RF-SM-1277B1 and RF-SM-1277B2 CC1312R Ultra-Low-Power Sub-1 GHz Wireless Module

Version 1.1

Shenzhen RF-star Technology Co., Ltd.

May 26th, 2023

1 Device Overview

1.1 Description

RF-SM-1277B1 and RF-SM-1277B2 are RF modules based on TI CC1312R, which combines a flexible low-power radio controller ARM® Cortex®-M0 and a powerful 48 MHz ARM® Cortex®-M4F microcontroller supporting multiple physical layers and RF standards including IEEE 802.15.4g, IPv6-enabled smart objects (6LoWPAN), MIOTY®, Wi-SUN®, proprietary systems, and the TI 15.4-Stack (Sub-1 GHz). RF-SM-1277B1/B2 integrates a 48.0 MHz crystal, a 32.768 kHz crystal, a balun, a band pass filter, an antenna matching and an option for RF output mode (IPEX antenna connector and a half-hole interface), which makes the module low cost, low power consumption and long wireless communication in Sub-1 GHz, also makes it an advanced available in sensing in building security systems, HVAC, smart meters, medical, wired networking, portable electronics, home theater & entertainment, and connected peripherals markets. For the working frequency, RF-SM-1277B1 supports 868 MHz and 915 MHz; RF-SM-1277B2 supports 433 MHz and 470 MHz.

1.2 Key Features

- RF Features
  - IEEE 802.15.4g
  - IPv6-enabled smart objects (6LoWPAN)
  - MIOTY®
  - Wi-SUN®
  - Wireless M-Bus
  - KNX RF
  - Amazon Sidewalk
  - Proprietary systems, including the TI 15.4-Stack (Sub-1 GHz)
- TX power:
  - Up to +14 dBm (RF-SM-1277B1)
  - Up to +13 dBm (RF-SM-1277B2)
- Sensitivity
  - Excellent receiver sensitivity: –124 dBm @ long-range mode, –110 dBm @ 50 kbps
  - Excellent selectivity (±100 kHz): 56 dB
  - Excellent blocking performance (±10 MHz): 90 dB
- Microcontroller
  - Powerful 48 MHz ARM® Cortex®-M4F processor
  - EEMBC CoreMark® Score: 142
  - EEMBC ULPBench™ score: 158
- Memory
  - 352 KB of in-system programmable flash
  - 256 KB of ROM for protocols and library
  - 8 KB of SRAM for Cache (or as general-purpose RAM)
  - 20 KB of ultra-low-leakage SRAM
- Wide Operation Range
  - Power supply: 2.2 V to 3.8 V
  - Operating temperature: -40 °C to +85 °C
  - Storage temperature: -40 °C to +125 °C
- On-Chip Internal DC/DC Converter
- Ultra-Low-Power Sensor Controller
- Wide Operation Range
  - 2-pin cJTAG and JTAG debugging
  - Supports over-the-air (OTA) update
  - Can run autonomously from the rest of the System
  - 16-bit architecture
  - 2 KB of ultra-low-leakage SRAM for code and data
- Peripherals
  - All digital peripheral pins can be routed to any GPIO
  - Four general-purpose timer modules (eight 16-bit or four 32-bit timers, PWM each)
  - 12-bit ADC, 200 ksamples/s, 8-channel analog

MUX
- Continuous time comparator
- Ultra-low-power clocked comparator
- Programmable current source
- UART
- 2× SSI (SPI, MICROWIRE, TI)
- I²C, I²S
- Real-time clock (RTC)
- AES-128 security module
- True random number generator (TRNG)
- Support for eight capacitive sensing buttons
- Integrated temperature sensor

• Low Power
- Wide supply voltage range: 1.8 V to 3.8 V
- RX: 5.4 mA
- TX at +10 dBm: 13.4 mA
- Active-mode MCU 48 MHz running Coremark: 2.5 mA (51 µA/MHz)
- Active-mode MCU: 48.5 CoreMark/mA
- Active-mode sensor controller at 24 MHz: 0.4 mA + 8.2 µA/MHz
- Sensor controller, one wake-up every second performing one 12-bit ADC sampling: 0.95 µA
- Standby: 0.7 µA (RTC running and RAM and CPU retention)
- Shutdown: 185 nA (wakeup on external events)

1.3 Applications

- 868-, 915-MHz ISM and SRD systems
- Low-power wireless systems with 50-kHz to 5-MHz channel spacing
- Home and building automation
- Wireless alarm and security systems
- Industrial Monitoring and Control
- Smart grid and automatic meter reading
- Wireless healthcare applications
- Wireless sensor networks
- Active RFID
- IEEE 802.15.4g, IP-enabled smart objects (6LoWPAN), wireless M-Bus, KNX systems, Wi-SUN™, and proprietary systems
- Energy-harvesting applications
- Electronic shelf label (ESL)
- Long-range sensor applications
- Heat-cost allocators

1.4 Functional Block Diagram

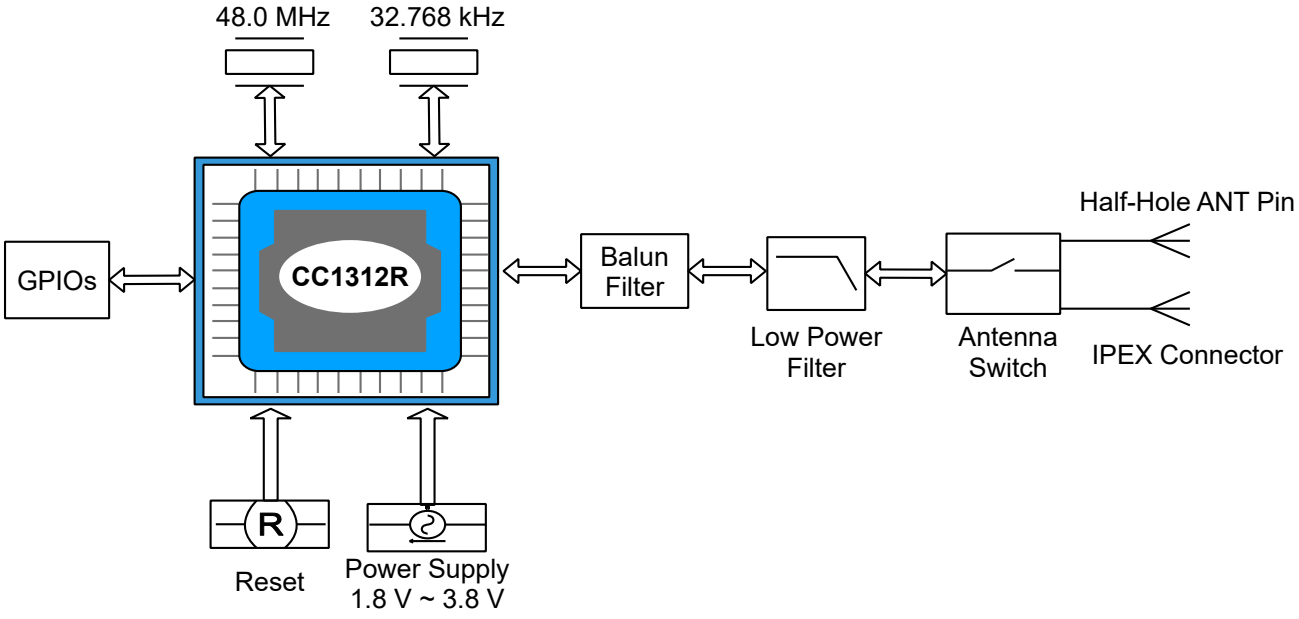


Figure 1. Functional Block Diagram of RF-SM-1277B1/B2

1.6 Part Number Conventions

The part numbers are of the form of RF-SM-1277B1/B2 where the fields are defined as follows:

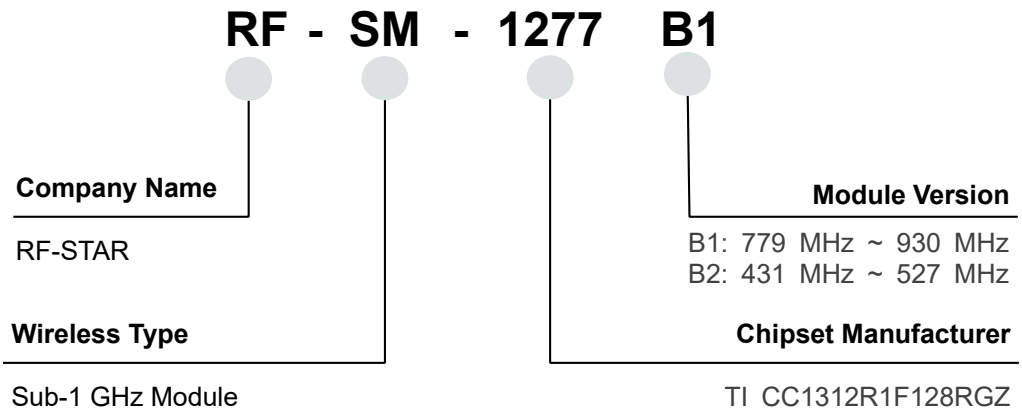


Figure 2. Part Number Conventions of RF-SM-1277B1/B2

Table of Contents

2 Module Configuration and Functions

2.1 Module Parameters

Table 1. Parameters of RF-SM-1277B1/B2

Chipset	CC1312R1F3RGZ
Supply Power Voltage	1.8 V ~ 3.8 V, recommended to 3.3 V
Protocol	IEEE 802.15.4g, IPv6-enabled smart objects(6LoWPAN), MIOTY®, Wireless M-Bus(T, S, C mode), Wi-SUN®, KNX RF, Amazon Sidewalk, proprietary systems, SimpleLink™ TI 15.4 stack (Sub-1 GHz)
Frequency	RF-SM-1277B1: 790 MHz ~ 930 MHz RF-SM-1277B2: 431 MHz ~ 527 MHz
Maximum Transmit Power	RF-SM-1277B1: +14 dBm RF-SM-1277B2: +13 dBm
Receiving Sensitivity	–121 dBm @ Sub-1 GHz (Long-Range Mode) –110 dBm @ Sub-1 GHz (50 kbps)
GPIO	30
Crystal	48 MHz, 32.768 kHz
RAM	88 KB
Flash	352 KB
Package	SMT packaging (1.27-mm half-hole pitch stamp stick)
Frequency Error	±20 kHz
Dimension	26.0 mm x 18.0 mm x 2.3 mm
Type of Antenna	IPEX connector / half-hole RF interface
Operating Temperature	-40 ℃ ~ +85 ℃
Storage Temperature	-40 ℃ ~ +125 ℃

2.2 Module Pin Diagram

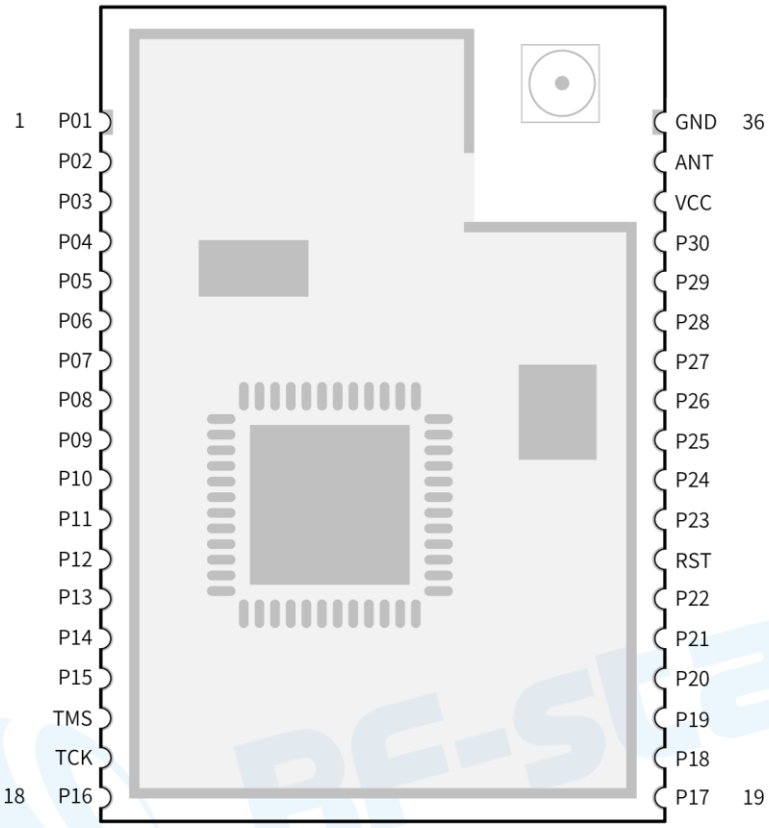


Figure 3. Pin Diagram of RF-SM-1277B1/B2

2.3 Pin Functions

Table 2. Pin Functions of RF-SM-1277B1/B2

Pin	Name	Chip Pin	Pin Type	Description
1	P01	DIO_1	Digital I/O	GPIO
2	P02	DIO_2	Digital I/O	GPIO
3	P03	DIO_3	Digital I/O	GPIO
4	P04	DIO_4	Digital I/O	GPIO
5	P05	DIO_5	Digital I/O	GPIO, Sensor Controller
6	P06	DIO_6	Digital I/O	GPIO, Sensor Controller
7	P07	DIO_7	Digital I/O	GPIO, Sensor Controller
8	P08	DIO_8	Digital I/O	GPIO
9	P09	DIO_9	Digital I/O	GPIO

10	P10	DIO_10	Digital I/O	GPIO
11	P11	DIO_11	Digital I/O	GPIO
12	P12	DIO_12	Digital I/O	GPIO
13	P13	DIO_13	Digital I/O	GPIO
14	P14	DIO_14	Digital I/O	GPIO
15	P15	DIO_15	Digital I/O	GPIO
16	TMS	JTAG_TMSC	-	JTAG TMSC, high-drive capability
17	TCK	JTAG_TCKC	-	JTAG TCK
18	P16	DIO_16	Digital I/O	GPIO, JTAG_TDO, high-drive capability
19	P17	DIO_17	Digital I/O	GPIO, JTAG_TDI, high-drive capability
20	P18	DIO_18	Digital I/O	GPIO
21	P19	DIO_19	Digital I/O	GPIO
22	P20	DIO_20	Digital I/O	GPIO
23	P21	DIO_21	Digital I/O	GPIO
24	P22	DIO_22	Digital I/O	GPIO
25	RST	RESET_N	-	Reset, active low.
26	P23	DIO_23	Digital or analog I/O	GPIO, Sensor Controller, analog
27	P24	DIO_24	Digital or analog I/O	GPIO, Sensor Controller, analog
28	P25	DIO_25	Digital or analog I/O	GPIO, Sensor Controller, analog
29	P26	DIO_26	Digital or analog I/O	GPIO, Sensor Controller, analog
30	P27	DIO_27	Digital or analog I/O	GPIO, Sensor Controller, analog
31	P28	DIO_28	Digital or analog I/O	GPIO, Sensor Controller, analog
32	P29	DIO_29	Digital or analog I/O	GPIO, Sensor Controller, analog
33	P30	DIO_30	Digital or analog I/O	GPIO, Sensor Controller, analog
34	VCC	VCC	-	1.8 V ~ 3.8 V, recommended to 3.3 V
35	ANT	-	-	External antenna pin
36	GND	GND	-	Ground

3 Specifications

3.1 Recommended Operating Conditions

Functional operation does not guarantee performance beyond the limits of the conditional parameter values in the table below. Long-term work beyond this limit will affect the reliability of the module more or less.

Table 3. Recommended Operating Conditions of RF-SM-1277B1/B2

Items	Condition	Min.	Typ.	Max.	Unit
Operating Supply Voltage	Battery Mode	1.8	3.3	3.8	V
Operating Temperature	/	-40	+25	+85	℃
Environmental Hot Pendulum	/	-20		+20	℃/min

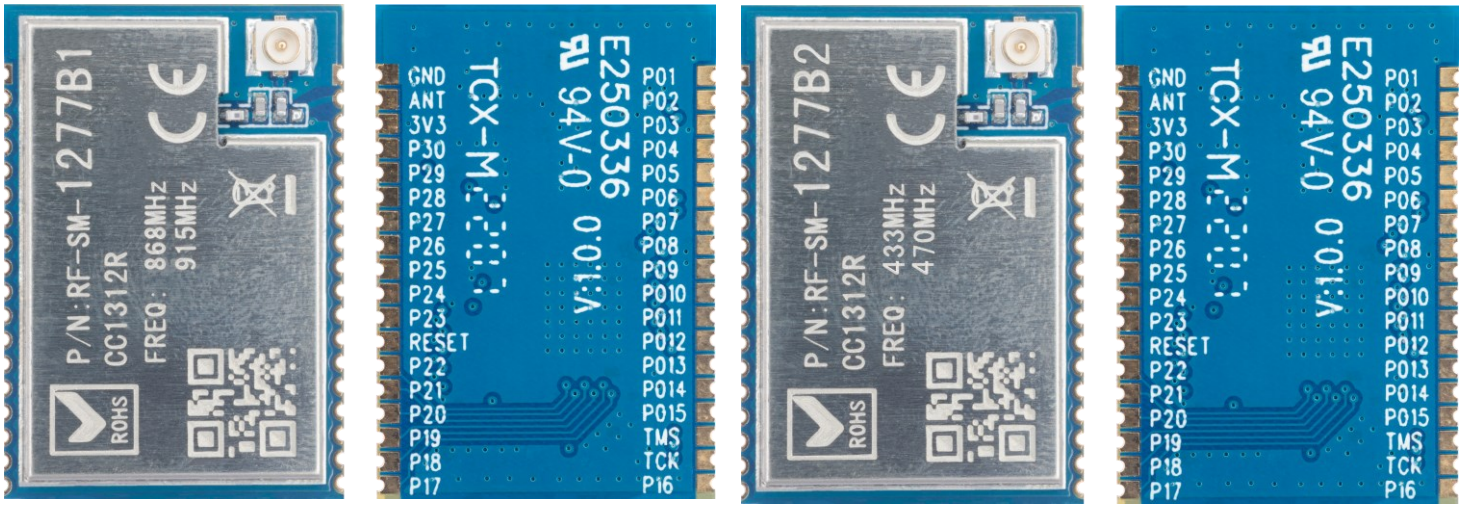
3.2 Handling Ratings

Table 4. Handling Ratings of RF-SM-1277B1/B2

Items	Condition	Min.	Typ.	Max.	Unit
Storage Temperature	Tstg	-40	+25	+125	℃
Human Body Model	HBM		±2000		V
Moisture Sensitivity Level			3		
Charged Device Model			±500		V

4 Application, Implementation, and Layout

4.1 Module Photos



RF-SM-1277B1 RF-SM-1277B2

Figure 4. Photos of RF-SM-1277B1/B2

4.2 Recommended PCB Footprint

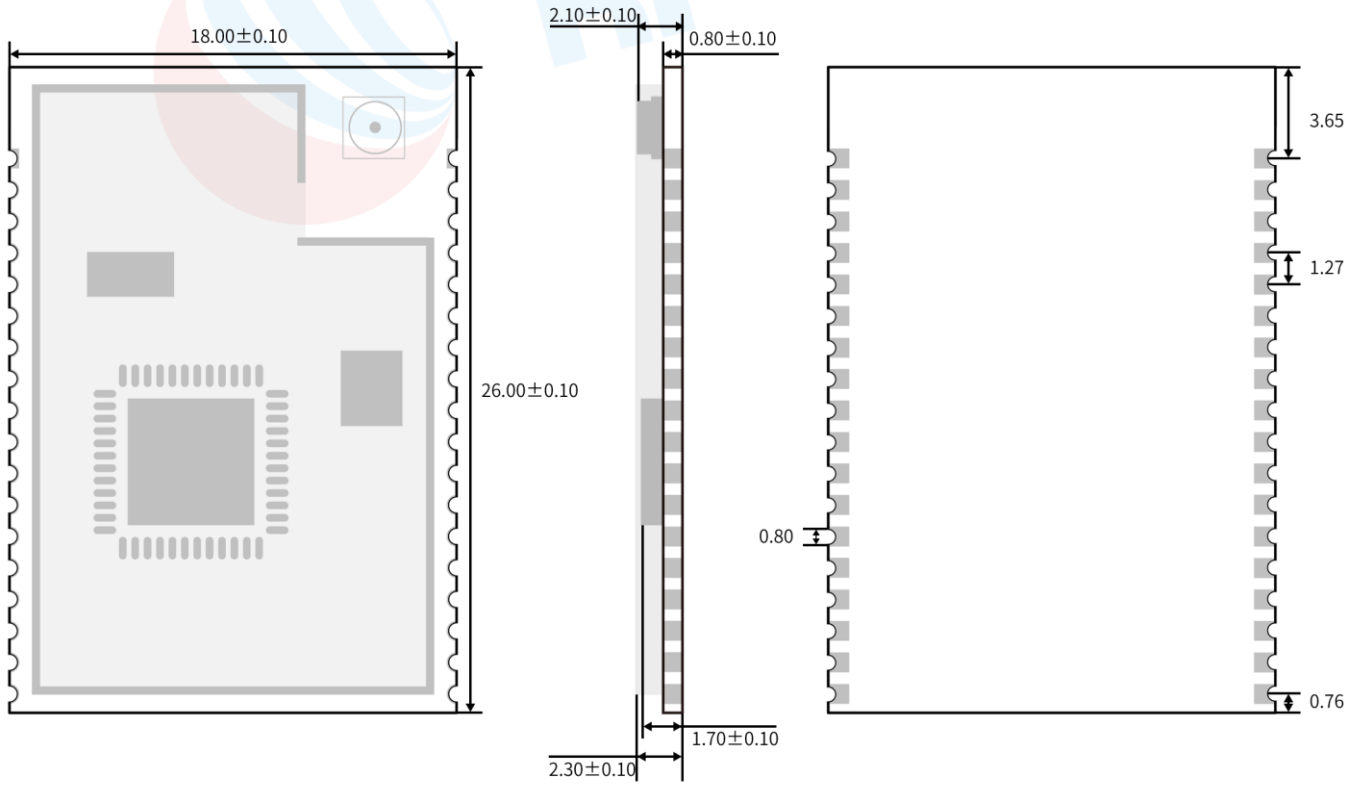


Figure 5. Recommended PCB Footprint of RF-SM-1277B1/B2 (mm)

4.3 Schematic Diagram

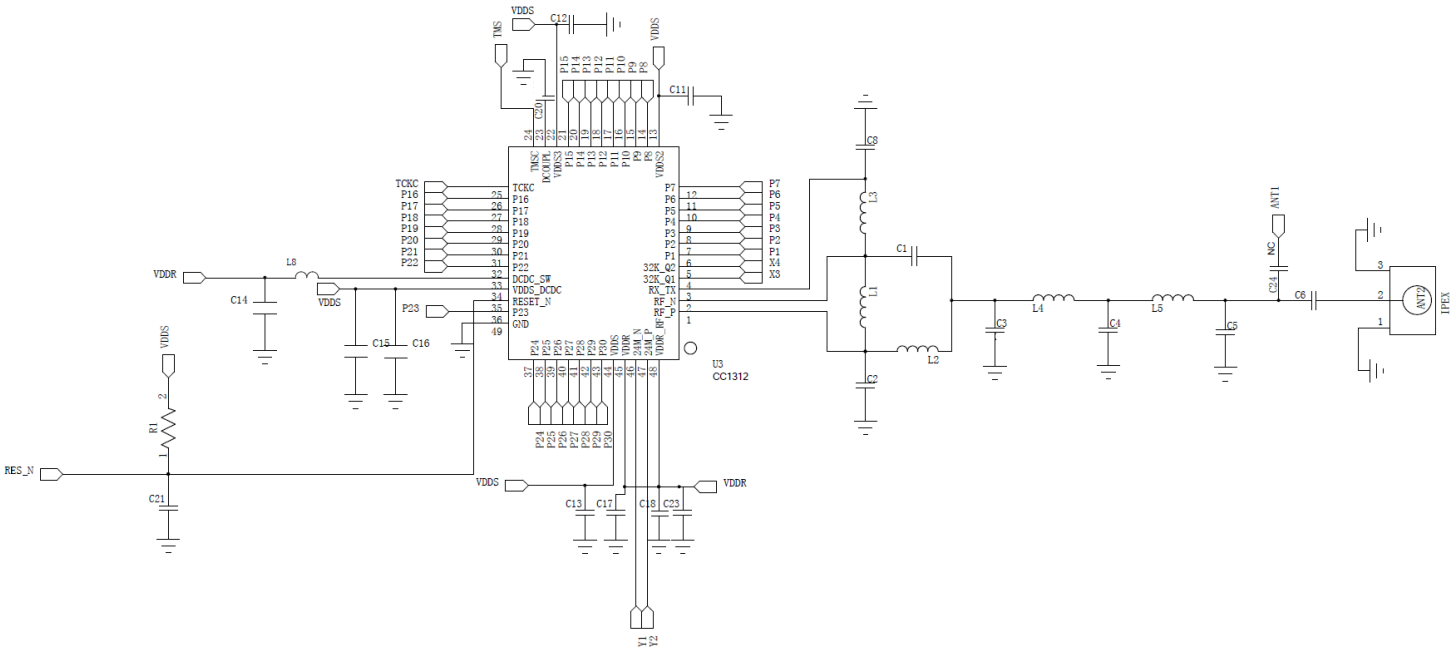


Figure 6. Schematic Diagram of RF-SM-1277B1/B2

5.4 Antenna

5.4.1 Antenna Design Recommendation

1. The antenna installation structure has a great influence on the module performance. It is necessary to ensure the antenna is exposed and preferably vertically upward. When the module is installed inside of the case, a high-quality antenna extension wire can be used to extend the antenna to the outside of the case.
2. The antenna must not be installed inside the metal case, which will cause the transmission distance to be greatly weakened.

5.4.2 Antenna Output Mode Modification

1. RF-SM-1277B1/B2 has two antenna output modes. The one is IPEX connector and the other is a stamp half-hole output (ANT pin, see pin function table for details).

The default delivery is the ***IPEX connector***, and the capacitor connected to the IPEX is welded. If you want to use the external antenna by the ANT pin, the capacitor position should be removed to the right solder joint to have the access to the ANT pin. The location of the capacitor is shown in the figure below.

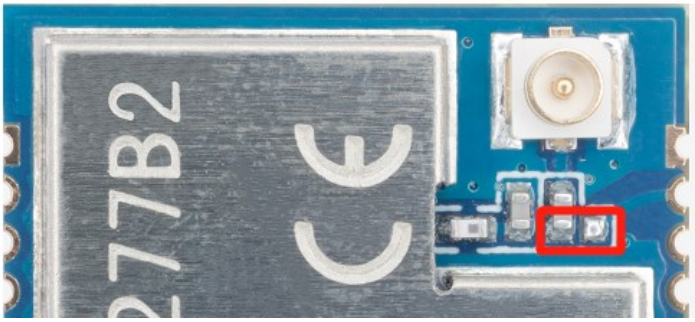


Figure 7. Antenna Output Mode Change of RF-SM-1277B1/B2

5.4.3 External Antenna Design Recommendation of the Half-Hole ANT Pin

1. A Π-type matching circuit is reserved for the antenna, and 50 Ω impedance control is performed on the RF traces. The traces are as short as possible, and 135° or arc traces are used as much as possible. No vias are used to change layers. More GND vias are placed around the RF traces.

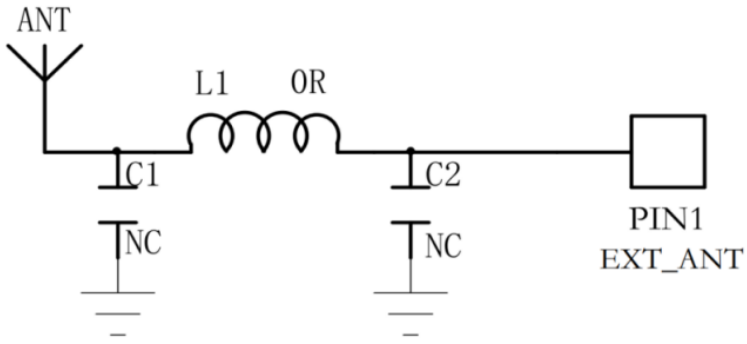


Figure 8. Reference Design of the External Antenna

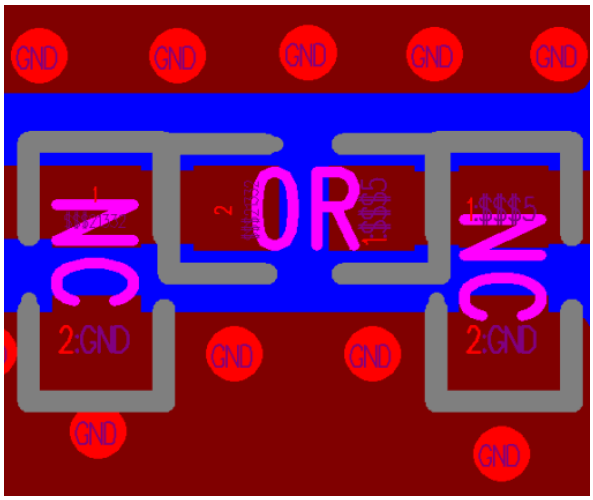


Figure 9. Reference Design of the External Antenna Traces

2. The RF trace width and copper-clad spacing can be calculated by SI9000 software, and the impedance is controlled to 50 Ω according to the actual board thickness, number of layers, plate, dielectric thickness, dielectric constant, copper thickness, line width, line spacing, and solder mask thickness.

   Example: FR4 is a double-layer board with a thickness of 1.0 mm. Through calculation, the width of the trace is 0.8254 mm, and the spacing between traces and copper is 0.22 mm.

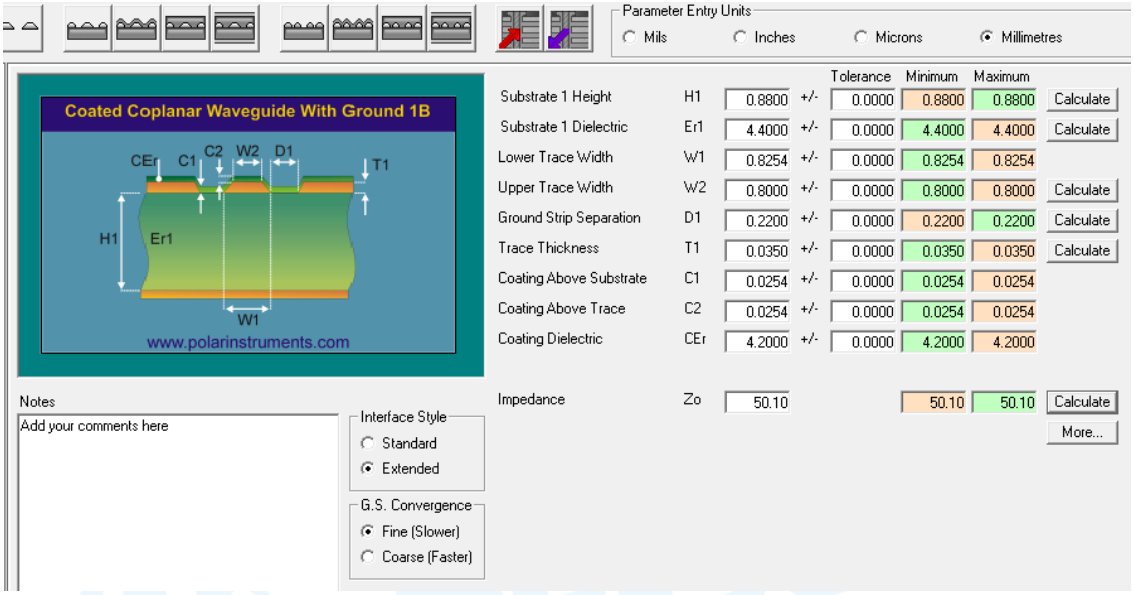


Figure 10. SI9000 Impedance Calculation Diagram

5.4.4 IPEX Connector Specification

RF-SM-1277B1/B2 module is integrated the IPEX version 1 antenna seat, the specification of the antenna seat is as follows:

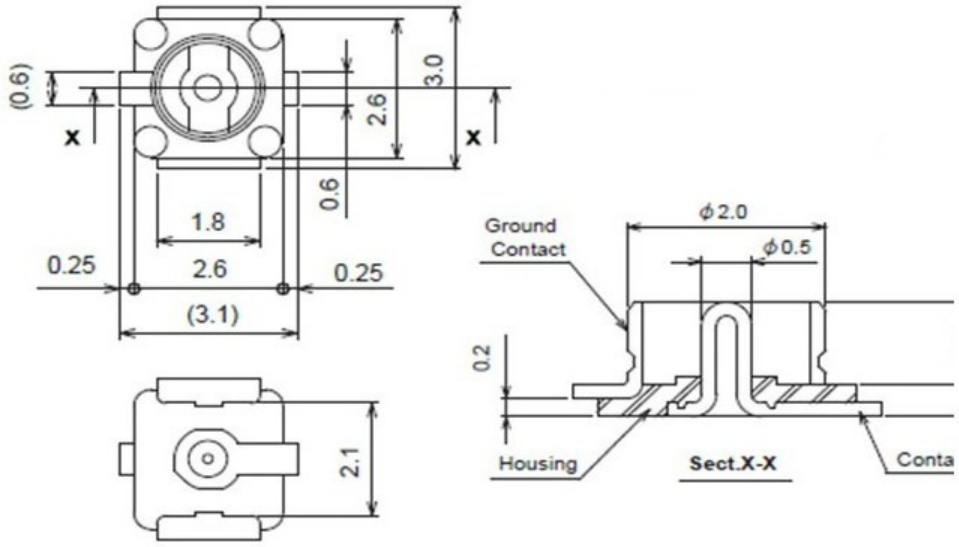


Figure 11. Specification of Antenna Seat

The specification of the IPEX wire end is as follows:

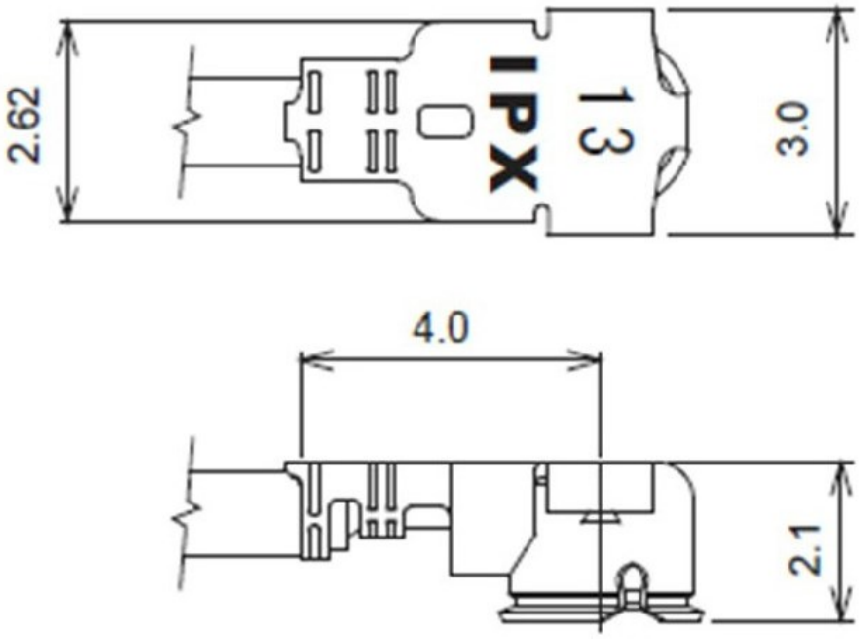


Figure 12. Specification of IPEX Wire

5.5 Basic Operation of Hardware Design

1. It is recommended to offer the module a DC stabilized power supply, a tiny power supply ripple coefficient, and reliable ground. Please pay attention to the correct connection between the positive and negative poles of the power supply. Otherwise, the reverse connection may cause permanent damage to the module;
2. Please ensure the supply voltage is between the recommended values. The module will be permanently damaged if the voltage exceeds the maximum value. Please ensure a stable power supply and no frequently fluctuating voltage.
3. When designing the power supply circuit for the module, it is recommended to reserve more than 30% of the margin, which is beneficial to the long-term stable operation of the whole machine. The module should be far away from the power electromagnetic, transformer, high-frequency wiring, and other parts with large electromagnetic interference.
4. The bottom of the module should avoid high-frequency digital routing, high-frequency analog routing, and power routing. If it has to route the wire on the bottom of the module, for example, it is assumed that the module is soldered to the Top Layer, the copper must be spread on the connection part of the top layer and the module, and be close to the digital part of the module and routed in the Bottom Layer (all copper is well-grounded).
5. Assuming that the module is soldered or placed in the Top Layer, it is also wrong to randomly route the Bottom Layer or other layers, which will affect the spurs and receiving sensitivity of the module to some degree;
6. Assuming that there are devices with large electromagnetic interference around the module, which will greatly affect the module performance. It is recommended to stay away from the module according to the strength of the interference. If circumstances permit, appropriate isolation and shielding can be done.

7. Assuming that there are routings of large electromagnetic interference around the module (high-frequency digital, high-frequency analog, power routings), which will also greatly affect the module performance. It is recommended to stay away from the module according to the strength of the interference. If circumstances permit, appropriate isolation and shielding can be done.
8. It is recommended to stay away from the devices whose TTL protocol is the same 2.4 GHz physical layer, for example, USB 3.0.

5.6 Trouble Shooting

5.6.1 Unsatisfactory Transmission Distance

1. When there is a linear communication obstacle, the communication distance will be correspondingly weakened. Temperature, humidity, and co-channel interference will lead to an increase in the communication packet loss rate. The performances of ground absorption and reflection of radio waves will be poor when the module is tested close to the ground.
2. Seawater has a strong ability to absorb radio waves, so the test results by the seaside are poor.
3. The signal attenuation will be very obvious if there is metal near the antenna or if the module is placed inside the metal shell.
4. The incorrect power register set or the high data rate in the open air may shorten the communication distance. The higher the data rate, the closer the distance.
5. The low voltage of the power supply is lower than the recommended value at ambient temperature, and the lower the voltage, the smaller the power is.
6. The unmatchable antennas and modules or the poor quality of antenna will affect the communication distance.

5.6.2 Vulnerable Module

1. Please ensure the supply voltage is between the recommended values. The module will be permanently damaged if the voltage exceeds the maximum value. Please ensure a stable power supply and no frequently fluctuating voltage.
2. Please ensure the anti-static installation and the electrostatic sensitivity of high-frequency devices.
3. Due to some humidity-sensitive components, please ensure the suitable humidity during installation and application. If there is no special demand, it is not recommended to use at too high or too low temperature.

5.6.3 High Bit Error Rate

1. There are co-channel signal interferences nearby. It is recommended to be away from the interference sources or modify the frequency and channel to avoid interferences.
2. The unsatisfactory power supply may also cause garbled. It is necessary to ensure the power supply's reliability.

3. If the extension wire or feeder wire is of poor quality or too long, the bit error rate will be high.

5.7 Electrostatics Discharge Warnings

The module will be damaged by the discharge of static. RF-star suggests that all modules should follow the 3 precautions below:

1. According to the anti-static measures, bare hands are not allowed to touch modules.
2. Modules must be placed in anti-static areas.
3. Take the anti-static circuitry (when inputting HV or VHF) into consideration in product design.

   Static may result in the degradation in performance of the module, even causing failure.

5.8 Soldering and Reflow Condition

1. Heating method: Conventional Convection or IR/convection.
2. Solder paste composition: Sn96.5/Ag3.0/Cu0.5
3. Allowable reflow soldering times: 2 times based on the following reflow soldering profile.
4. Temperature profile: Reflow soldering shall be done according to the following temperature profile.
5. Peak temperature: 245 ℃.

Table 5. Temperature Table of Soldering and Reflow

Profile Feature	Sn-Pb Assembly	Pb-Free Assembly
Solder Paste	Sn63 / Pb37	Sn96.5 / Ag3.0 / Cu0.5
Min. Preheating Temperature (T_{min})	100 ℃	150 ℃
Max. Preheating Temperature (T_{max})	150 ℃	200 ℃
Preheating Time (T_{min} to T_{max}) (t_1)	60 s ~ 120 s	60 s ~ 120 s
Average Ascend Rate (T_{max} to T_p)	Max. 3 ℃/s	Max. 3 ℃/s
Liquid Temperature (T_L)	183 ℃	217 ℃
Time above Liquidus (t_L)	60 s ~ 90 s	30 s ~ 90 s
Peak Temperature (T_p)	220 ℃ ~ 235 ℃	230 ℃ ~ 250 ℃
Average Descend Rate (T_p to T_{max})	Max. 6 ℃/s	Max. 6 ℃/s
Time from 25 ℃ to Peak Temperature (t_2)	Max. 6 minutes	Max. 8 minutes
Time of Soldering Zone (t_P)	20±10 s	20±10 s

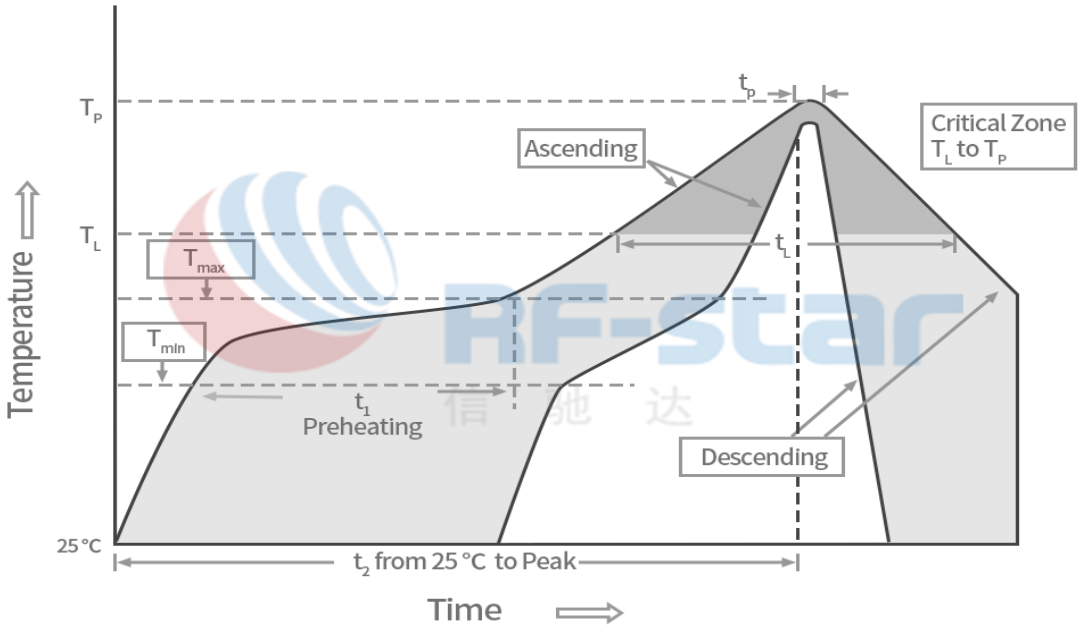


Figure 13. Recommended Reflow for Lead-Free Solder

5 Optional Package Specification

The default package method is ***by tray***. If you need the modules to be shipped by tape & reel, pls contact us in advance.

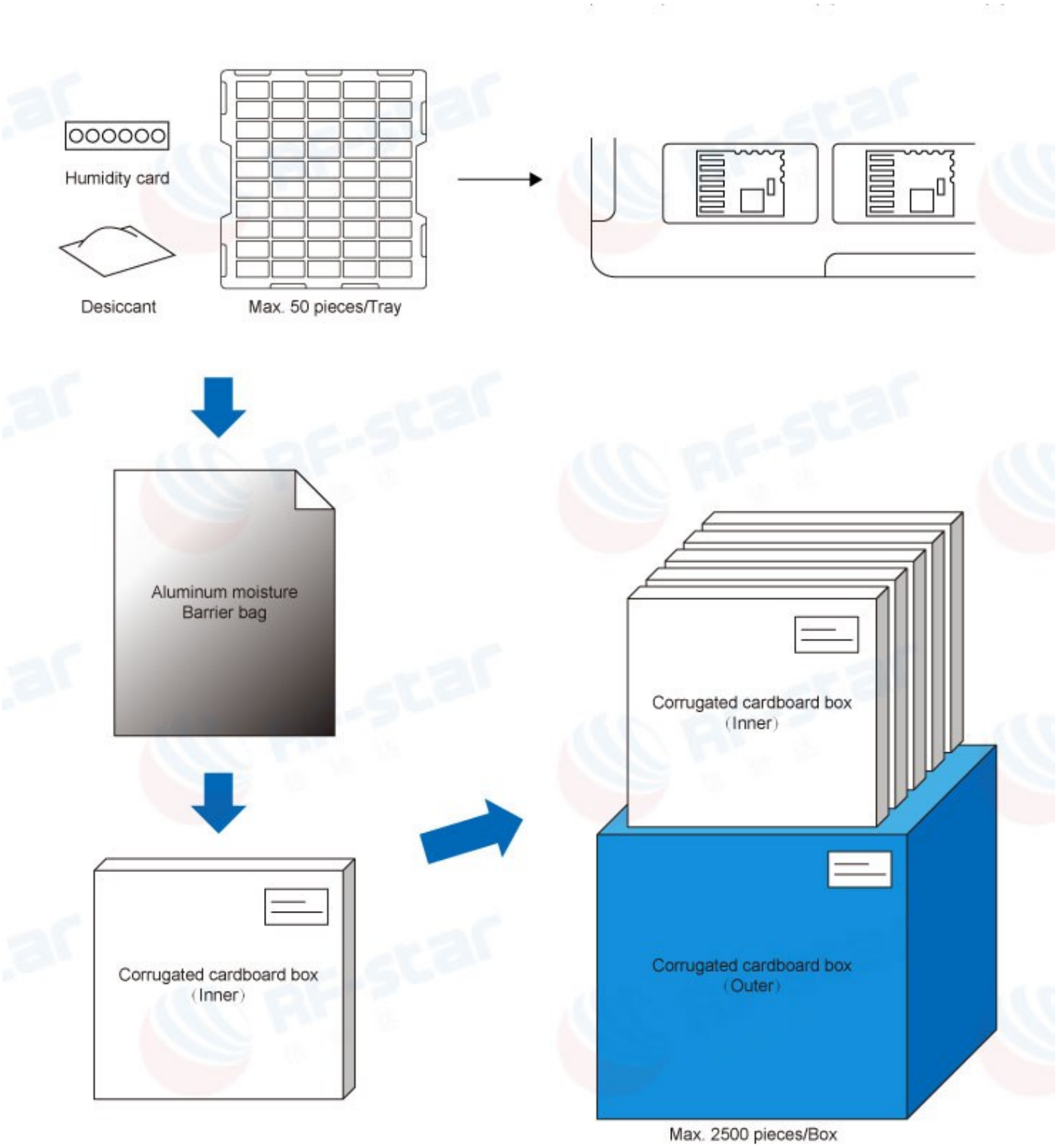


Figure 14. Default Package by Tray

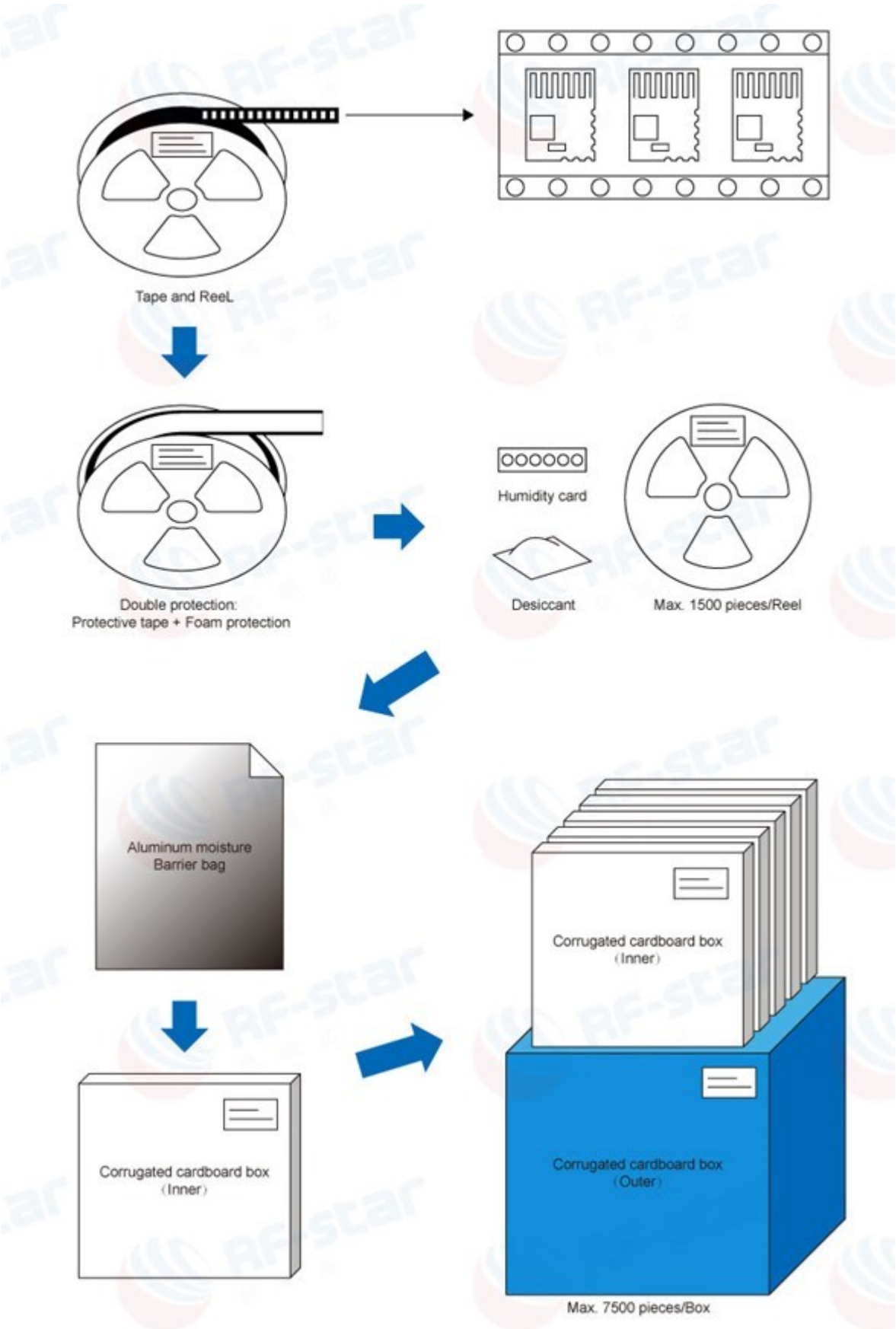


Figure 15. Package by Tape & Reel

6 Revision History

Date	Version No.	Description
2022.09.13	V1.0	The initial version is released.
2022.10.17	V1.1	Update the schedamic diagram. Update the max. TX power. Update the antenna charpter.
2023.05.26	V1.0	Update MSL level. Update the Shenzhen office address.

Note:

1. The document will be optimized and updated from time to time. Before using this document, please make sure it is the latest version.
2. To obtain the latest document, please download it from the official website: www.rfstariot.com and www.szrfstar.com.

7 Contact Us

SHENZHEN RF-STAR TECHNOLOGY CO., LTD.

Shenzhen HQ:

Add.: Room 502, Podium Building No. 12, Shenzhen Bay Science and Technology Ecological Park, Nanshan District, Shenzhen, Guangdong, China, 518063

Tel.: 86-755-8632 9829

Chengdu Branch:

Add.: N2-1604, Global Center, North No. 1700, Tianfu Avenue, Hi-Tech District, Chengdu, Sichuan, China, 610095

Tel.: 86-28-8692 5399

Email: sunny@szrfstar.com, sales@szrfstar.com

Web.: www.rfstariot.com, www.szrfstar.com