RF-BM-4077B1L CC2640R2L

Bluetooth 5.1 Low Energy Wireless Module

Version 1.0

Shenzhen RF-star Technology Co., Ltd.

May 26th, 2023

All rights reserved. Those responsible for unauthorized reproduction will be prosecuted.

1 Device Overview

1.1 Description

RF-BM-4077B1L is a PCB module based on TI CC2640R2L wireless MCU supporting Bluetooth 5.1 Low Energy (BLE) stack. To minimize users' design effort, RF-BM-4077B1L module has integrated a 24 MHz crystal, a 32.768 kHz crystal, an LC balun, and an inverted-F PCB antenna. The CC2640 SoC contains a 32-bit ARM Cortex™-M3 main processor at 48 MHz, a rich peripheral feature set. Its 2.4GHz radio processes very low active current and outstanding RF performance. It is pre-programmed with an application communication protocol over its serial interface and an AT command set, which allow users to quickly connect their application to build a reliable BLE connection for their products. This module fits into a wide range of BLE applications where robust connection, long battery lifetime, small form factor, and ease of use are important.

1.2 Key Features

- RF
  - 2.4 GHz RF transceiver compatible with Bluetooth low energy 5.1 and specification
  - Excellent receiver sensitivity (-97 dBm for BLE)
  - Programmable output power up to +5 dBm
  - Signal-ended or differential RF interface
- Microcontroller
  - Powerful ARM® Cortex®-M3
  - EEMBC CoreMark® score: 142
  - Up to 48-MHz clock speed
  - 275 KB of nonvolatile memory including 128 KB of in-system programmable flash
  - Up to 28 KB of system SRAM, of which 20 KB is ultra-low leakage SRAM
  - 8 KB of SRAM for cache or system RAM use
  - 2-Pin cJTAG and JTAG debugging
  - Supports over-the-air upgrade (OTA)
- Peripherals
  - 12 bit ADC, 200 ksamples/s, 8 channel analog MUX
  - Continuous time comparator
  - Ultra-low-power analog comparator
  - Programmable current source
  - UART
  - 2 × SSI (SPI, MICROWIRE, TI)
  - I^2C
  - I^2S
  - Real-time clock (RTC)
  - AES-128 security module
  - True random number generator (TRNG)
- Low Power
  - Wide supply voltage range: 1.8 V to 3.8 V
  - Active-mode RX: 5.9 mA
  - Active-mode TX at 0 dBm: 6.1 mA
  - Active-mode TX at 5 dBm: 9.1 mA
  - Active-mode MCU: 61 μA/MHz
  - Active-mode MCU: 48.5 CoreMark/mA
  - Standby: 1.5 μA (RTC running and RAM/CPU retention)
  - Shutdown: 100 nA (wake up on external events)

1.3 Applications

- Smart toys
- Fitness equipment
- Environmental sensor nodes
- Passive key-less entry (PKE)
- Smart door locks
- Phone accessories
- Health-care equipment
- Smart lighting
- Energy harvesting
- Thermometer
- Human input devices
- Sports equipment

1.4 Functional Block Diagram

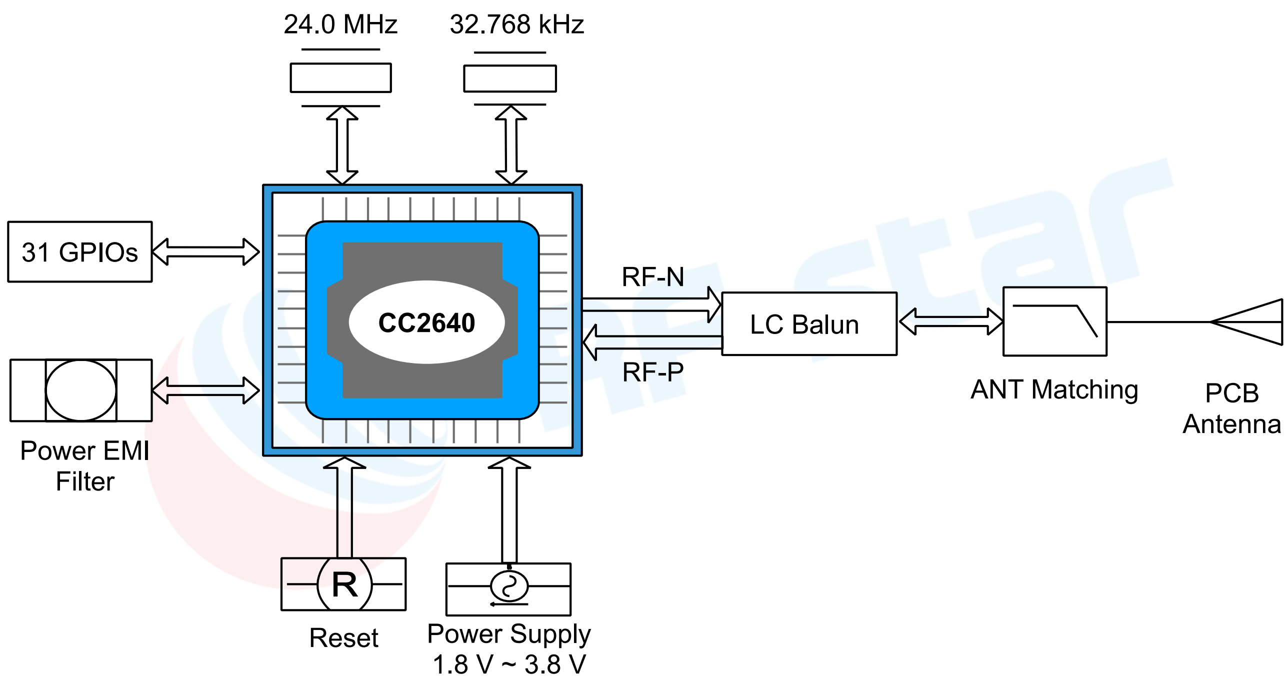


Figure 1. Functional Block Diagram of RF-BM-4077B1L

1.5 Part Number Conventions

The part numbers are of the form of RF-BM-4077B1L where the fields are defined as follows:

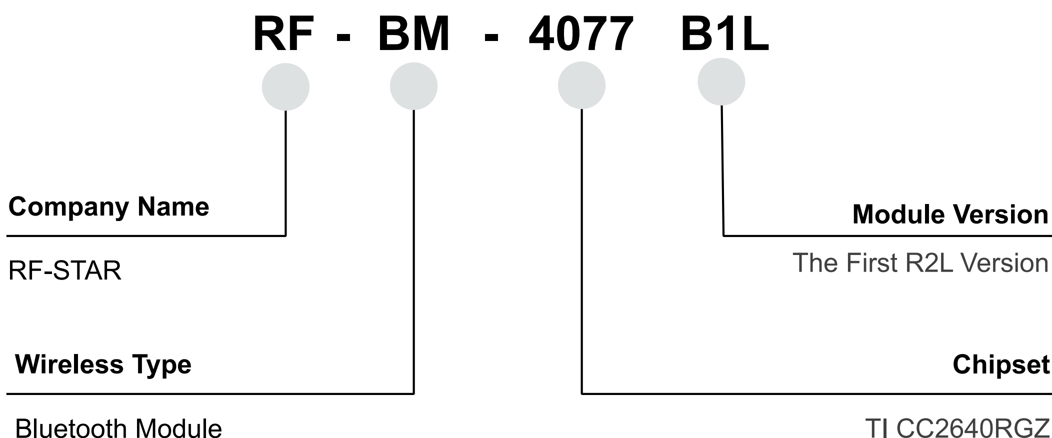


Figure 2. Part Number Conventions of RF-BM-4077B1L

Table of Contents

1 Device Overview 2
1.1 Description 2
1.2 Key Features 2
1.3 Applications 3
1.4 Functional Block Diagram 3
1.5 Part Number Conventions 3
Table of Contents 4
2 Module Configuration and Functions 5
2.1 Module Parameters 5
2.2 Module Pin Diagram 6
2.3 Pin Functions 6
3 Specifications 8
3.1 Recommended Operating Conditions 8
3.2 Handling Ratings 8
4 Application, Implementation, and Layout 9
4.1 Module Photos 9
4.2 Recommended PCB Footprint 9
4.3 Schematic Diagram 10
4.4 Reference Design 10
4.5 Antenna 11
4.5.1 Antenna Design Recommendation 11
4.6 Basic Operation of Hardware Design 11
4.7 Trouble Shooting 12
4.7.1 Unsatisfactory Transmission Distance 12
4.7.2 Vulnerable Module 13
4.7.3 High Bit Error Rate 13
4.8 Electrostatics Discharge Warnings 13
4.9 Soldering and Reflow Condition 13
5 Optional Package Specification 15

6 Revision History 17
7 Contact Us 18

2 Module Configuration and Functions

2.1 Module Parameters

Table 1. Parameters of RF-BM-4077B1L

Chipset	CC2640R2LRGZ
Supply Power Voltage	1.8 V ~ 3.8 V, recommended to 3.3 V
Frequency	2402 MHz ~ 2480 MHz
Transmit Power	-21.0 dBm ~ +5.0 dBm (typical: 0 dBm)
Receiving Sensitivity	-97 dBm
GPIO	31
Crystal	24 MHz, 32.768 kHz
RAM	20 KB
Flash	128 KB
Package	SMT Packaging (1.27-mm half-hole pitch stamp stick)
Interface	UART, I^2S, I^2C, SPI, ADC
Frequency Error	±20 kHz
Dimension	23.5 mm x 17.0 mm x 1.7 mm
Type of Antenna	PCB antenna
Operating Temperature	-40 ℃ ~ +85 ℃
Storage Temperature	-40 ℃ ~ +125 ℃

2.2 Module Pin Diagram

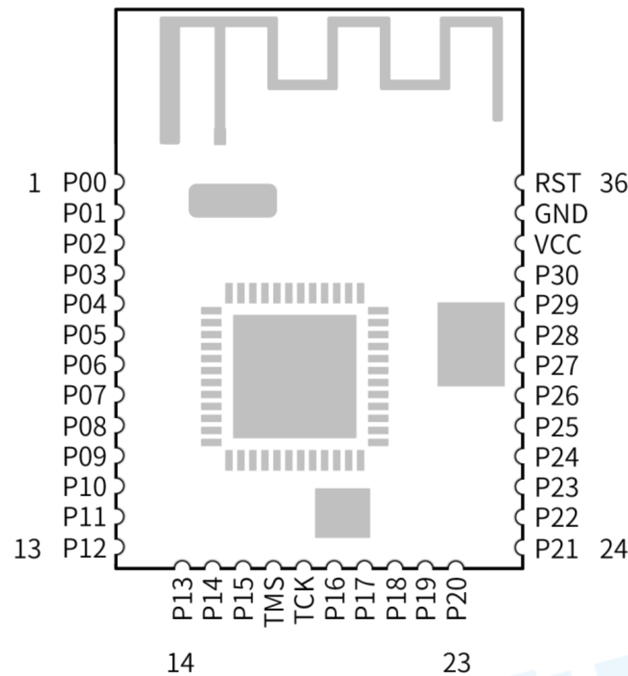


Figure 3. Pin Diagram of RF-BM-4077B1L

2.3 Pin Functions

Table 2. Pin Functions of RF-BM-4077B1L

Pin	Name	Chip Pin	Function	Description
1	P00	DIO_0	I/O	GPIO, Sensor Controller
2	P01	DIO_1	I/O	GPIO, Sensor Controller
3	P02	DIO_2	I/O	GPIO, Sensor Controller
4	P03	DIO_3	I/O	GPIO, Sensor Controller
5	P04	DIO_4	I/O	GPIO, Sensor Controller
6	P05	DIO_5	I/O	GPIO, Sensor Controller, high-drive capability
7	P06	DIO_6	I/O	GPIO, Sensor Controller, high-drive capability
8	P07	DIO_7	I/O	GPIO, Sensor Controller, high-drive capability
9	P08	DIO_8	I/O	GPIO
10	P09	DIO_9	I/O	GPIO
11	P10	DIO_10	I/O	GPIO
12	P11	DIO_11	I/O	GPIO
13	P12	DIO_12	I/O	GPIO
14	P13	DIO_13	I/O	GPIO

15	P14	DIO_14	I/O	GPIO
16	P15	DIO_15	I/O	GPIO
17	JTAG_TMSC	JTAG_TMSC	—	JTAG TMSC, high-drive capability
18	JTAG_TCKC	JTAG_TCKC	—	JTAG TCKC
19	P16	DIO_16	I/O	GPIO, JTAG_TDO, high-drive capability
20	P17	DIO_17	I/O	GPIO, JTAG_TDI, high-drive capability
21	P18	DIO_18	I/O	GPIO
22	P19	DIO_19	I/O	GPIO
23	P20	DIO_20	I/O	GPIO
24	P21	DIO_21	I/O	GPIO
25	P22	DIO_22	I/O	GPIO
26	P23	DIO_23	I/O	GPIO, Sensor Controller, Analog
27	P24	DIO_24	I/O	GPIO, Sensor Controller, Analog
28	P25	DIO_25	I/O	GPIO, Sensor Controller, Analog
29	P26	DIO_26	I/O	GPIO, Sensor Controller, Analog
30	P27	DIO_27	I/O	GPIO, Sensor Controller, Analog
31	P28	DIO_28	I/O	GPIO, Sensor Controller, Analog
32	P29	DIO_29	I/O	GPIO, Sensor Controller, Analog
33	P30	DIO_30	I/O	GPIO, Sensor Controller, Analog
34	VCC	VCC	VCC	Power supply 1.8 V ~ 3.8 V, Recommend 3.3 V
35	GND	GND	GND	Ground
36	RESET	RESET_N	RESET	Reset, active low, no internal pullup.

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-BM-4077B1L

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-BM-4077B1L

Items	Condition	Min.	Typ.	Max.	Unit
Storage Temperature	Tstg	-40	+25	+125	℃
Human Body Model	HBM		±2500		V
Moisture Sensitivity Level			3		
Charged Device Model			±500		V

4 Application, Implementation, and Layout

4.1 Module Photos

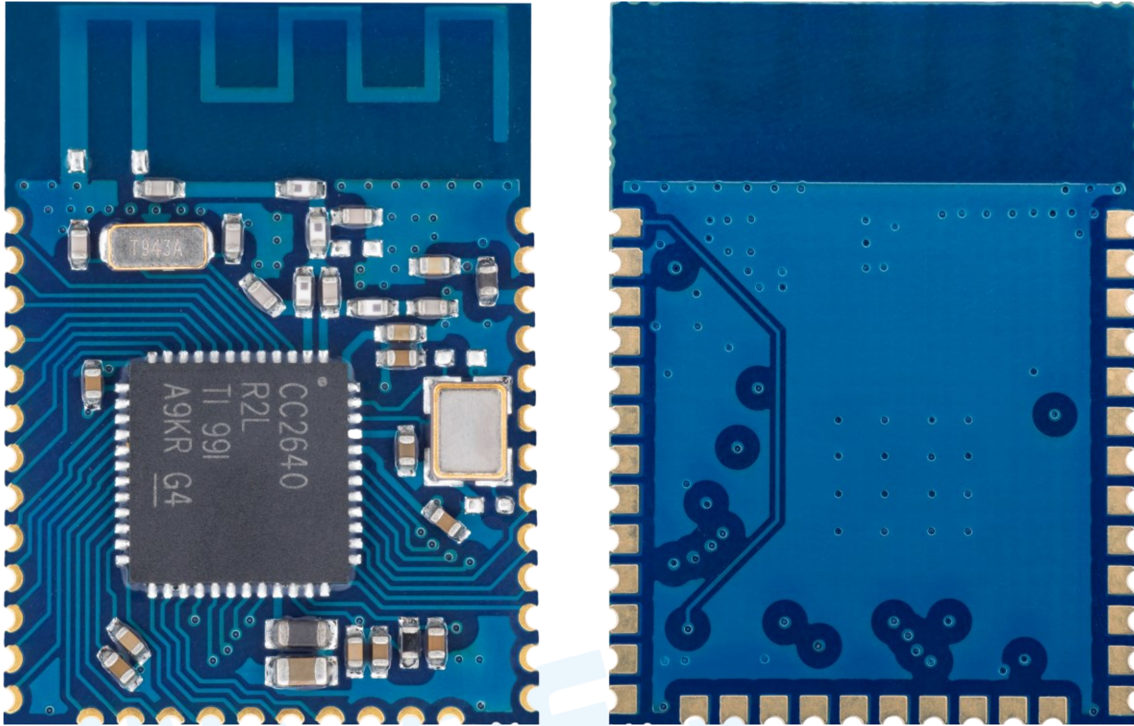


Figure 4. Photos of RF-BM-4077B1L

4.2 Recommended PCB Footprint

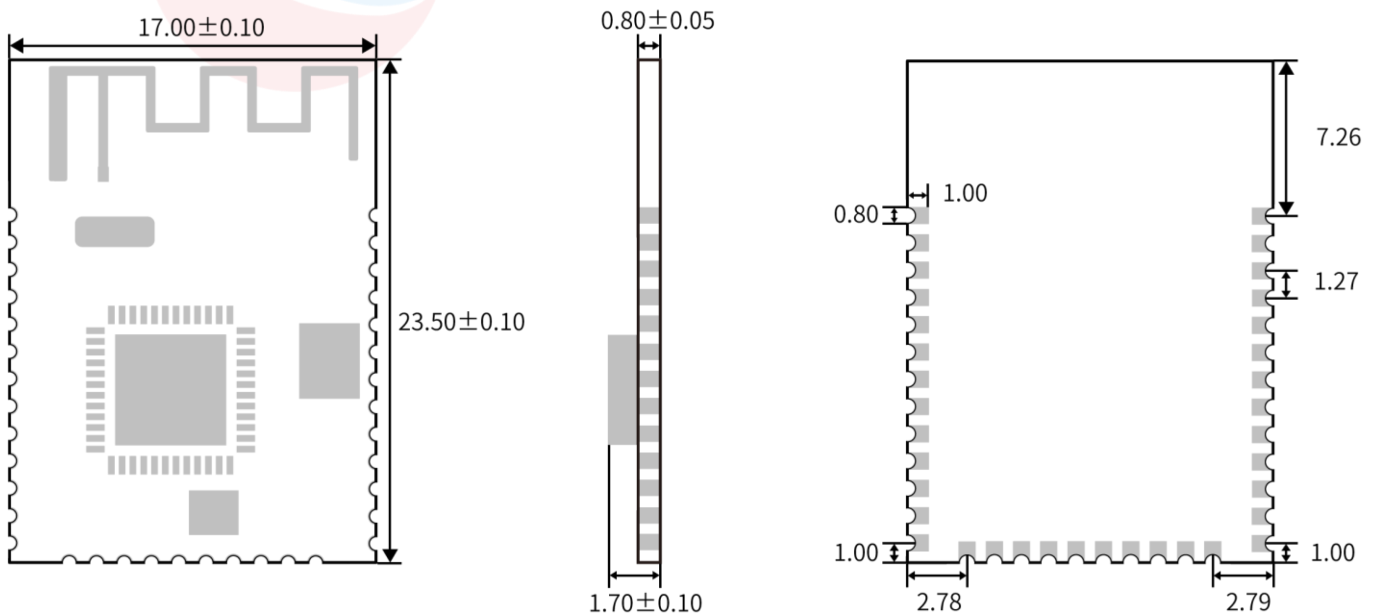


Figure 5. Recommended PCB Footprint of RF-BM-4077B1L (mm)

4.3 Schematic Diagram

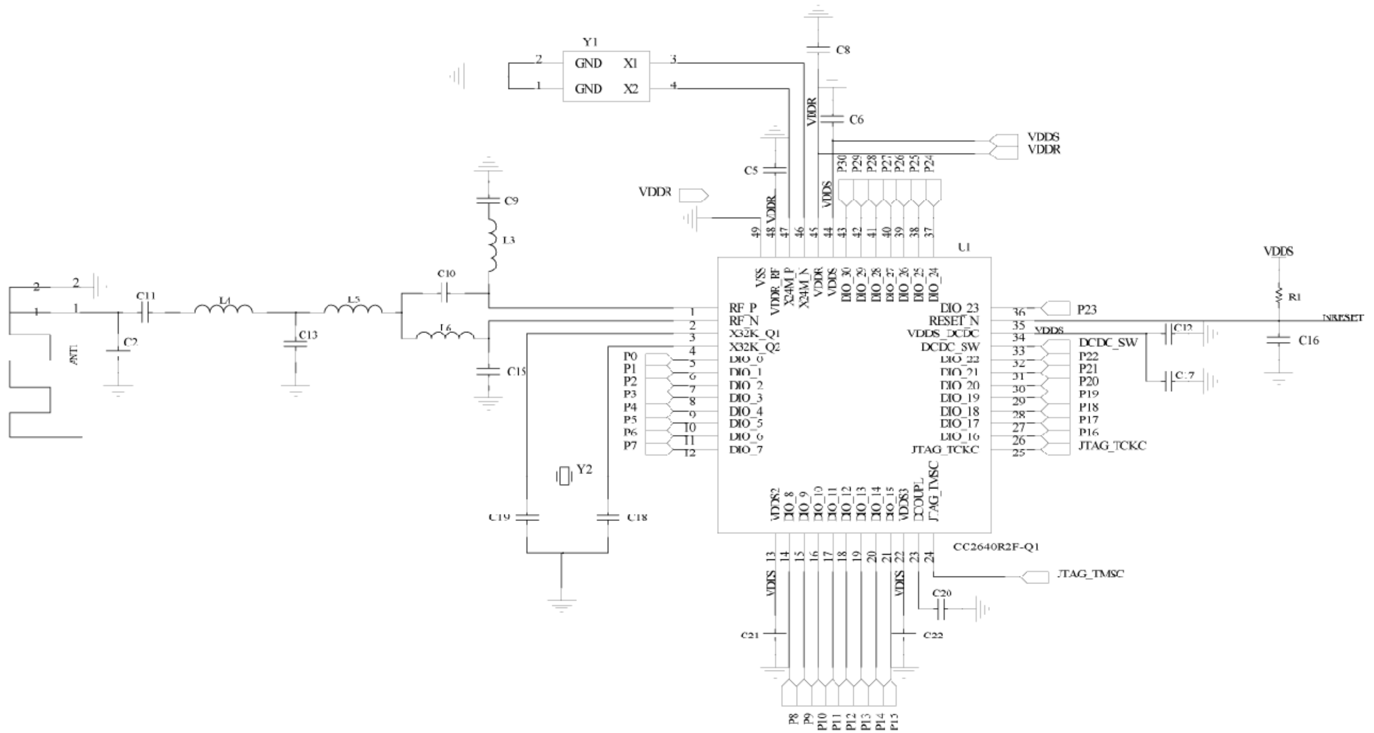
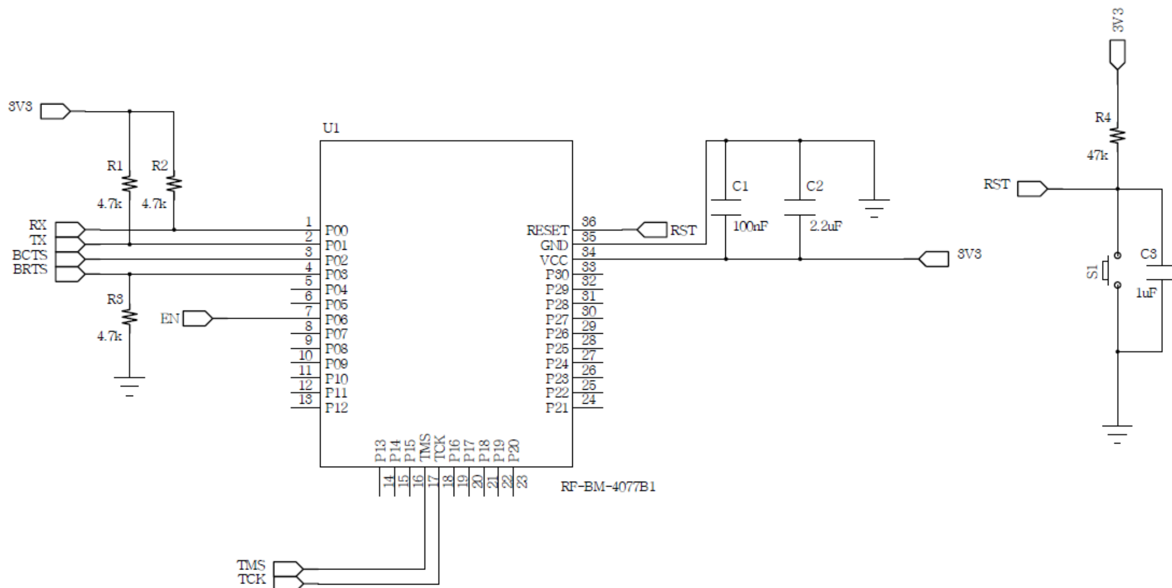


Figure 6. Schematic Diagram of RF-BM-4077B1L

4.4 Reference Design



Note: EN low enable.

Figure 7. Reference Design of RF-BM-4077B1L

4.5 Antenna

4.5.1 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.
3. The recommendation of antenna layout.

   The inverted-F antenna position on PCB is free-space electromagnetic radiation. The location and layout of the antenna are key factors to increase the data rate and transmission range.

   Therefore, the layout of the module antenna location and routing is recommended as follows:

   (1) Place the antenna on the edge (corner) of the PCB.

   (2) Make sure that there is no signal line or copper foil in each layer below the antenna.

   (3) It is best to hollow out the antenna position in the following figure to ensure that the S11 of the module is minimally affected.

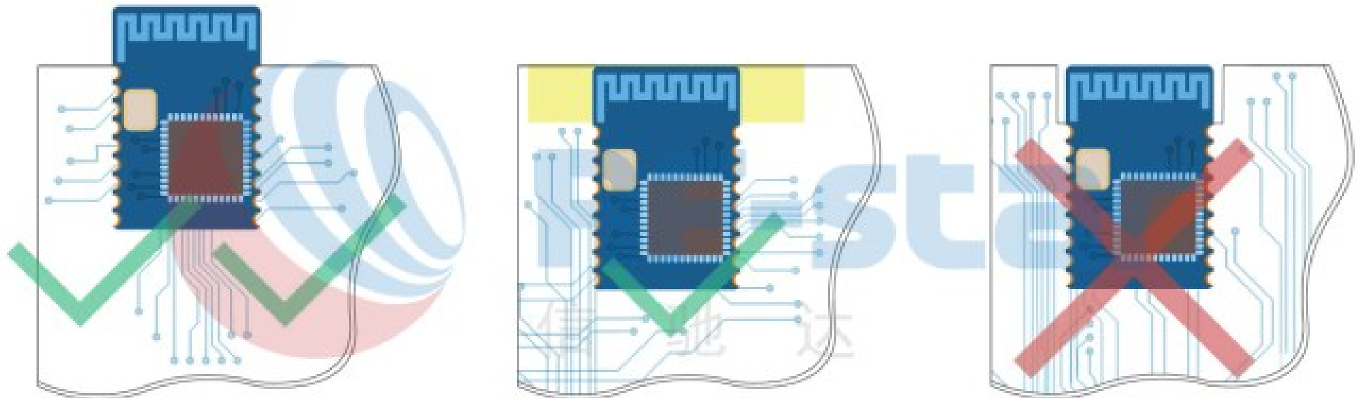


Figure 8. Recommendation of Antenna Layout

Note: The hollow-out position is based on the antenna used.

4.6 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.

4.7 Trouble Shooting

4.7.1 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 performance 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 the antenna will affect the communication distance.

4.7.2 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 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.

4.7.3 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.

4.8 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.

4.9 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

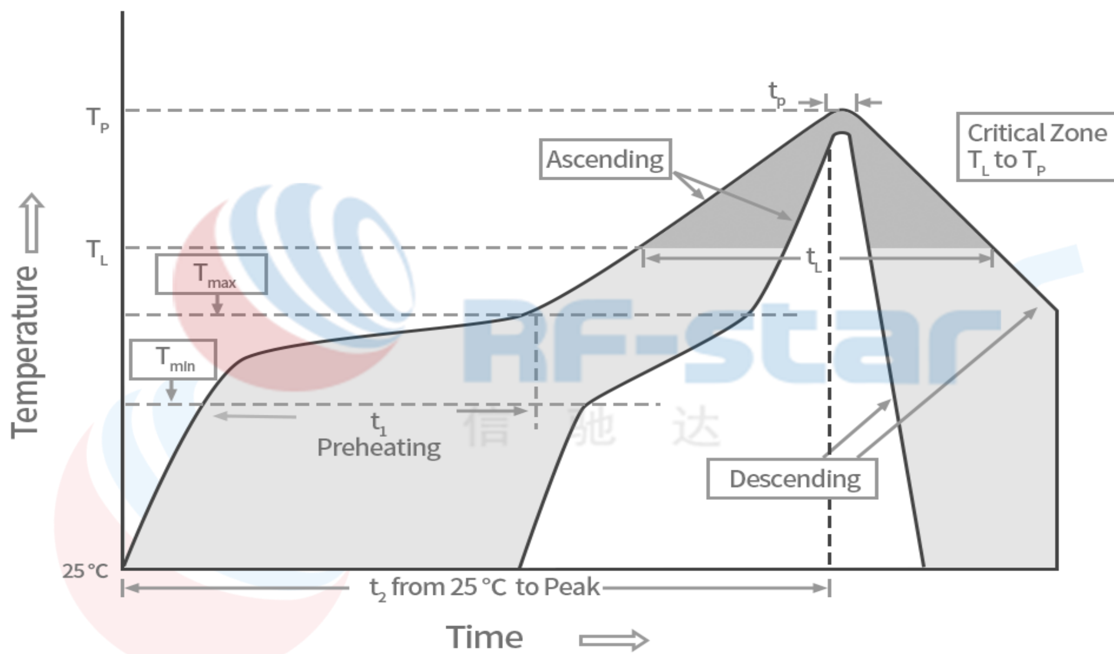


Figure 9. Recommended Reflow for Lead-Free Solder

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.

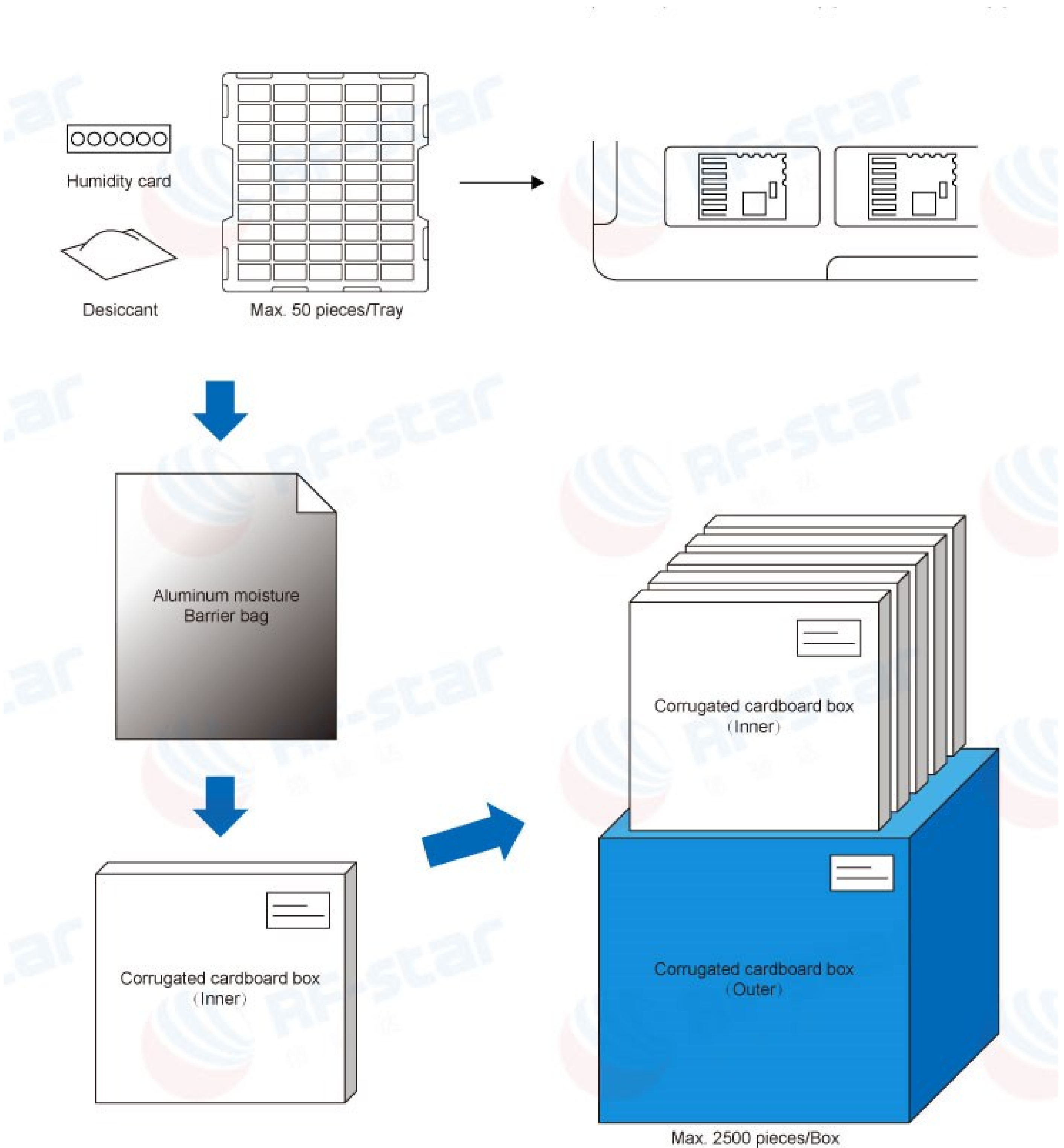


Figure 10. Default Package by Tray

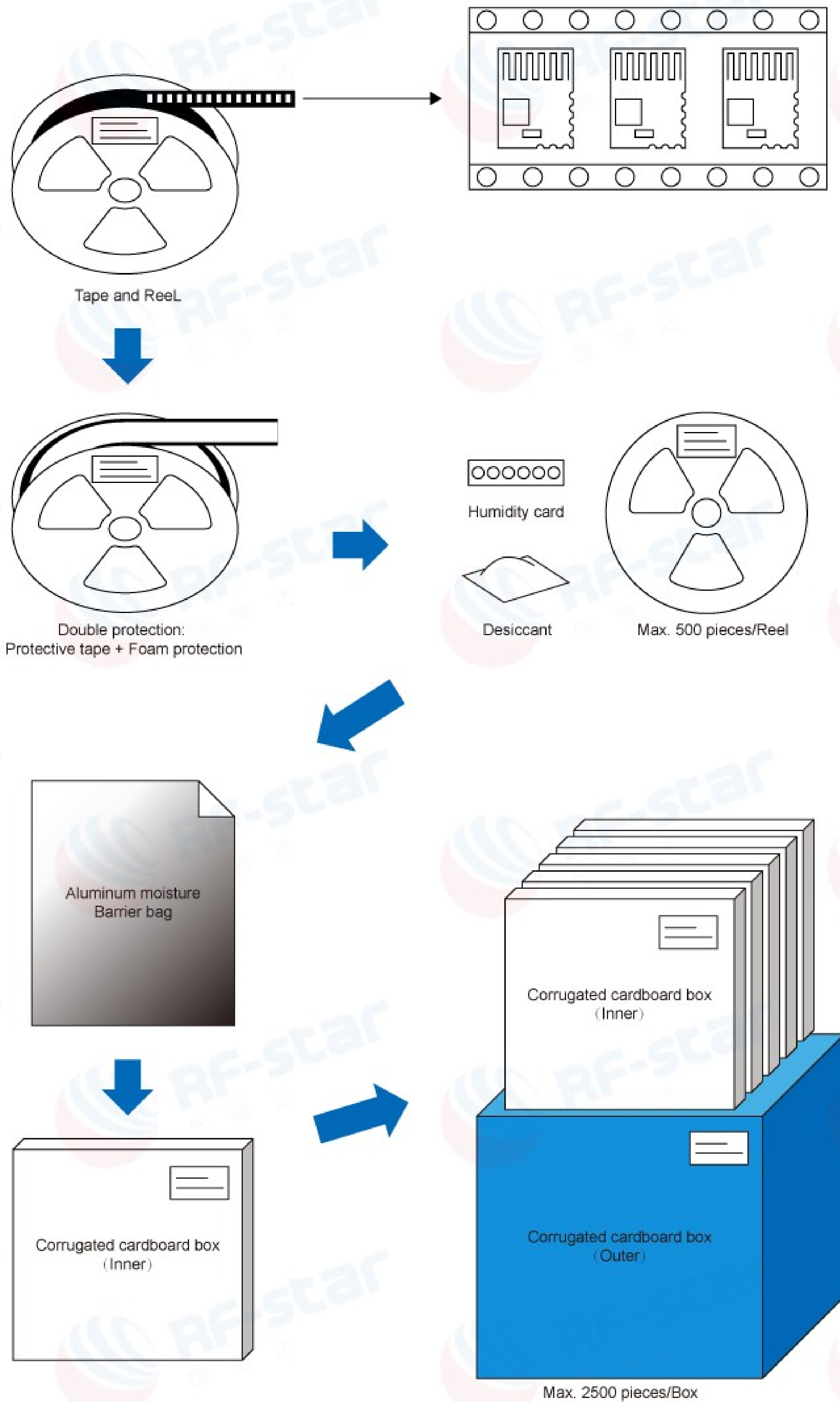


Figure 11. Package by Tape & Reel

6 Revision History

Date	Version No.	Description
2018.01.23	V1.0	The initial version is released.
2023.05.26	V1.1	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