RF-BM-4044B2 and RF-BM-4044B3

CC2640R2FRSM

Bluetooth 5.1 Low Energy Module

Version 1.1

Shenzhen RF-star Technology Co., Ltd.

May 26th, 2023

1 Device Overview

1.1 Module Series

There is a series of RF-BM-4044Bx Bluetooth 5.1 Low Energy modules. All of them are based on TI CC2640R2FRSM SoC.

Table 1. Module Series of RF-BM-4044Bx

Model	Dimension	Antenna Output Mode	Chip Model
4044B2	16.6 mm x 11.2 mm x 1.7 mm	PCB onboard antenna	CC2640R2FRSM
4044B3	15.2 mm x 11.2 mm x 2.1 mm	IPEX connector	

1.2 Description

RF-BM-4044B2 and RF-BM-4044B3 modules are designed based on CC2640R2FRSM System-on-Chip, which fully supports the single-mode Bluetooth 5.1 Low Energy operation. The module contains a 32-bit ARM Cortex-M3 processor, with a working frequency of 48.0 MHz. The module has rich peripherals function libraries, and a unique ultra-low power sensor controller, which is fit for connecting the external sensors in sleep mode or acquiring analog and digital data independently. RF-BM-4044B2 is pin-compatible with RF-BM-4044B3. 4044B2 is the high-performance onboard PCB antenna and the 4044B3 is equipped with an IPEX connector for the feasible external antennas.

1.3 Key Features

- RF Features
  - Bluetooth low energy 5.1
  - Bluetooth Long Range
  - Data rate: 1 Mbps, 2 Mbps, 125 kbps, 500 kbps
- TX power: -21 dBm ~ +2 dBm
- RF sensitivity
  - -97 dBm @ 1 Mbps
  - -92 dBm @ 2 Mbps
  - -103 dBm @ 125 kbps (LE Coded)
  - -101 dBm @ 500 kbps (LE Coded)
- Differential RF interface
- Microcontroller
  - Powerful 48 MHz ARM® Cortex®-M3
  - EEMBC CoreMark® Score: 142
  - 2-pin cJTAG and JTAG debugging
  - Supports over-the-air upgrade (OTA)
- Memory
  - 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
- Ultra-low power sensor controller
  - 16-bit architecture
  - 2 KB of ultra-low leakage SRAM for code and data
- Rich Peripherals
  - All digital peripheral pins can be routed to any GPIO
  - 10 GPIOs
  - 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 analog 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)

• Dimension

- RF-BM-4044B2: 16.6 mm x 11.2 mm x 1.7 mm
- RF-BM-4044B3: 15.2 mm x 11.2 mm x 2.1 mm

• Certificate

- RF-BM-4044B2
  - ➢ FCC
  - ➢ SRRC
  - ➢ RoHS

1.4 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

1.5 Functional Block Diagram

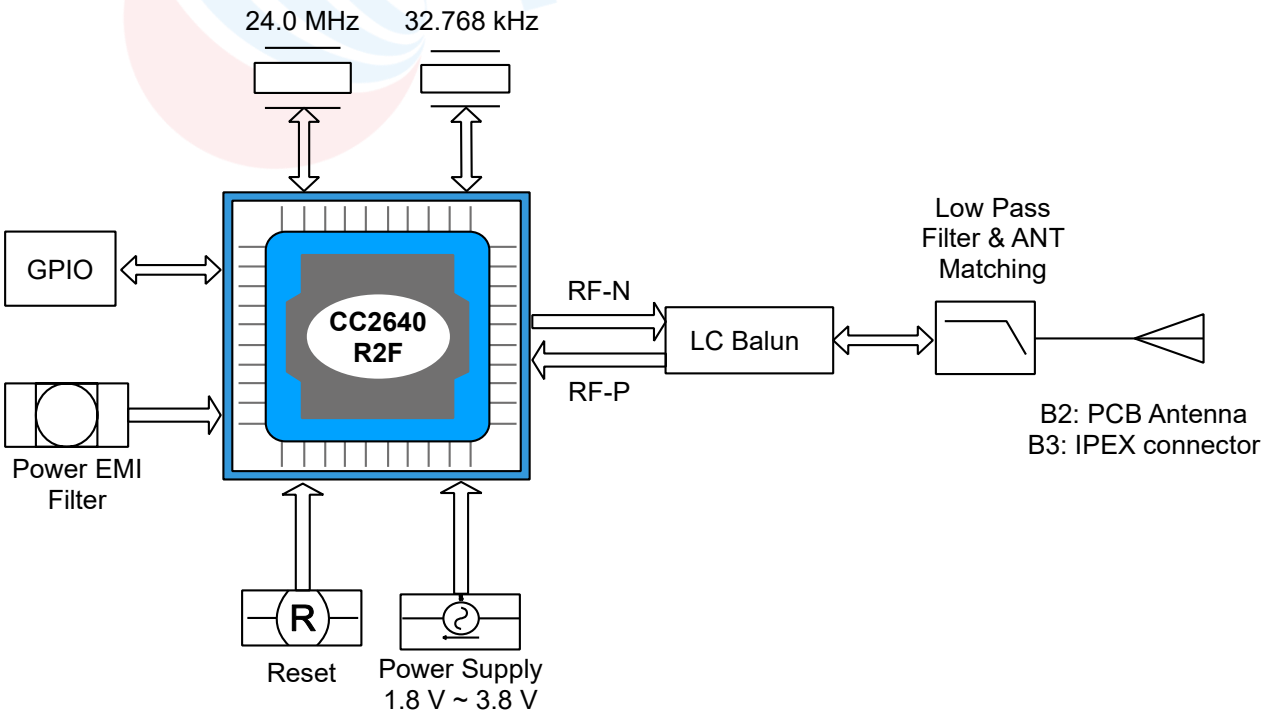


Figure 1. Functional Block Diagram of RF-BM-4044B2/4044B3

1.6 Part Number Conventions

The part numbers are of the form of RF-BM-4044B2/4044B3 where the fields are defined as follows:

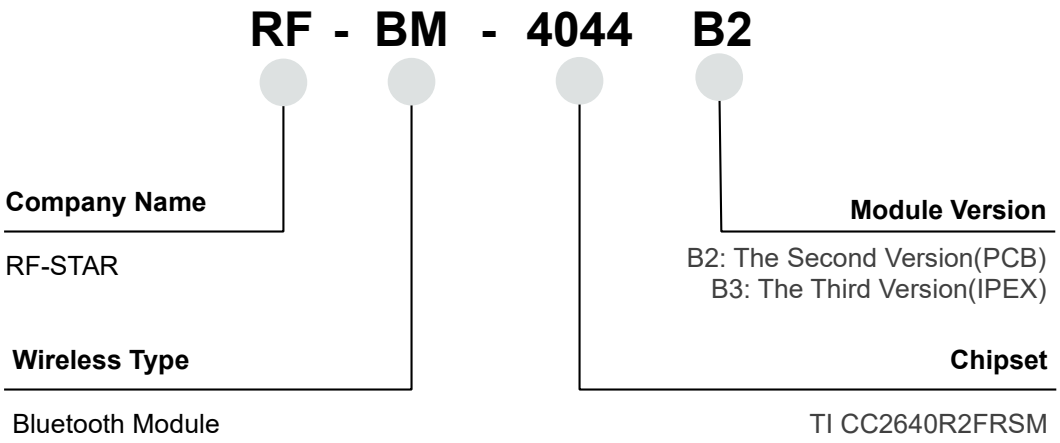


Figure 2. Part Number Conventions of RF-BM-4044B2/4044B3

Table of Contents

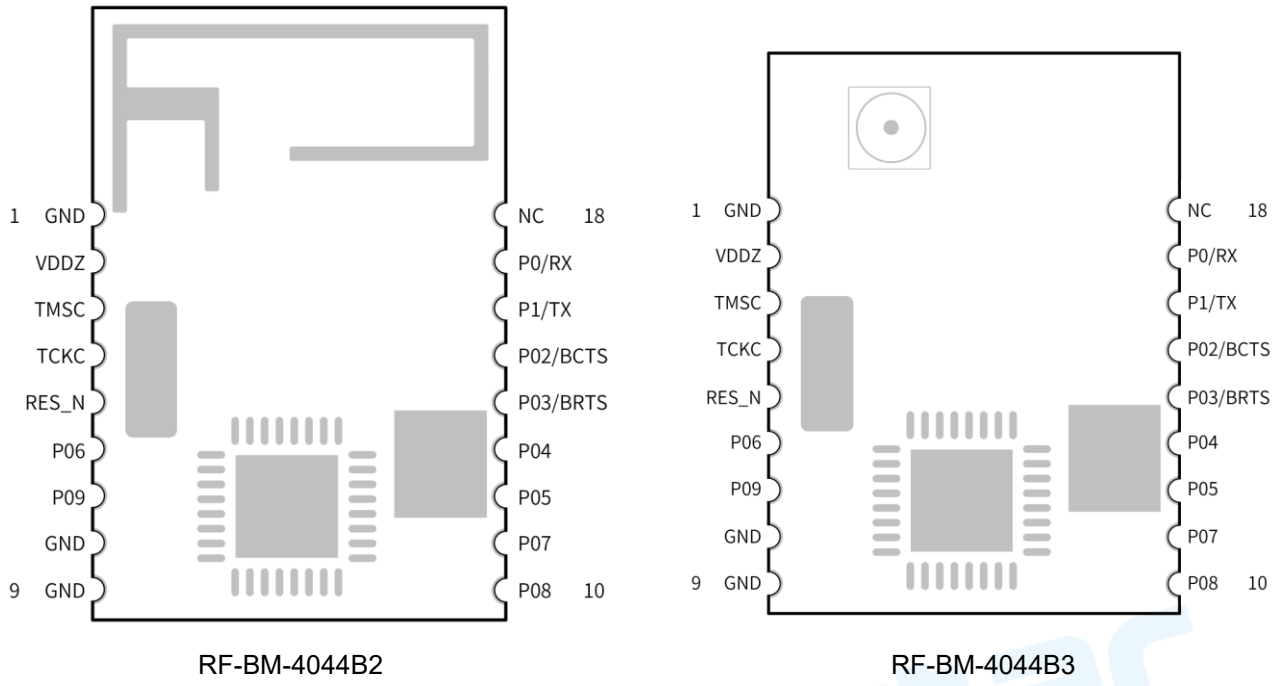
2 Module Configuration and Functions

2.1 Module Parameters

Table 2. Parameters of RF-BM-4044B2/4044B3

Chipset	CC2640R2FRSM
Supply Power Voltage	1.8 V ~ 3.8 V, recommended to 3.3 V
Frequency	2402 MHz ~ 2480 MHz
Transmit Power	-21.0 dBm ~ +2.0 dBm (typical: 0 dBm)
Receiving Sensitivity	-97 dBm @ 1 Mbps -92 dBm @ 2 Mbps -103 dBm @ 125 kbps (LE Coded) -101 dBm @ 500 kbps (LE Coded)
GPIO	10
Crystal	24 MHz, 32.768 kHz
RAM	20 KB
Flash	128 KB
Package	SMT Packaging (1.27-mm half-hole pitch stamp stick)
Frequency Error	±20 kHz
Dimension	RF-BM-4044B2: 16.6 mm x 11.2 mm x 1.7 mm RF-BM-4044B3: 15.2 mm x 11.2 mm x 2.1 mm
Type of Antenna	RF-BM-4044B2: PCB antenna RF-BM-4044B3: IPEX connector
Operating Temperature	-40 ℃ ~ +85 ℃
Storage Temperature	-40 ℃ ~ +125 ℃

2.2 Module Pin Diagram



RF-BM-4044B2 RF-BM-4044B3

Figure 3. Pin Diagram of RF-BM-4044B2/4044B3

2.3 Pin Functions

Table 3. Pin Functions of RF-BM-4044B2/4044B3

Pin	Name	Chip Pin	Pin Type	Description
1	GND	GND	GND	GND
2	VDDZ	VCC	Power	Power supply 1.8 V ~ 3.8 V, recommend 3.3 V
3	TMSC	JTAG_TMSC	Digital I/O	JTAG TMSC
4	TCKC	JTAG_TCKC	Digital I/O	JTAG TCKC
5	RES_N	RESET	RESET	Reset, active low.
6	P06	DIO_6	Digital/Analog I/O	GPIO, Sensor Controller, Analog
7	P09	DIO_9	Digital/Analog I/O	GPIO, Sensor Controller, Analog
8	GND	GND	GND	Ground
9	GND	GND	GND	Ground
10	P08	DIO_8	Digital/Analog I/O	GPIO, Sensor Controller, Analog
11	P07	DIO_7	Digital/Analog I/O	GPIO, Sensor Controller, Analog
12	P05	DIO_5	Digital/Analog I/O	GPIO, Sensor Controller, Analog
13	P04	DIO_4	Digital I/O	GPIO, Sensor Controller, JTAG_TDI
14	P03	DIO_3	Digital I/O	GPIO, Sensor Controller, JTAG_TDO

15	P02	DIO_2	Digital I/O	GPIO, Sensor Controller, high-drive capacity
16	P01	DIO_1	Digital I/O	GPIO, Sensor Controller, high-drive capacity
17	P00	DIO_0	Digital I/O	GPIO, Sensor Controller, high-drive capacity
18	NC	-	-	

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 4. Recommended Operating Conditions of RF-BM-4044B2/4044B3

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 5. Handling Ratings of RF-BM-4044B2/4044B3

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			±750		V

3.3 RF Test

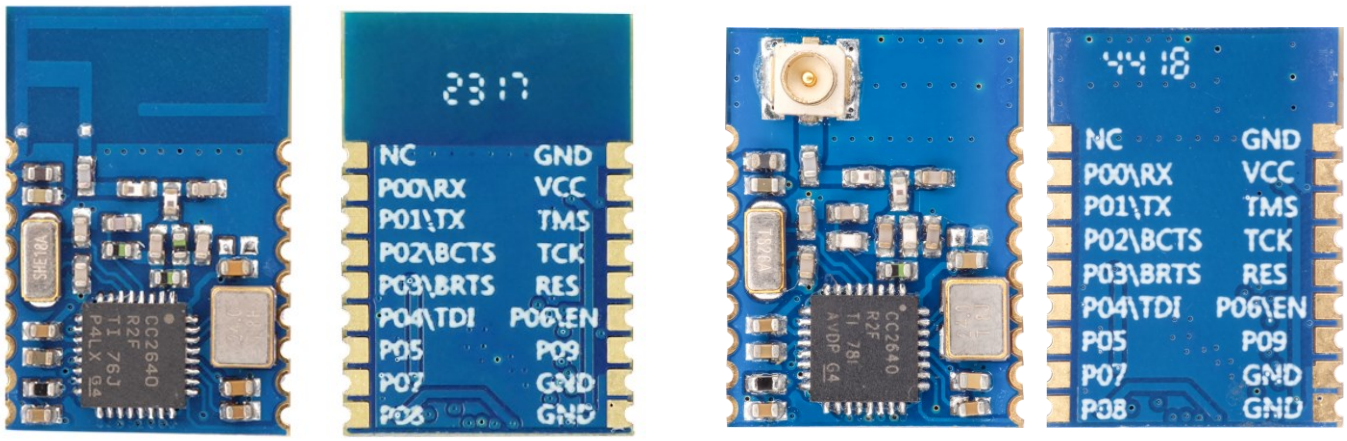
When measured on the RF-BM-4044B2 reference design with T A = 25 ℃, V BAT = 3.3 V with DC/DC, the channel of 39th (2442 MHz) enabled unless otherwise noted.

Table 6. Table of RF Test

Test Item	Parameter	Test Value	Unit
Transmitter	Power	2 (Max.)	dBm
	Frequency Error	±20	kHz
	Radiation (30 m ~ 1 G)	-36	dBm
	Radiation (1 G ~ 12.75 G)	-30	dBm
Receiver	Sensitivity (8% PER)	-93	dBm

4 Application, Implementation, and Layout

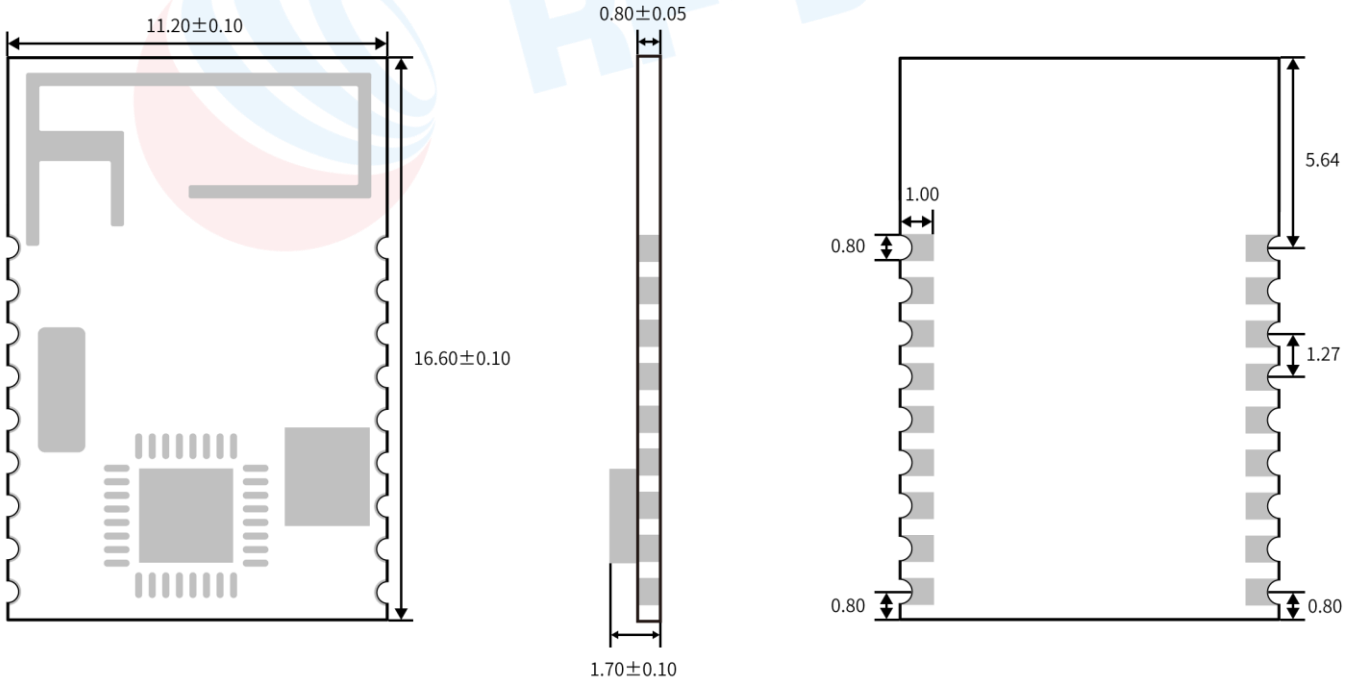
4.1 Module Photos



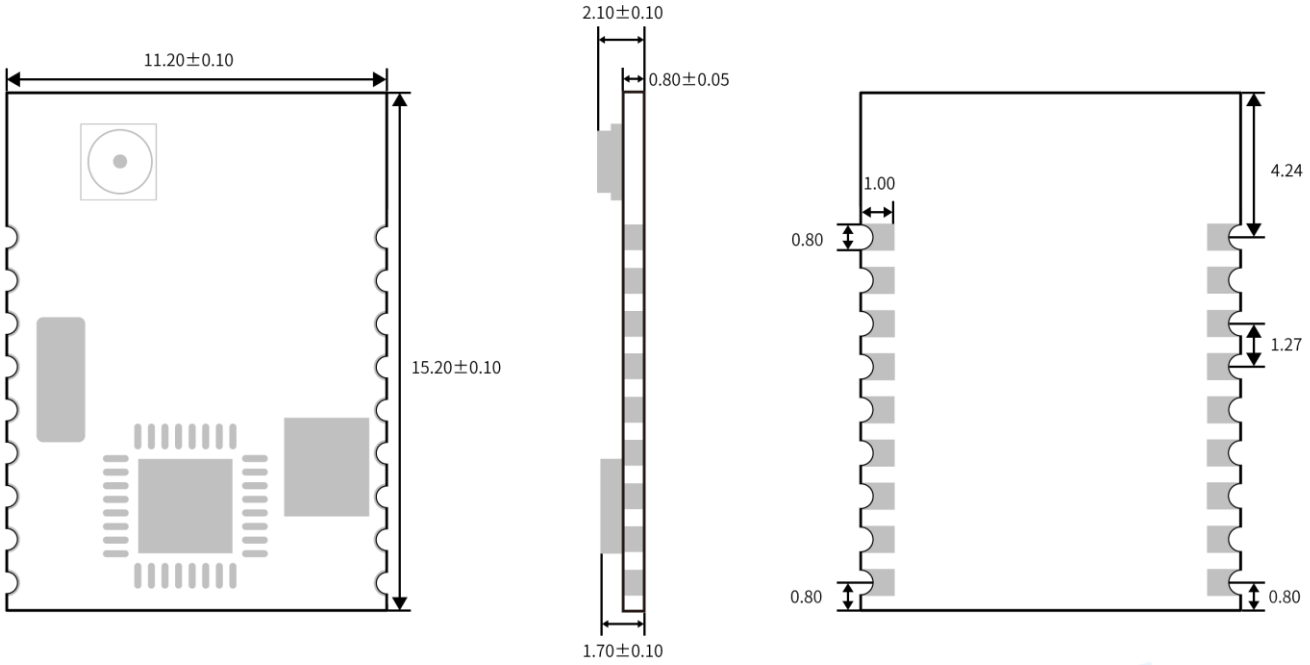
RF-BM-4044B2 RF-BM-4044B3

Figure 4. Photos of RF-BM-4044B2/4044B3

4.2 Recommended PCB Footprint



RF-BM-4044B2



RF-BM-4044B3

Figure 5. Recommended PCB Footprint of RF-BM-4044B2/4044B3 (mm)

4.3 Schematic Diagram

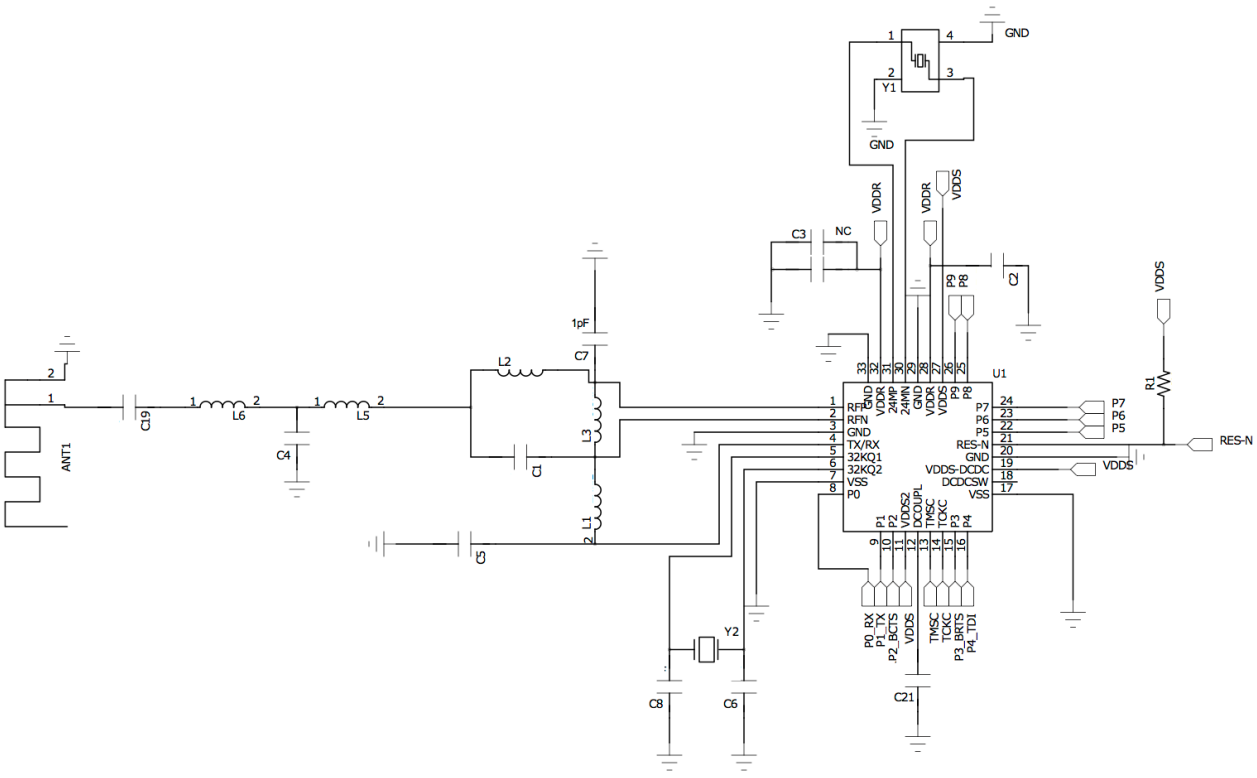
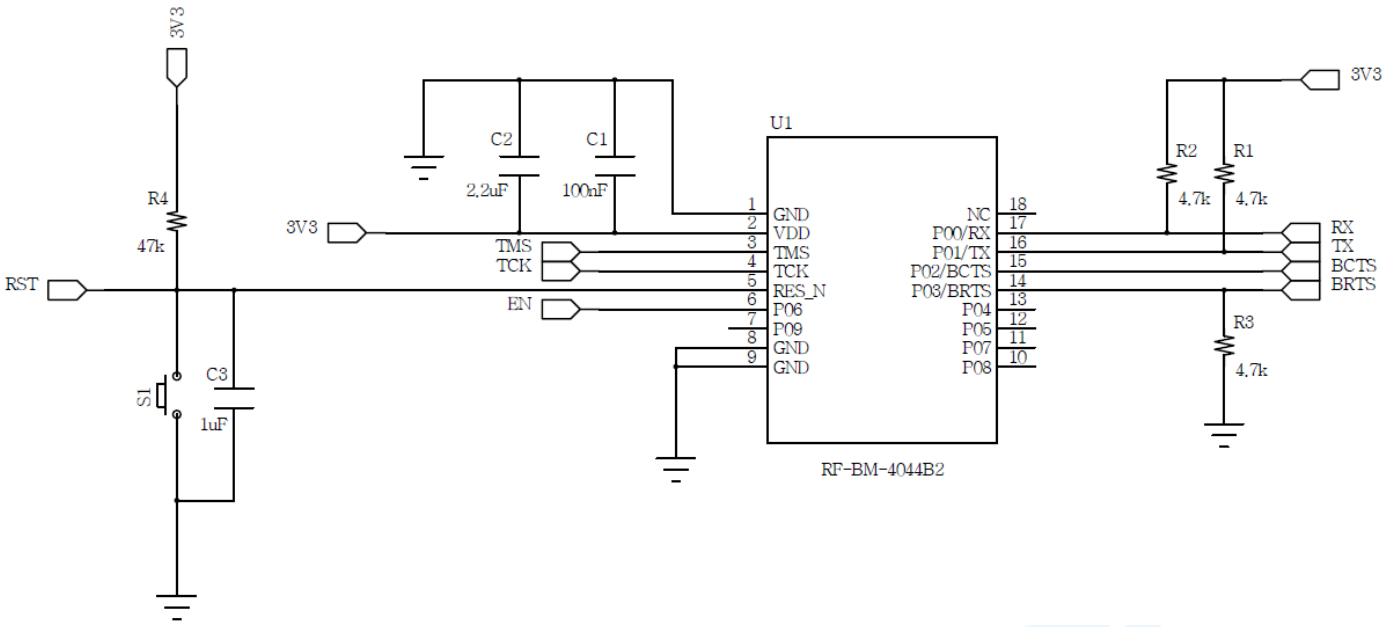


Figure 6. Schematic Diagram of RF-BM-4044B2/4044B3

4.4 Reference Design



Note: EN low enable.

Figure 7. Reference Design of RF-BM-4044B2/4044B3

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.

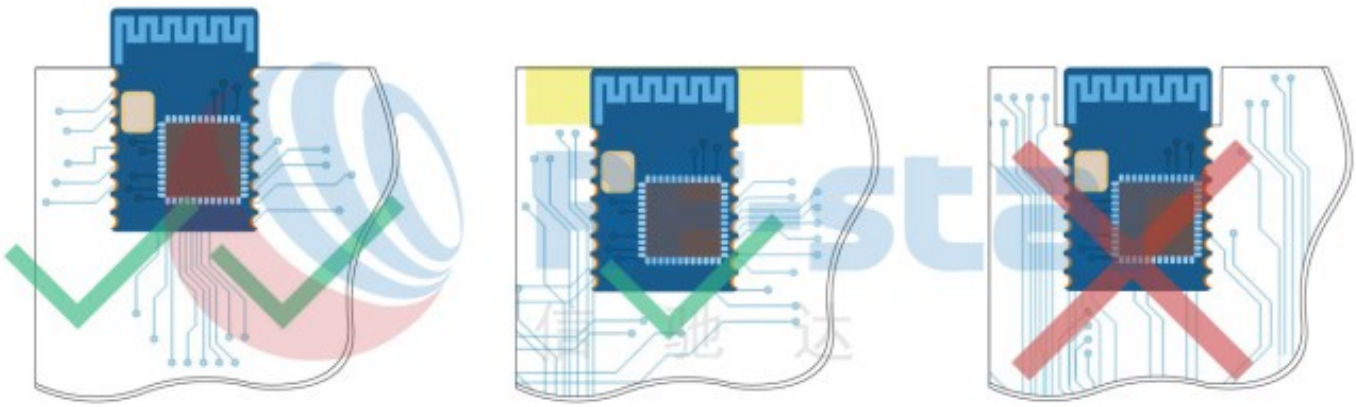


Figure 8. Recommendation of Antenna Layout

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

5.4.2 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.

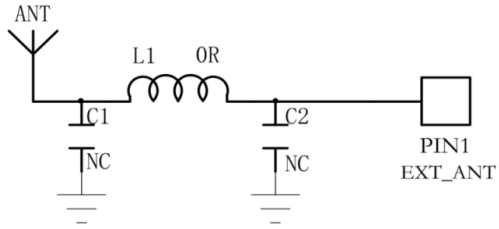


Figure 9. Reference Design of the External Antenna

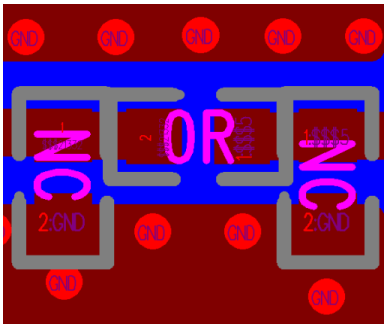


Figure 10. Reference Design of the External Antenna Traces

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.

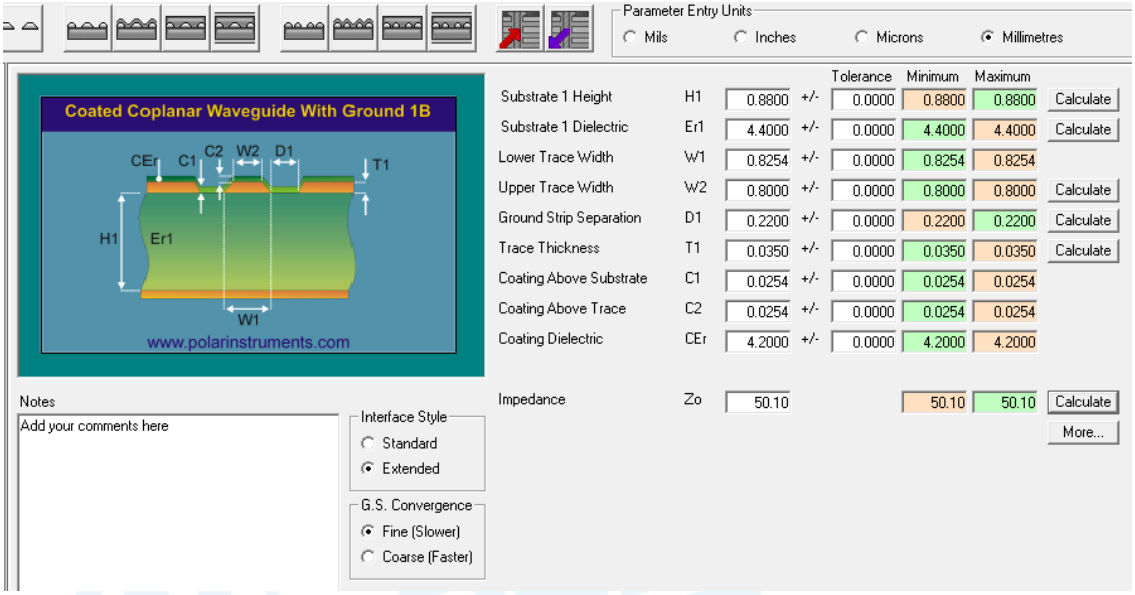


Figure 11. SI9000 Impedance Calculation Diagram

5.4.3 IPEX Connector Specification

RF-BM-4044B3 module is integrated the IPEX version 1 antenna seat, the specification of the antenna seat is as follows:

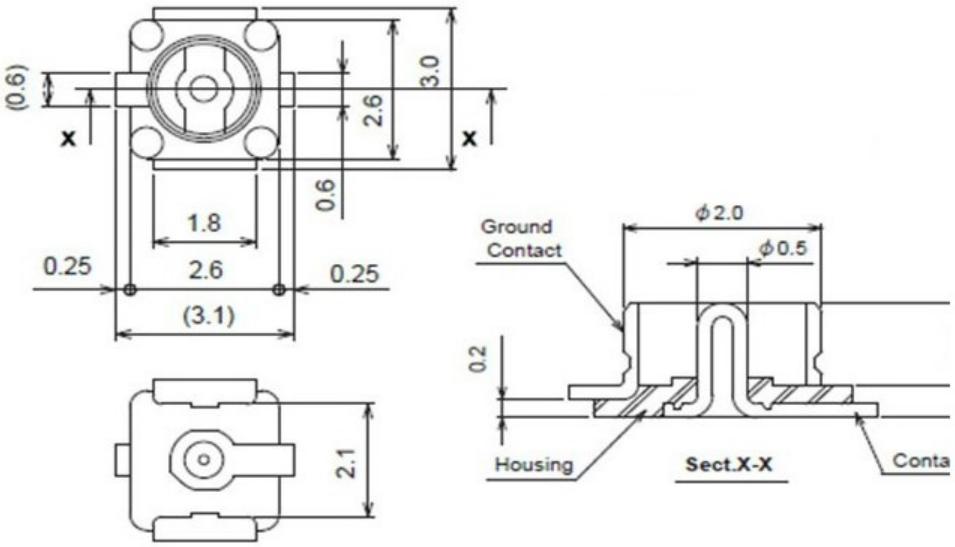


Figure 12. Specification of Antenna Seat

The specification of the IPEX wire end is as follows:

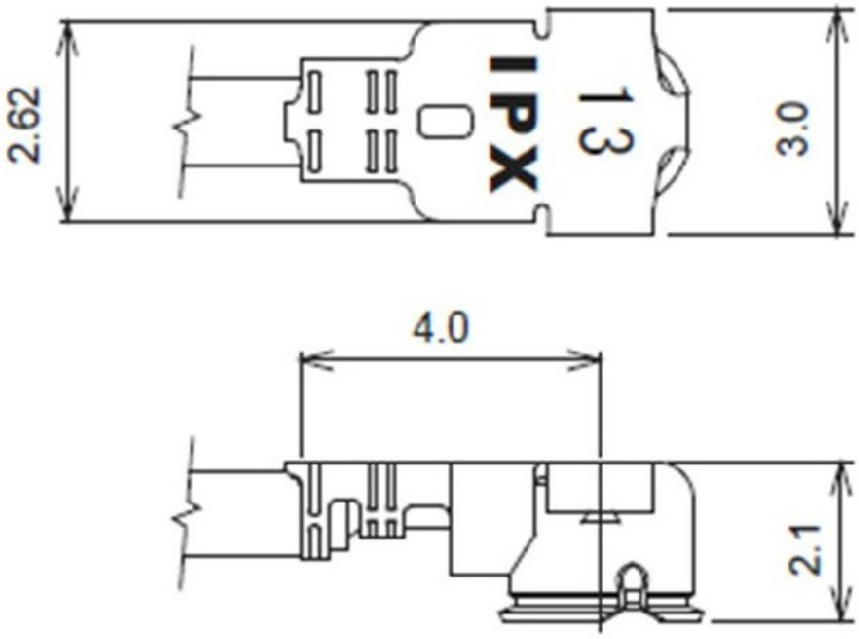


Figure 13. Specification of IPEX Wire

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 7. 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

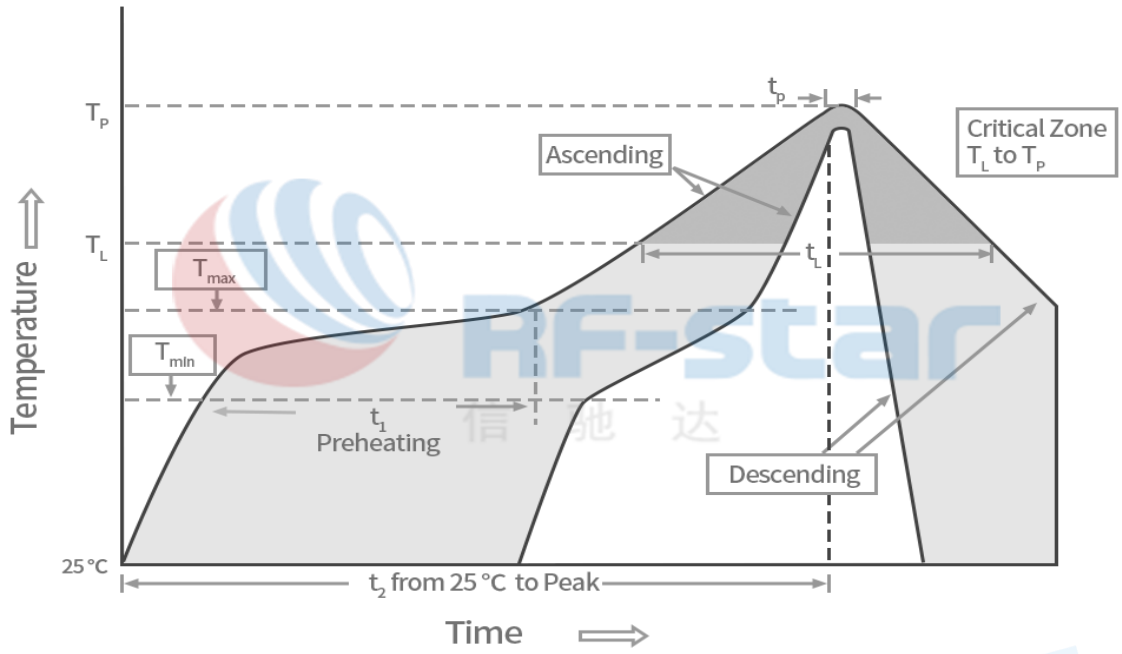


Figure 14. Recommended Reflow for Lead-Free Solder

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.

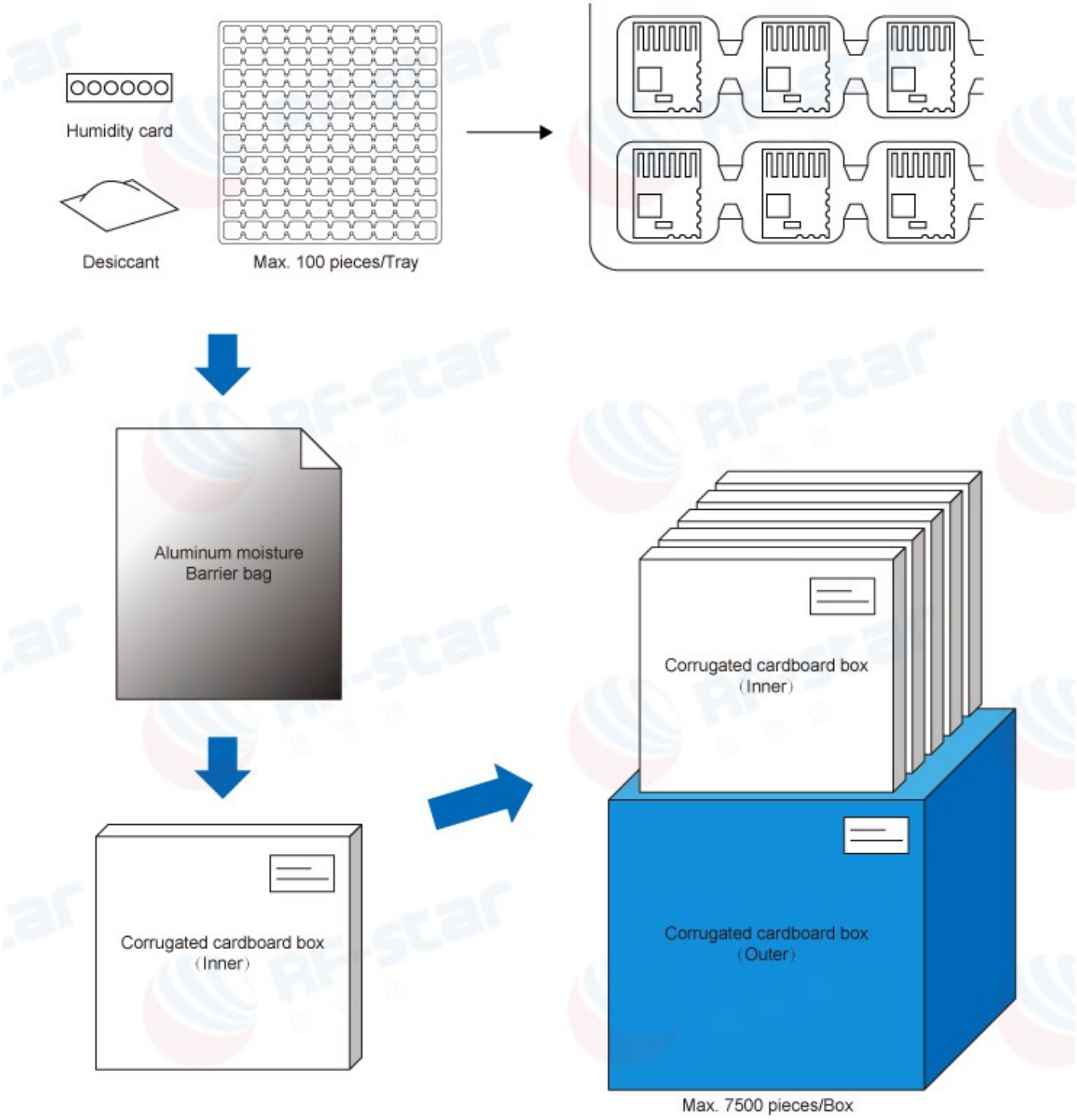


Figure 15. Default Package by Tray

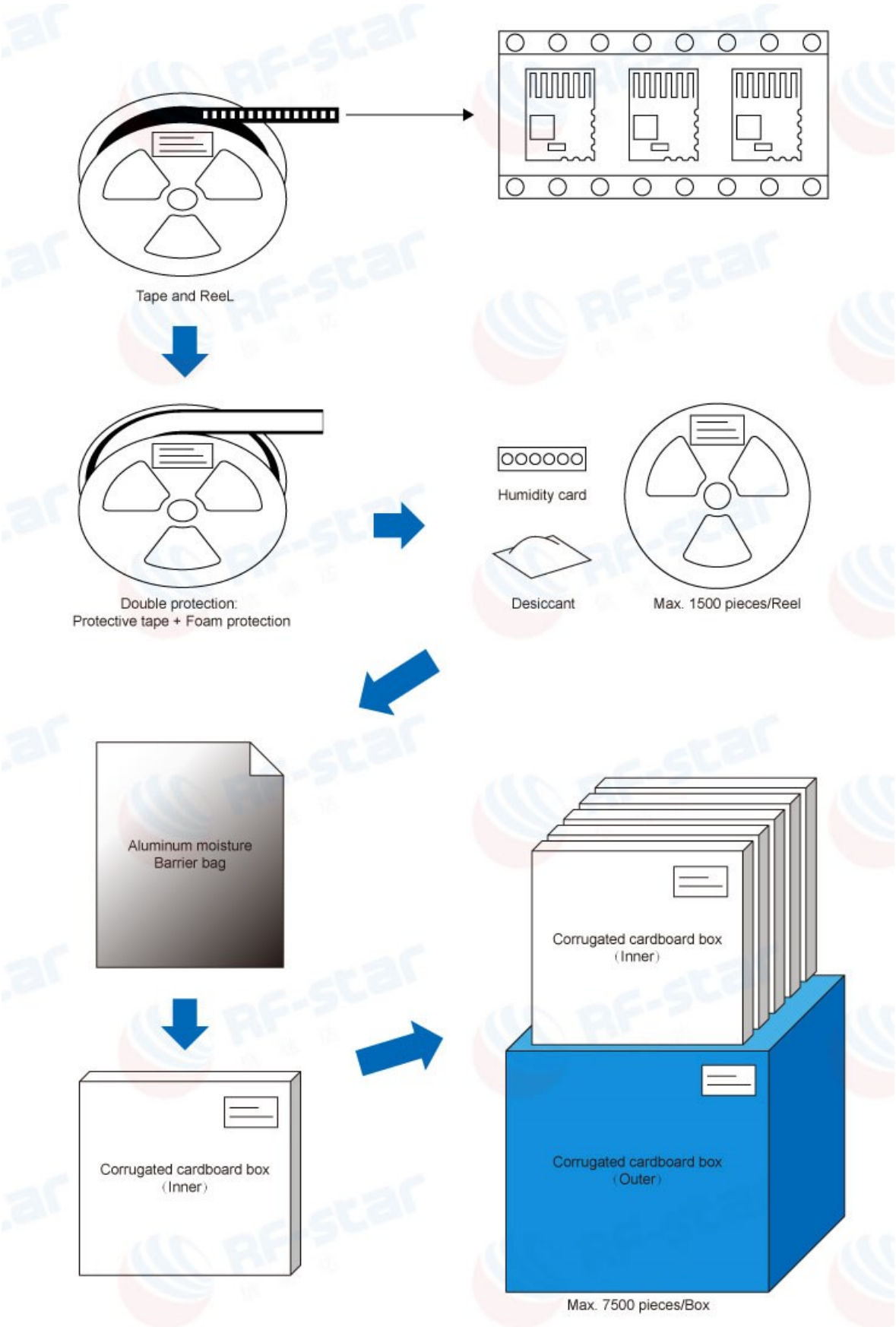


Figure 16. Package by Tape & Reel

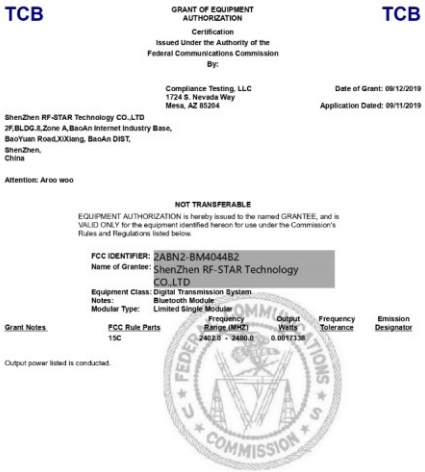
6 Certification

6.1 FCC

Warnings:

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.

FCC ID: 2ABN2-BM4044B2


TCB GRANT OF EQUIPMENT AUTHORIZATION TCB

Certification
Issued Under the Authority of the
Federal Communications Commission
By:

Compliance Testing, LLC
1724 S. Nevada Way
Mesa, AZ 85204

Date of Grant: 09/12/2019
Application Dated: 09/11/2019

ShenZhen RF-STAR Technology CO.,LTD
2F,BLDG.8,Zone A,BaoAn Internet Industry Base,
BaoYuan Road,XiXiang, BaoAn DIST,
ShenZhen,
China

Attention: Aroo woo

NOT TRANSFERABLE

EQUIPMENT AUTHORIZATION is hereby issued to the named GRANTEE, and is VALID ONLY for the equipment identified hereon for use under the Commission's Rules and Regulations listed below.

FCC IDENTIFIER: 2ABN2-BM4044B2
Name of Grantee: ShenZhen RF-STAR Technology CO.,LTD
Equipment Class: Digital Transmission System
Notes: Bluetooth Module
Modular Type: Limited Single Modular

Grant Notes	FCC Rule Parts	Frequency Range (MHZ)	Output Watts	Frequency Tolerance	Emission Designator
	15C	2402.0 - 2480.0	0.0017338		

Output power listed is conducted.

Figure 17. FCC certificate of RF-BM-4044B2

6.2 RoHS

RoHS Report No.: U00201190830003E

Query Password: QW6480


UONE

Test Report

Report No.: U00201190830003E Query Password: QW6480 Date: Sep. 5, 2019 Page 1 of 7

Applicant: ShenZhen RF-STAR Technology CO.,LTD
Contact information: Room 601, BlockC,Skyworthbuilding, Nanshan High-Tech Park, Shenzhen.

The following sample(s) was (were) submitted and identified by client as:

Sample Description : Bluetooth Module
Model No. : RF-BM-4044B2
Sample Received Date : Aug. 30, 2019
Testing Period : From Aug. 30, 2019 to Sep. 3, 2019
Test Request : Please refer to next page(s).
Test Result(s) : Please refer to next page(s).

Signed for and on behalf of Shen Zhen UONE Test Co., LTD.

Prepared by: Anna Li | Checked by: Nora Deng | Approved by: Pascal Shi

Figure 18. RoHS Certificate of RF-BM-4044B2

6.3 SRRC

SRRC CMIIT ID: 2019DP6529

Figure 19. SRRC Certificate of RF-BM-4044B2

7 Revision History

Date	Version No.	Description
2018.01.23	V1.0	The initial version is released.
2018.04.25	V1.1	Update the parameters of modules.
2018.08.02	V1.1	Update company address.
2020.05.15	V1.1	Update Chengdu company address.
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.

8 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