| 3. Electrical specifications..... | 9 |
| 3.1. Absolute maximum rating..... | 9 |
| 3.2. Maximum ESD..... | 9 |
| 3.3. Operating Conditions | 10 |
| 3.3.1. Operating temperature range..... | 10 |
| 3.3.2. Supply/power pins..... | 10 |
| 3.3.3. Current consumption..... | 10 |
| 3.3.4. LoRa RF characteristics..... | 10 |

| | |
|------------------------------------|----|
| 4. Mechanical specifications | 11 |
| 5. RAK833 Module schematic | 12 |
| 6. Reference Application | 15 |
| 7. Contact | 16 |
| 8. Change Note..... | 17 |

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.

RAK833areacompleteandcostefficientLoRa gateway solutionofferingupto10 programmable parallel demodulation paths. It targeted at smart metering fixed networks and Internet of Things applications with up to 500 nodes per km² in moderately interfered environment. ThemoduleshavetheindustrystandardPCIExpressMiniCardformfactor,whichenablesea syintegrationintoanapplicationboardandisalsoidealformanufacturingofsmallseries.

1.2. Product Parameters

| Module | Frequency |
|-----------------------|---|
| Protocol | LoRaWAN 1.0.2 |
| Lora Chipset | SX1301 |
| Dual-Band | 868MHz,915MHz |
| Frequency Range | EU 863-870MHz US 923.3-927.5 MHz |
| 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 |
| Max RF Output | Up to +9 dBm |
| Mean RF Output | Up to +9 dBm |
| Operation Temperature | -48 to +85° C |

Table1: Module Parameters

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 functionalities. Additional signal conditioning circuitry is implemented for PCI Express Mini Card compliance, and one U. FL connectors are available for external antennas integration.

1.3. Order NO.

| Part Number | Description |
|--------------------|---------------------------------|
| RAK833-SPI/USB-915 | USB and SPI, 923.3MHz-927.5 MHz |
| RAK833-SPI/USB-868 | USB and SPI, 863MHz-870 MHz |
| RAK833-SPI-915 | SPI, 923.3MHz-927.5 MHz |
| RAK833-SPI-868 | SPI, 863MHz-870 MHz |

Table2: Module Number

2. Interfaces

2.1. Overview



Figure2:Module View

2.2. Interface

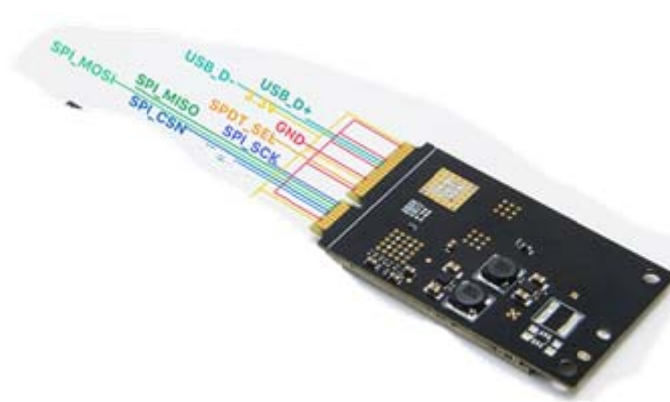


Figure3:Module Interface

2.3. Pin definition with mini-PCIE

| No | Mini PCIe PIN Rev.2.0 | RAK833 PIN | Power | I/O | Description | Remarks |
|----|-----------------------|------------|---------|-----|--------------------|--------------------------------|
| 1 | WAKE# | NC | | N/A | | Internallynotconnected |
| 2 | 3.3Vaux | 3.3Vaux | 3.3Vaux | N/A | RAK833supply input | Connectto3.3V |
| 3 | COEX1 | NC | | N/A | | Internallynotconnected |
| 4 | GND | GND | GND | N/A | Ground | ConnecttoGround |
| 5 | COEX2 | NC | | N/A | | Internallynotconnected |
| 6 | 1.5V | NC | | N/A | | Internallynotconnected |
| 7 | CLKREQ# | NC | | N/A | | Internallynotconnected |
| 8 | UIM_PWR | NC | | N/A | | Internallynotconnected |
| 9 | GND | GND | GND | N/A | Ground | Connecttoground |
| 10 | UIM_DATA | NC | | N/A | | Internallynotconnected |
| 11 | REFCLK- | NC | | N/A | | Internallynotconnected |
| 12 | UIM_CLK | NC | | N/A | | Internallynotconnected |
| 13 | REFCLK+ | NC | | N/A | | Internallynotconnected |
| 14 | UIM_RESET | NC | | N/A | | Internallynotconnected |
| 15 | GND | GND | GND | N/A | Ground | Connecttoground |
| 16 | UIM_SPU | NC | | N/A | | Internallynotconnected |
| 17 | UIM_IC_DM | SPDT_SEL | | N/A | | Internal 10K ohm pull-up |
| 18 | GND | GND | GND | N/A | Ground | Connecttoground |
| 19 | N/A | N/A | | N/A | | N/A |
| 20 | W_DISABLE1# | NC | | N/A | | Internallynotconnected |
| 21 | GND | GND | GND | N/A | Ground | Connecttoground |
| 22 | PERST# | RESET | | I | RAK833resetinput | Active high(≥100ns) for SX1301 |
| 23 | PERn0 | NC | | N/A | | Internallynotconnected |
| 24 | 3.3Vaux | 3.3Vaux | 3.3Vaux | I | RAK833supply input | Connectto3.3V |
| 25 | PERp0 | NC | | N/A | | Internallynotconnected |

| | | | | | | |
|----|-------------|-----------|---------|-----|---------------------|--|
| 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 |
| 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 3.3V |
| 40 | GND | GND | GND | N/A | Ground | Connect to ground |
| 41 | 3.3Vaux | 3.3Vaux | 3.3Vaux | I | RAK833 supply input | Connect to 3.3V |
| 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 3.3V |

Table3: 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.

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 condition 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 defines the 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 (IEC134).

| Symbol | Description | Condition | Min. | Max. | Unit |
|----------|------------------------------|---|------|------|------|
| 3.3Vaux | Module supply voltage | Input DC voltage at 3.3Vaux pins | -0.3 | 3. | V |
| USB | USB D+/D- pins | Input DC voltage at USB interface pins | | 3. | V |
| SPDT_SEL | Port select | Input DC voltage at SPDT_SEL input pins | -0.3 | 3. | V |
| RESET | RAK833 reset input | Input DC voltage at RESET input pin | -0.3 | 3. | V |
| SPI | SPI interface | Input DC voltage at SPI interface pin | -0.3 | 3. | V |
| Rho ANT | Antenna radiation efficiency | Output RF load mismatch radiation efficiency at ANT | | 10:1 | VSWR |
| Tstq | 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 IEC61000-4-2 |
| | | | 8000 | V | Air Discharge according to IEC61000-4-2 |


Table 5: Maximum ESD ratings



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

3.3. Operating Conditions

 Unless otherwise indicated, all operating conditions 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) |

Table6: Environmental conditions

3.3.2. Supply/power pins

| Symbol | Parameter | Min. | Typical | Max. | Unit |
|---------|-----------------------------------|------|---------|------|------|
| 3.3Vaux | Module supply operating input vol | 3.00 | 3.30 | 3.60 | V |

Table7: 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 |

Table8: 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] |
|------------------------|------------------|-------------------|
| 500 | 12 | -134 |
| 500 | 7 | -120 |

Table9: 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.

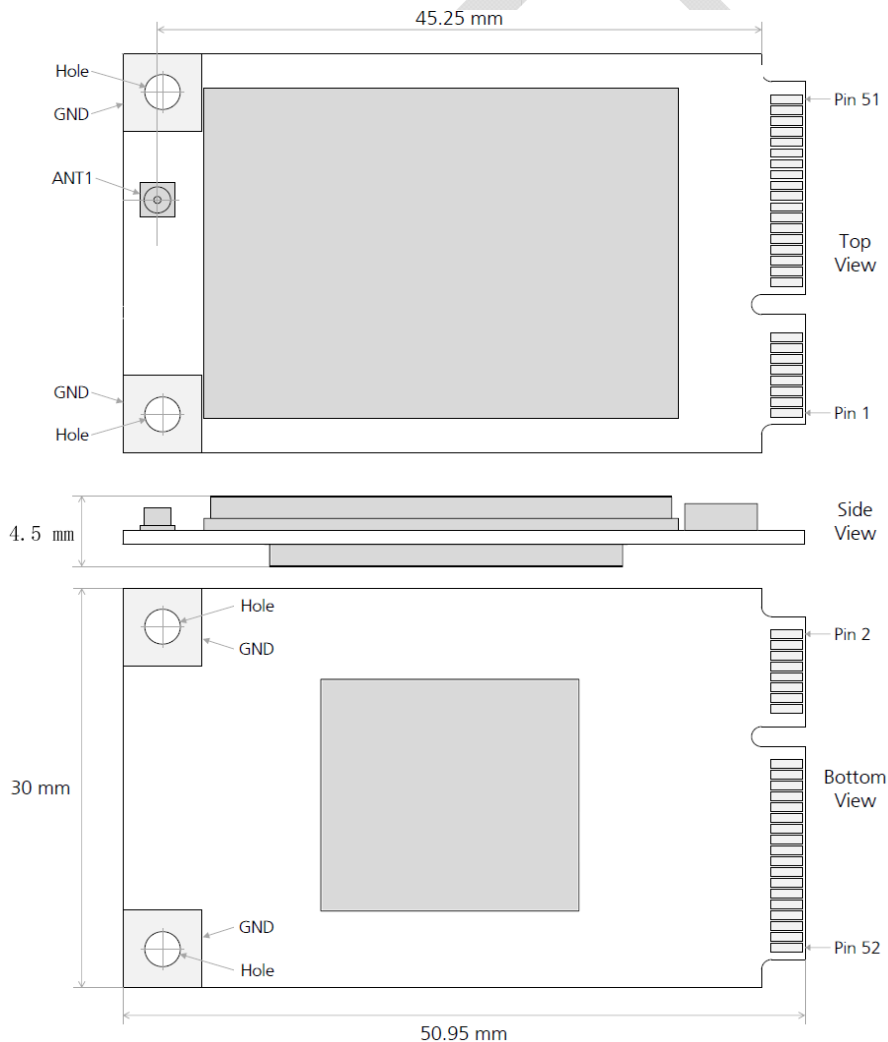


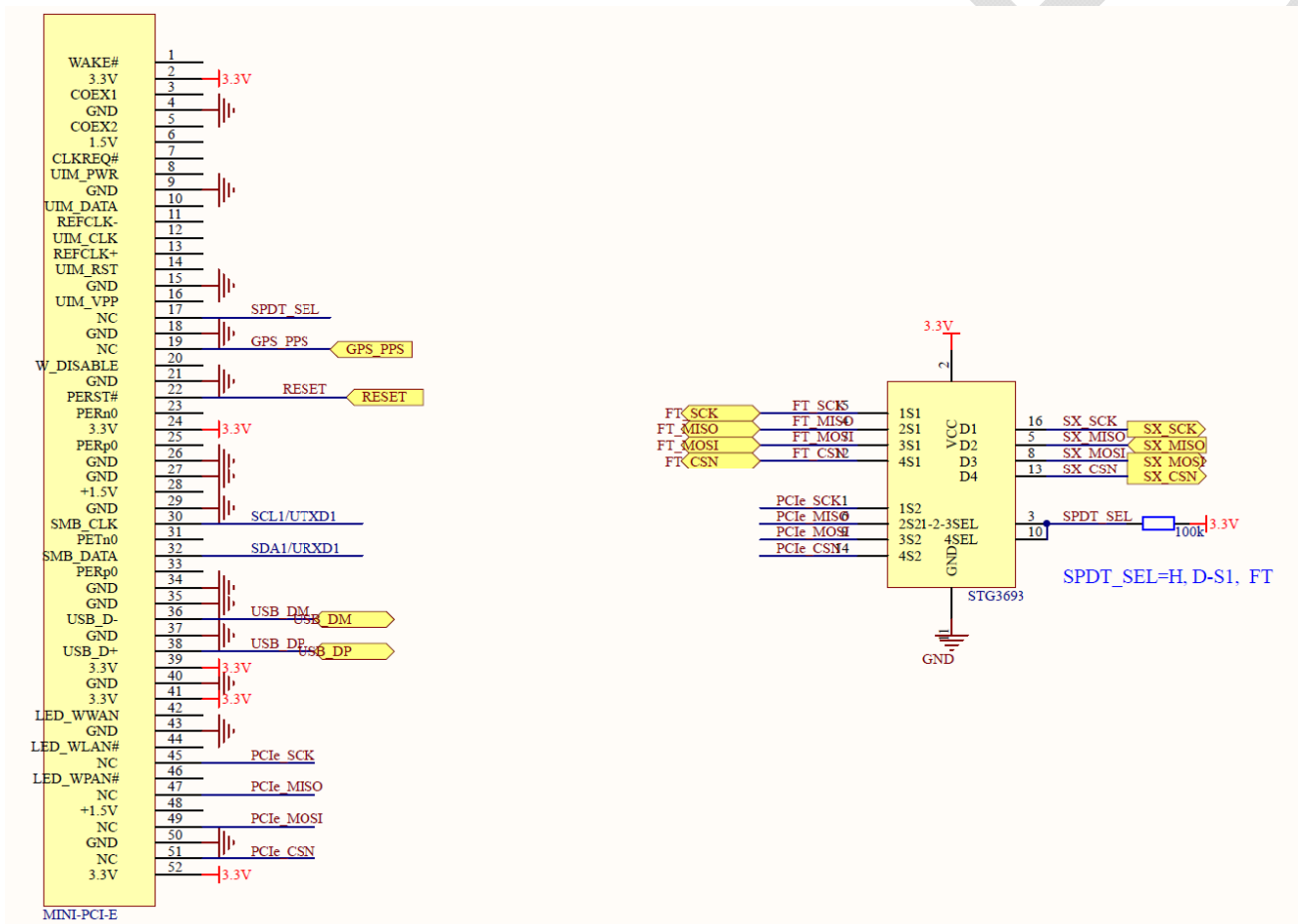
Figure4:RAK833cardmechanicaldimensions(topview,sideview,bottomview)

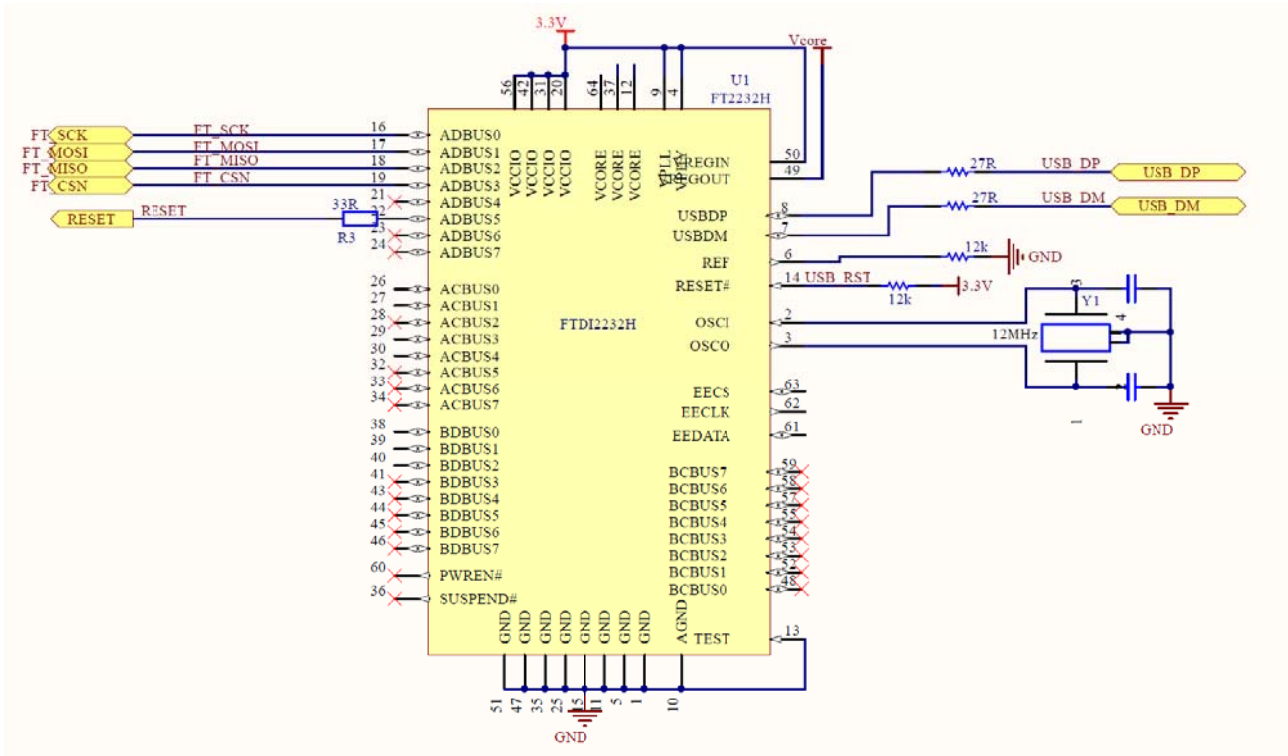


For further details regarding mechanical specifications see the *PCI Express Mini Card Electromechanical Specification* [9].

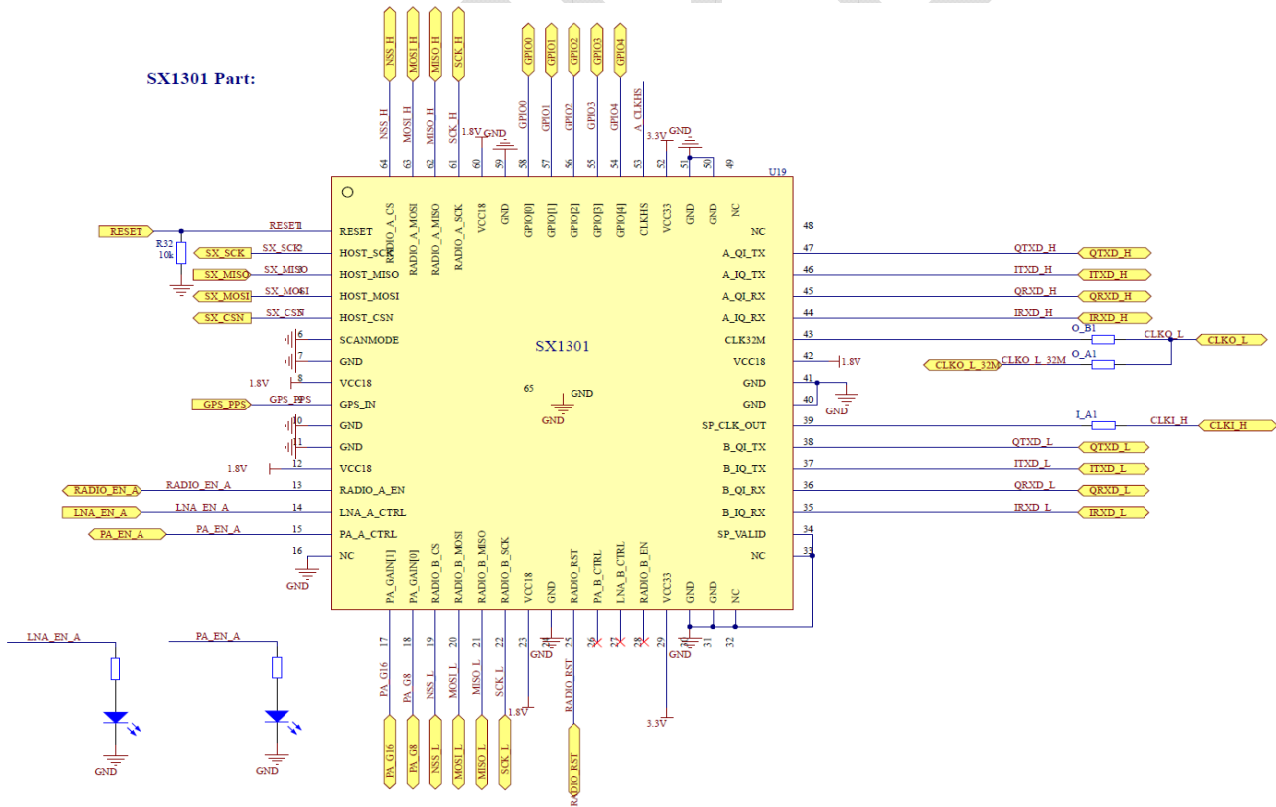
5. RAK833 Module schematic

RAK833 card refer Semtech's reference design of SX1301, add a 4 channel SPDT to switch SPI of SX1301 to PCI edge connector or FT232H which convert SPI to USB2.0 interface.





SX1301 Part:



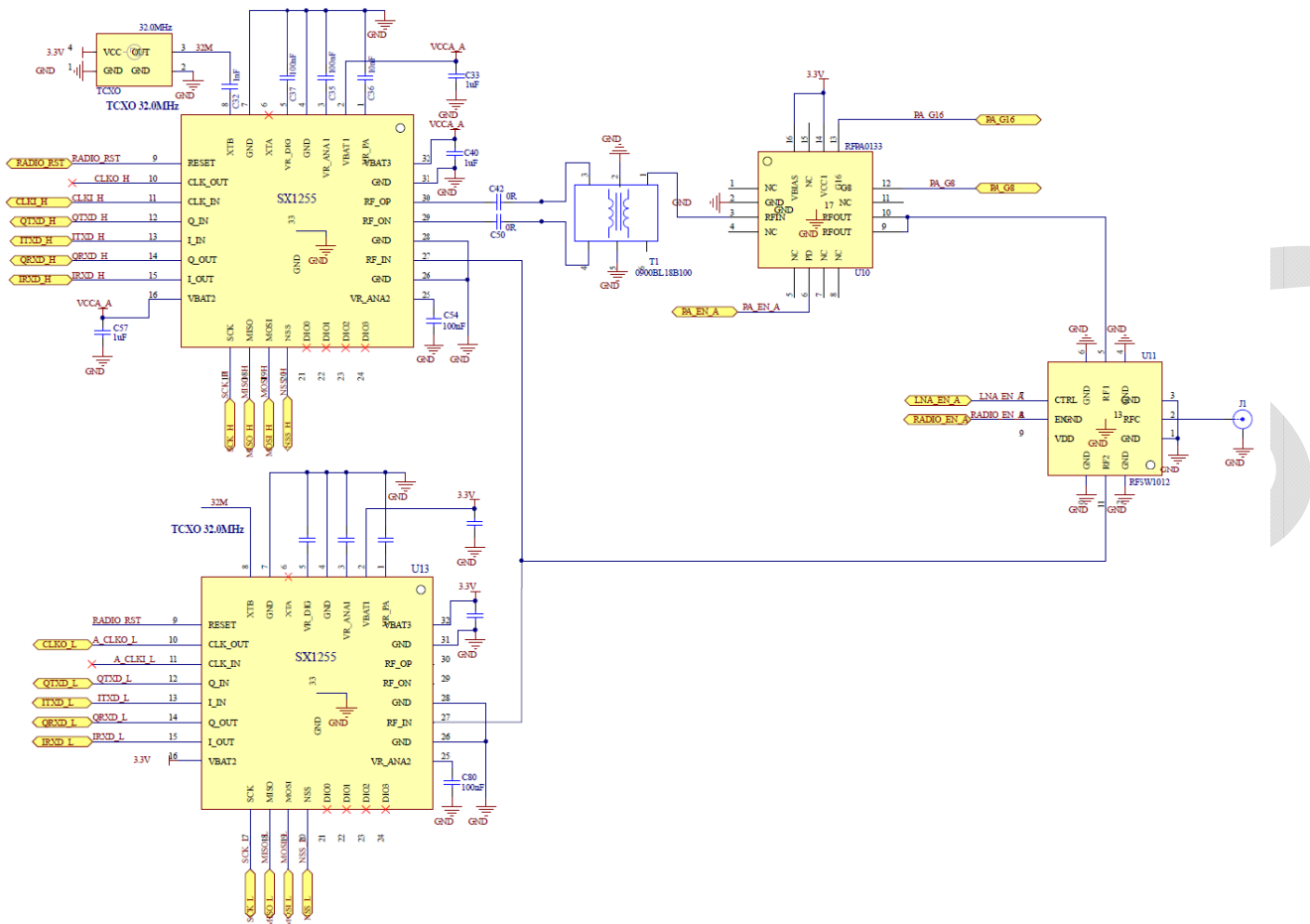


Figure5:RAK833cardinnerschematic.

☞ 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 least 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.

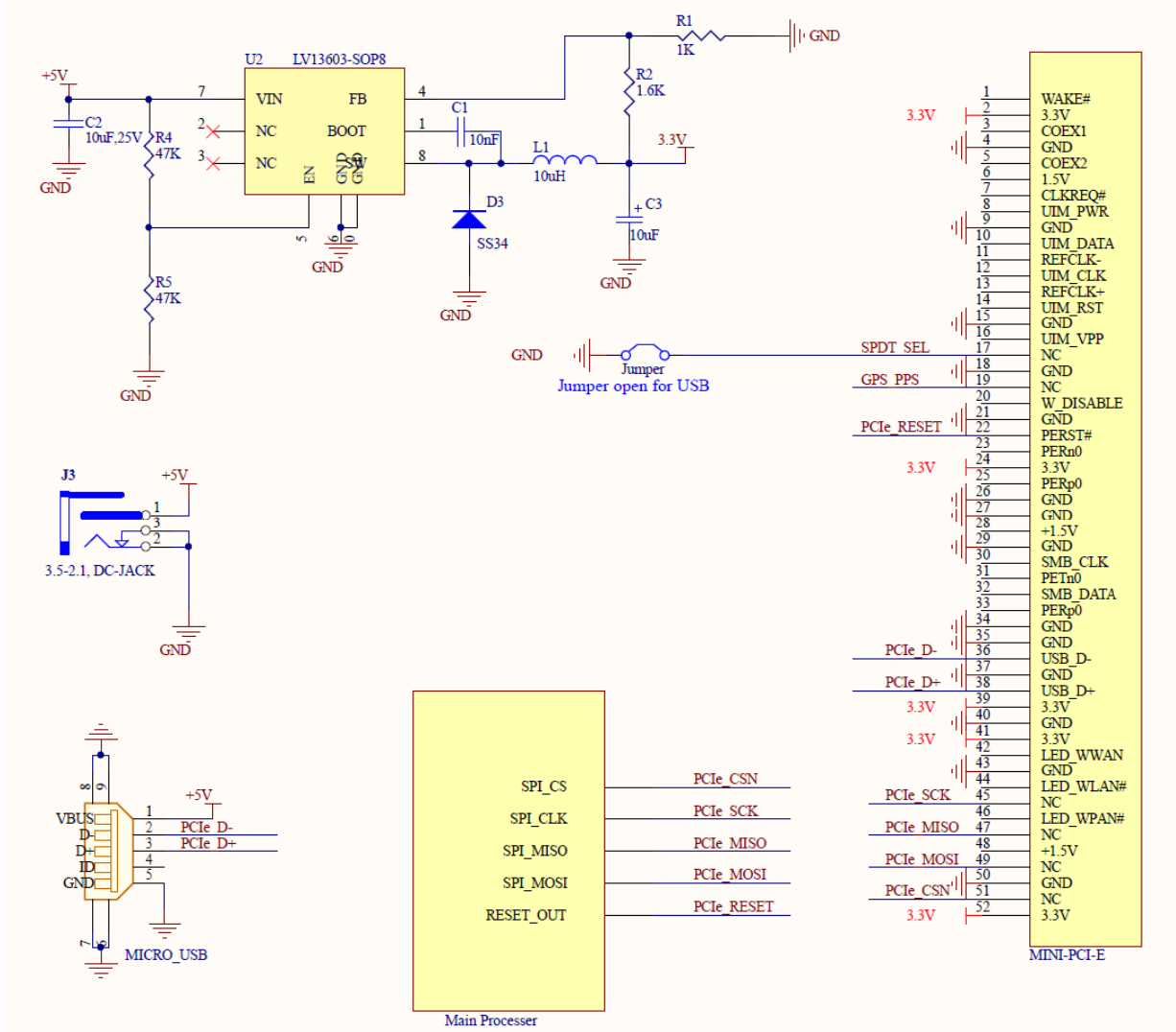


Figure6:RAK833cardreferenceminimum schematic.

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, 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.

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-RAK833.

Maximum antenna gain allowed for use with this device is 2 dBi.

This module complies with FCC radiation exposure limits set forth for an uncontrolled environment .This equipment should be installed and operated with minimum distance 20 cm between the radiator& your body.

7. Contact

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8. Change Note

| Version | Date | Change |
|---------|------------|---|
| V1.0 | 2018-01-11 | Draft |
| V1.1 | 2018-03-11 | Addmodulepicture 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. |

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