RF-BM-4044B4 and RF-BM-4044B5

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
4044B4	8.0 mm x 8.0 mm x 1.5 mm	Chip Antenna / half hole RF ANT pin	CC2640R2FRSM
4044B5	8.5 mm x 10.5 mm x 2.0 mm		

1.2 Description

RF-BM-4044B4 and RF-BM-4044B5 modules are designed based on CC2640R2FRSM Bluetooth 5.1 Low Energy System-on-Chip, fully supports the single mode BLE operation. The module contains a 32-bit ARM Cortex™-M3 processor, with the working frequency at 48.0 MHz which is the same as the main processor. The module has rich peripherals function libraries, and a unique ultra-low power sensor controller, which is fit for connecting the external sensors in the sleep mode and/or acquiring analog and digital data independently. The biggest differences of 4044B5 from 4044B4 are with the metal shield and the both-side pads.

1.3 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 +2 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)
- Ultra-low power sensor controller
  - 16 bit architecture
  - 2 KB of ultra-low leakage SRAM for code and data
- 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 MCU: 61 μA/MHz
- Active-mode MCU: 48.5 CoreMark/mA
- Active-mode sensor controller: 0.4 mA + 8.2 μA/MHz
- Standby: 1.1 μA (RTC running and RAM/CPU retention)
- Shutdown: 100 nA (wake up on external events)

• Dimension
- RF-BM-4044B4: 8 mm x 8 mm x 1.5 mm
- RF-BM-4044B5: 8.5 mm x 10.5 mm x 2.0 mm

• Certificate
- RF-BM-4044B4
  - ➢ SRRC

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

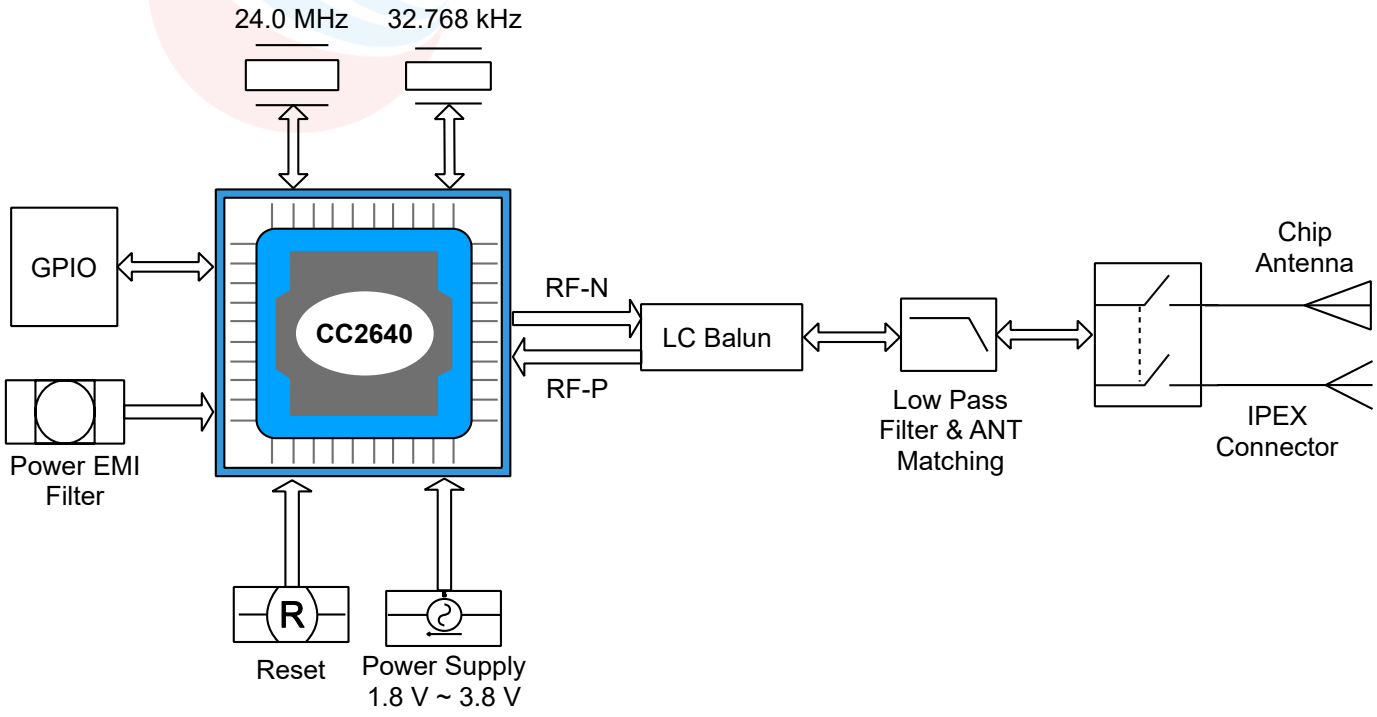


Figure 1. Functional Block Diagram of RF-BM-4044B4/4044B5

1.6 Part Number Conventions

The part numbers are of the form of RF-BM-4044B4/4044B5 where the fields are defined as follows:

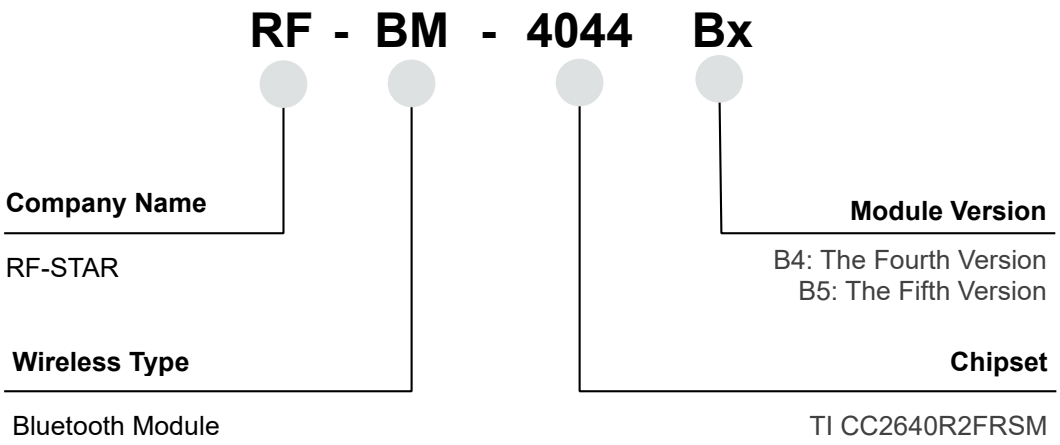


Figure 2. Part Number Conventions of RF-BM-4044B4/4044B5

Table of Contents

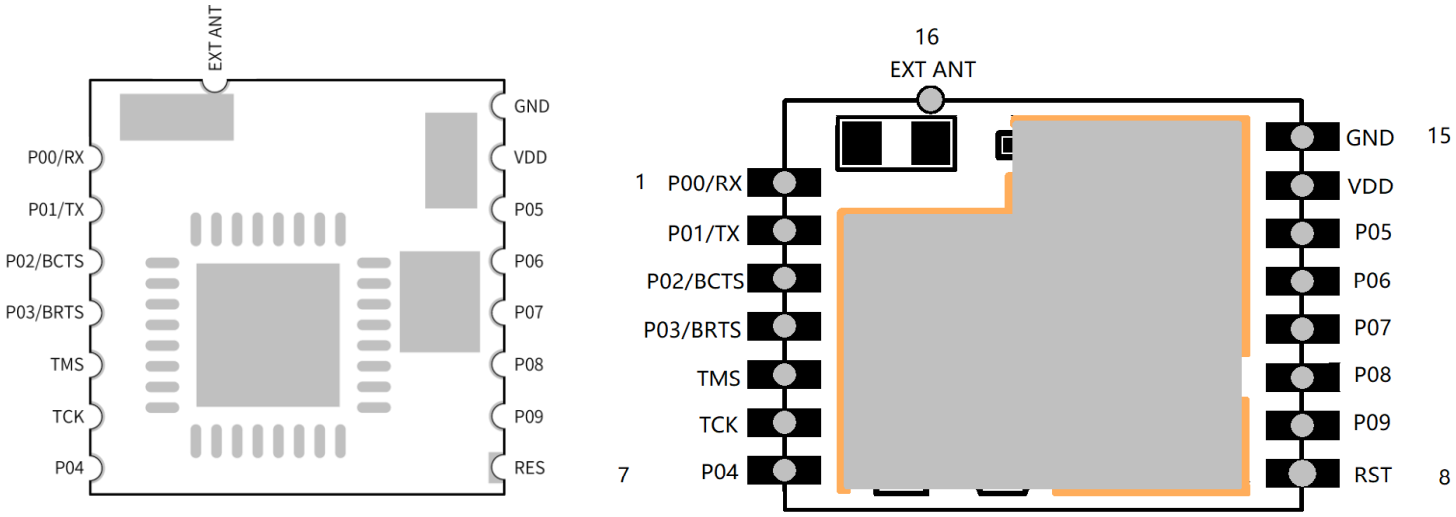
2 Module Configuration and Functions

2.1 Module Parameters

Table 2. Parameters of RF-BM-4044B4/4044B5

Chipset	CC2640R2FRSM
Supply Power Voltage	1.8 V ~ 3.8 V, 3.3 V is recommended
Frequency	2402 MHz ~ 2480 MHz
Transmit Power	-21.0 dBm ~ +2.0 dBm (typical: 0 dBm)
Receiving Sensitivity	-97 dBm
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-4044B4: 8.0 mm x 8.0 mm x 1.5 mm RF-BM-4044B5: 8.5 mm x 10.5 mm x 2.0 mm
Type of Antenna	Chip Antenna / half hole RF ANT pin
Operating Temperature	-40 ℃ ～ +85 ℃
Storage Temperature	-40 ℃ ～ +125 ℃

2.2 Module Pin Diagram



RF-BM-4044B4 RF-BM-4044B5

Figure 3. Pin Diagram of RF-BM-4044B4/4044B5

2.3 Pin Functions

Table 3. Pin Functions of RF-BM-4044B4/4044B5

Pin	Name	Chip Pin	Pin Type	Description
1	P00/RX	DIO_0	Digital I/O	GPIO, Sensor Controller, high-drive capacity
2	P01/TX	DIO_1	Digital I/O	GPIO, Sensor Controller, high-drive capacity
3	P02/BCTS	DIO_2	Digital I/O	GPIO, Sensor Controller, high-drive capacity
4	P03/BRTS	DIO_3	Digital I/O	GPIO, Sensor Controller, JTAG_TDO
5	TMS	JTAG_TMSC	Digital I/O	JTAG TMSC
6	TCK	JTAG_TCKC	Digital I/O	JTAG TCKC
7	P04	DIO_4	Digital I/O	GPIO, Sensor Controller, JTAG_TDI
8	RES	RESET	RESET	Reset, active low. Internal pullup.
9	P09	DIO_9	Digital/Analog I/O	GPIO, Sensor Controller, Analog
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	P06	DIO_6	Digital/Analog I/O	GPIO, Sensor Controller, Analog
13	P05	DIO_5	Digital/Analog I/O	GPIO, Sensor Controller, Analog
14	VCC	VCC	VDD	Power supply: 1.8 V ~ 3.8, recommended to 3.3 V.
15	GND	GND	GND	Ground
16	EXT- ANT	-	-	External antenna output. Default as chip antenna.

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-4044B4/4044B5

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-4044B4/4044B5

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 Power Consumption

Table 6. Table of Power Consumption

When measured on the RF-BM-4044B4 reference design with T A = 25 ℃, V BAT = 3.3 V with DC/DC enabled unless otherwise noted.

Test Item	Average Current	Test Condition
Power consumption on sleep	0.1 μA	EN is in high level.
Broadcast	60 μA	Broadcast interval: 200 ms.
Connection	70 μA	Connection interval: 100 ms
Module receives UART data and transmits to APP	180 μA	(20 bytes, 10 time/s) Connection interval: 100 ms
Module receives APP data and transmits to MCU	160 μA	(20 bytes, 10 time/s) Connection interval: 100 ms

3.4 RF Test

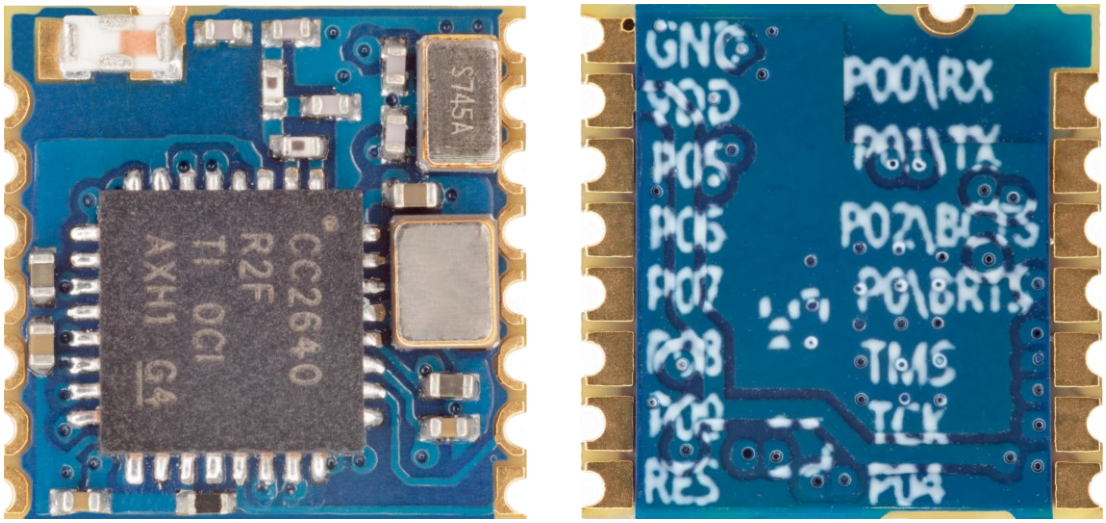
Table 7. Table of RF Test

When measured on the RF-BM-4044B4 reference design with T A = 25 ℃, V BAT = 3.3 V with DC/DC, channel of 39th (2442 MHz) enabled unless otherwise noted.

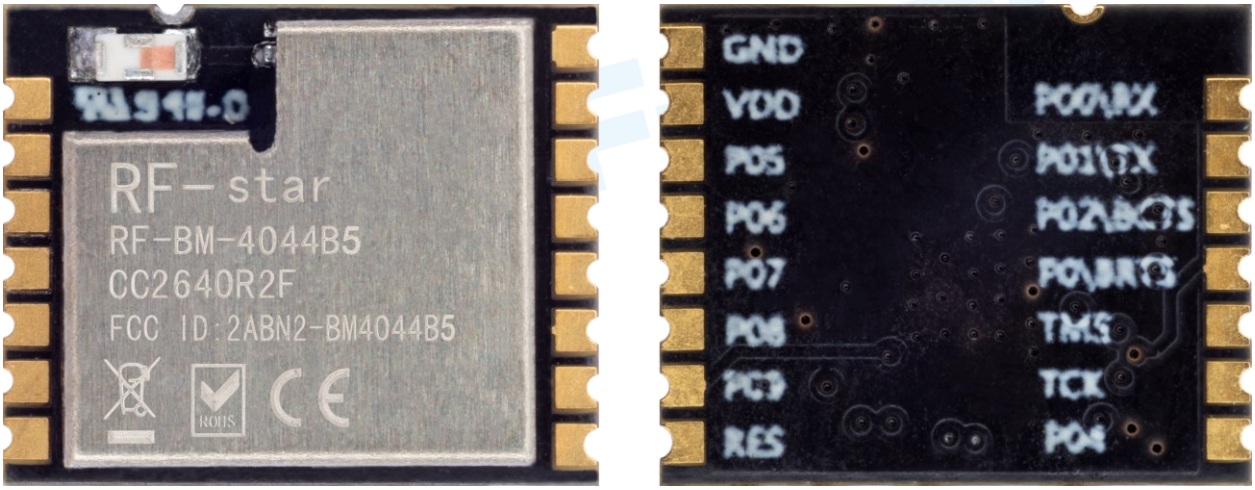
Test Item	Parameter	Test Value	Unit
Transmitter	Power	2 (Max.)	dBm
	Frequency Error	±20	kHz
	Radiation (30 m ~ 1 G)	-36	dBm
	Radiation (1 G ~ 12.75 G)	-30	dBm
Receiver	Sensitivity (8% PER)	-93	dBm

4 Application, Implementation, and Layout

4.1 Module Photos



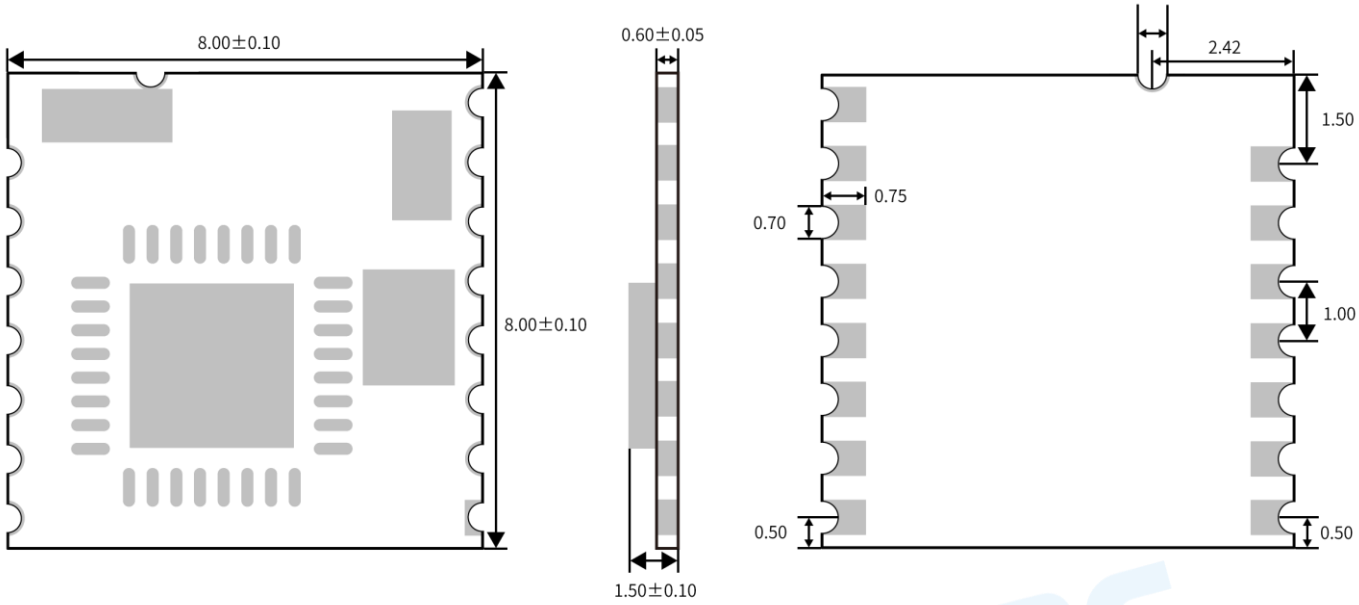
RF-BM-4044B4



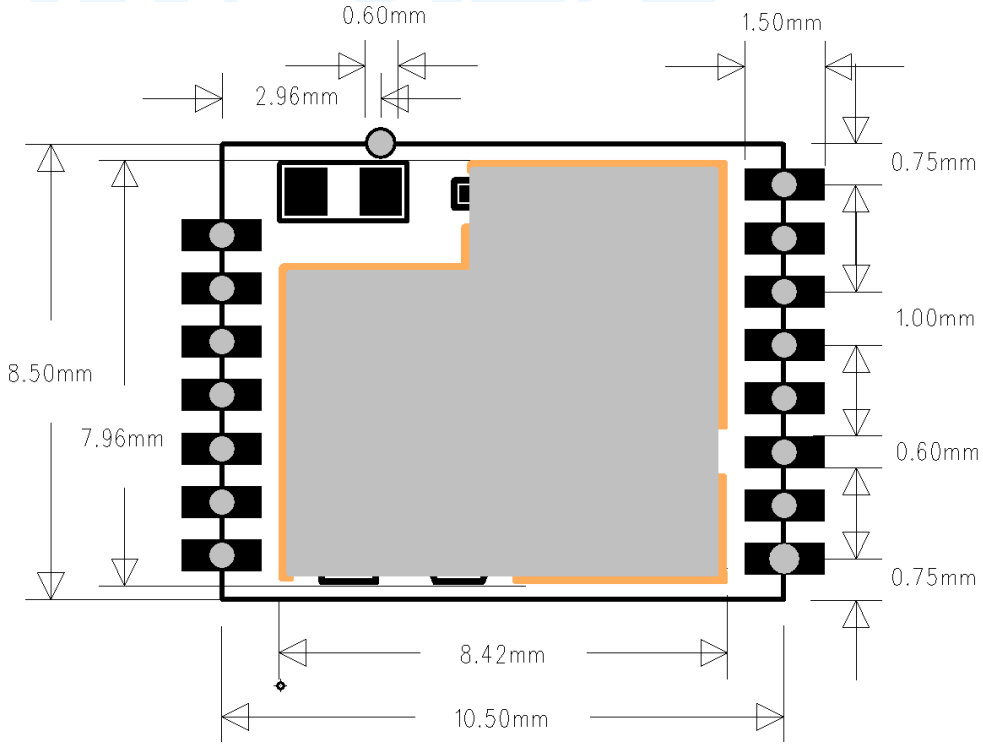
RF-BM-4044B5

Figure 4. Photos of RF-BM-4044B4/4044B5

4.2 Recommended PCB Footprint



RF-BM-4044B4



RF-BM-4044B5

Figure 5. Recommended PCB Footprint of RF-BM-4044B4/4044B5 (mm)

4.3 Schematic Diagram

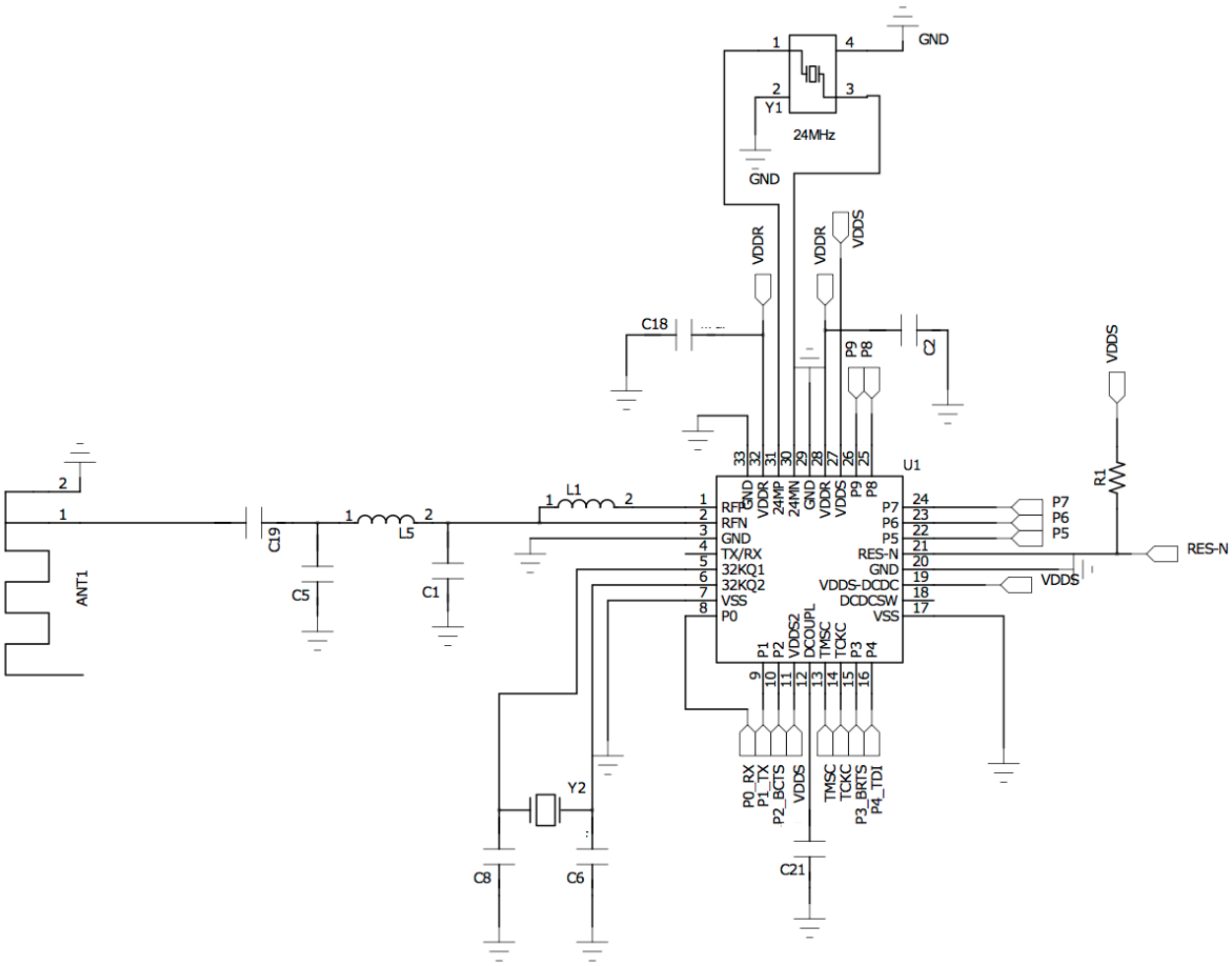


Figure 6. Schematic Diagram of RF-BM-4044B4/4044B5

4.4 Reference Design

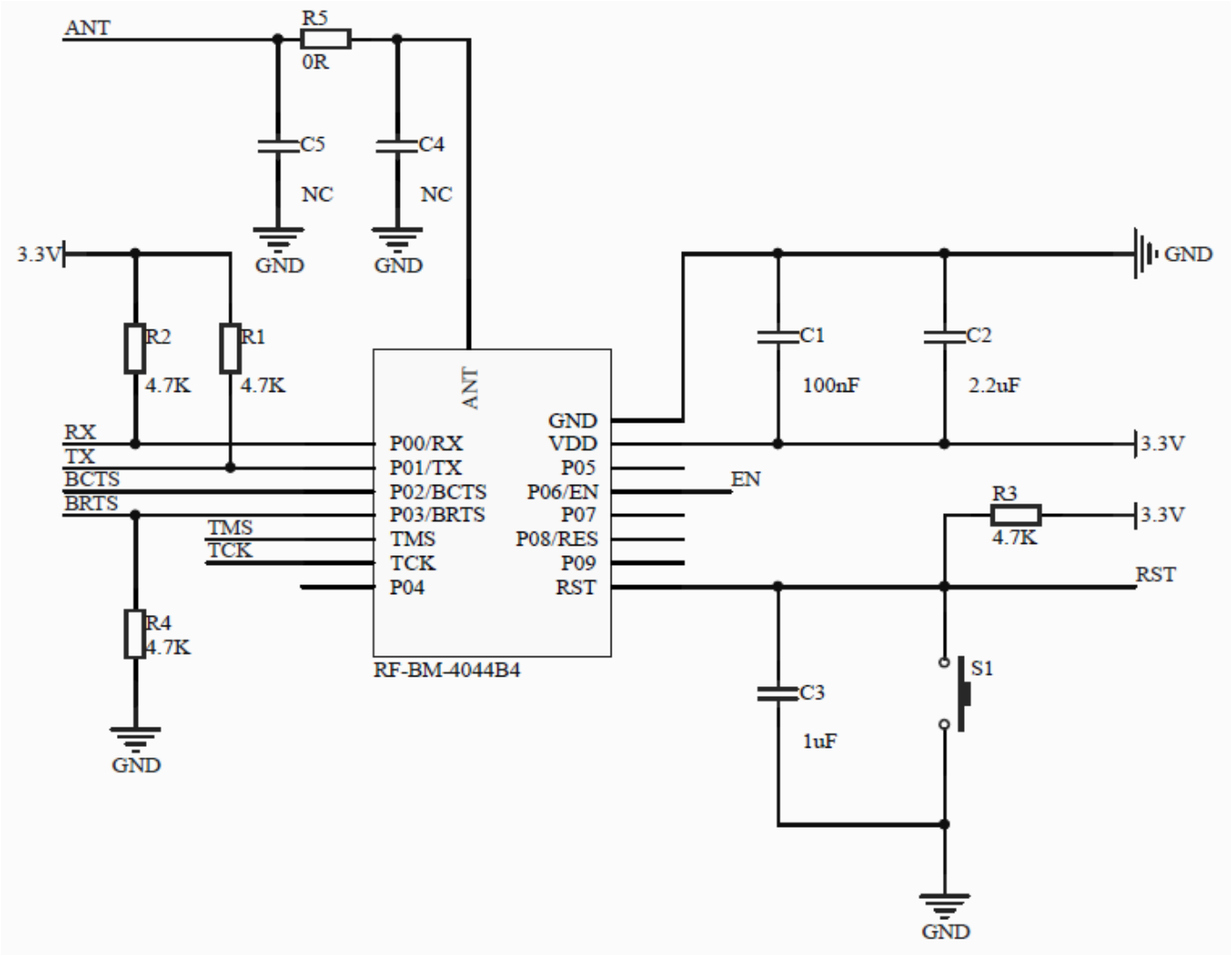


Figure 7. Reference Design of RF-BM-4044B4/4044B5

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.

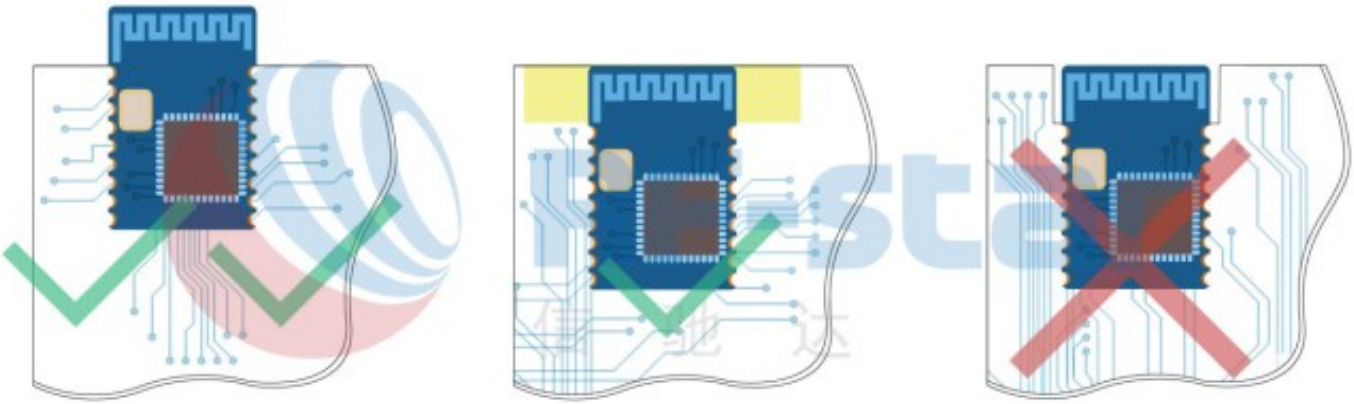


Figure 8. Recommendation of Antenna Layout

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.

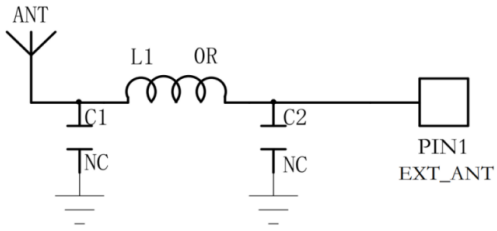


Figure 9. Reference Design of the External Antenna

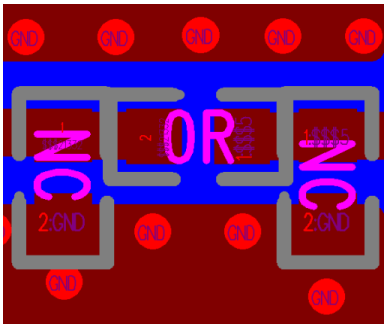


Figure 10. Reference Design of the External Antenna Traces

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.

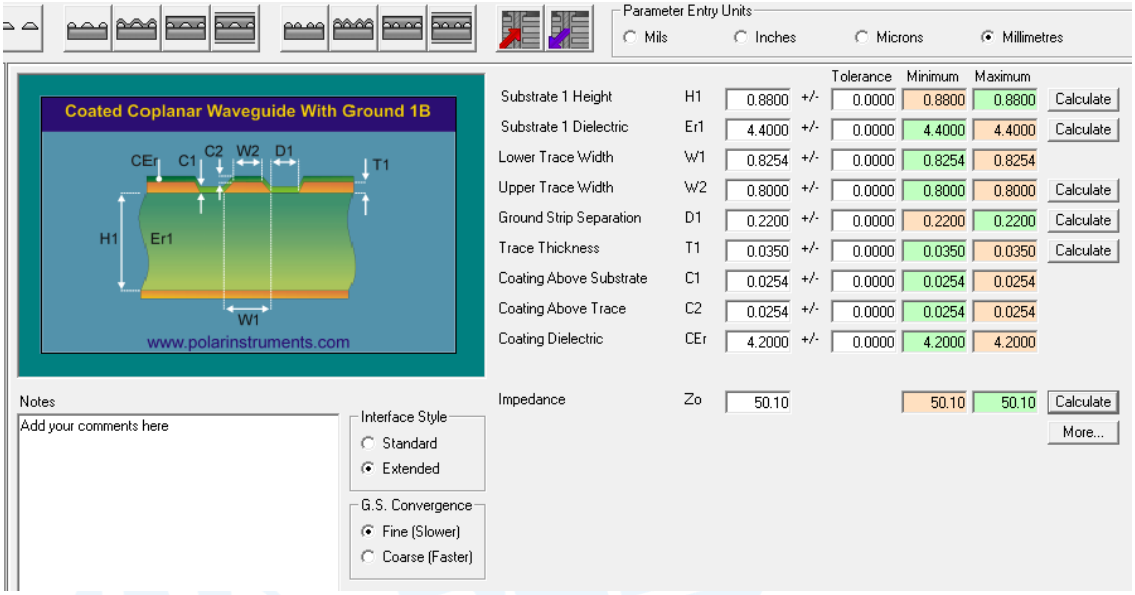


Figure 11. SI9000 Impedance Calculation Diagram

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 8. 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

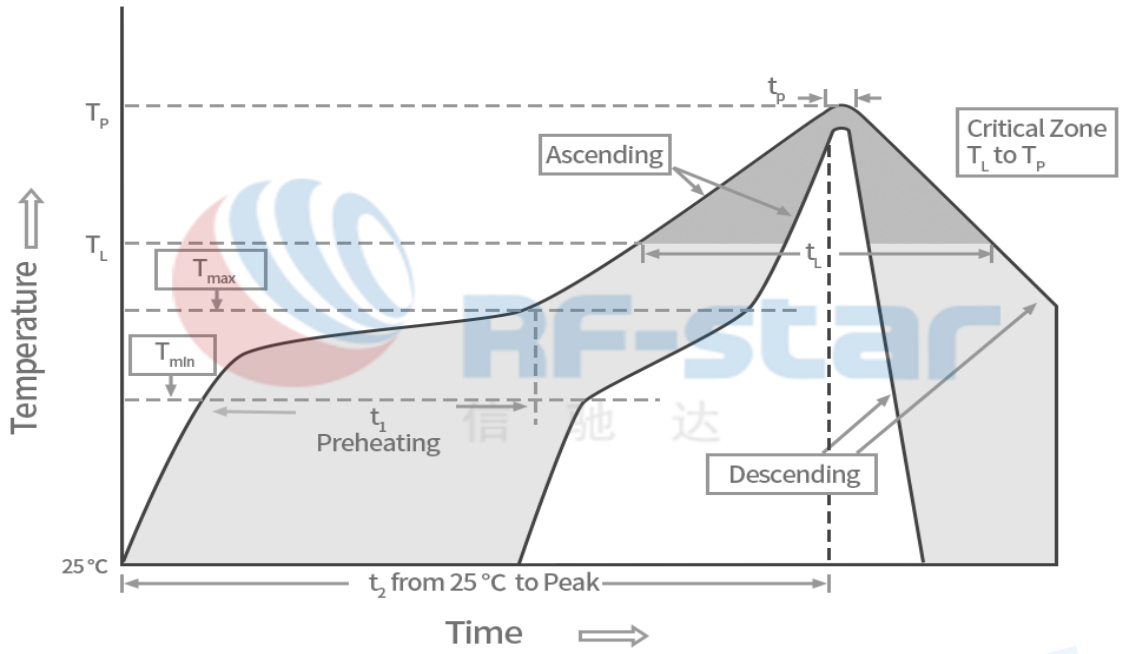


Figure 12. Recommended Reflow for Lead-Free Solder

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.

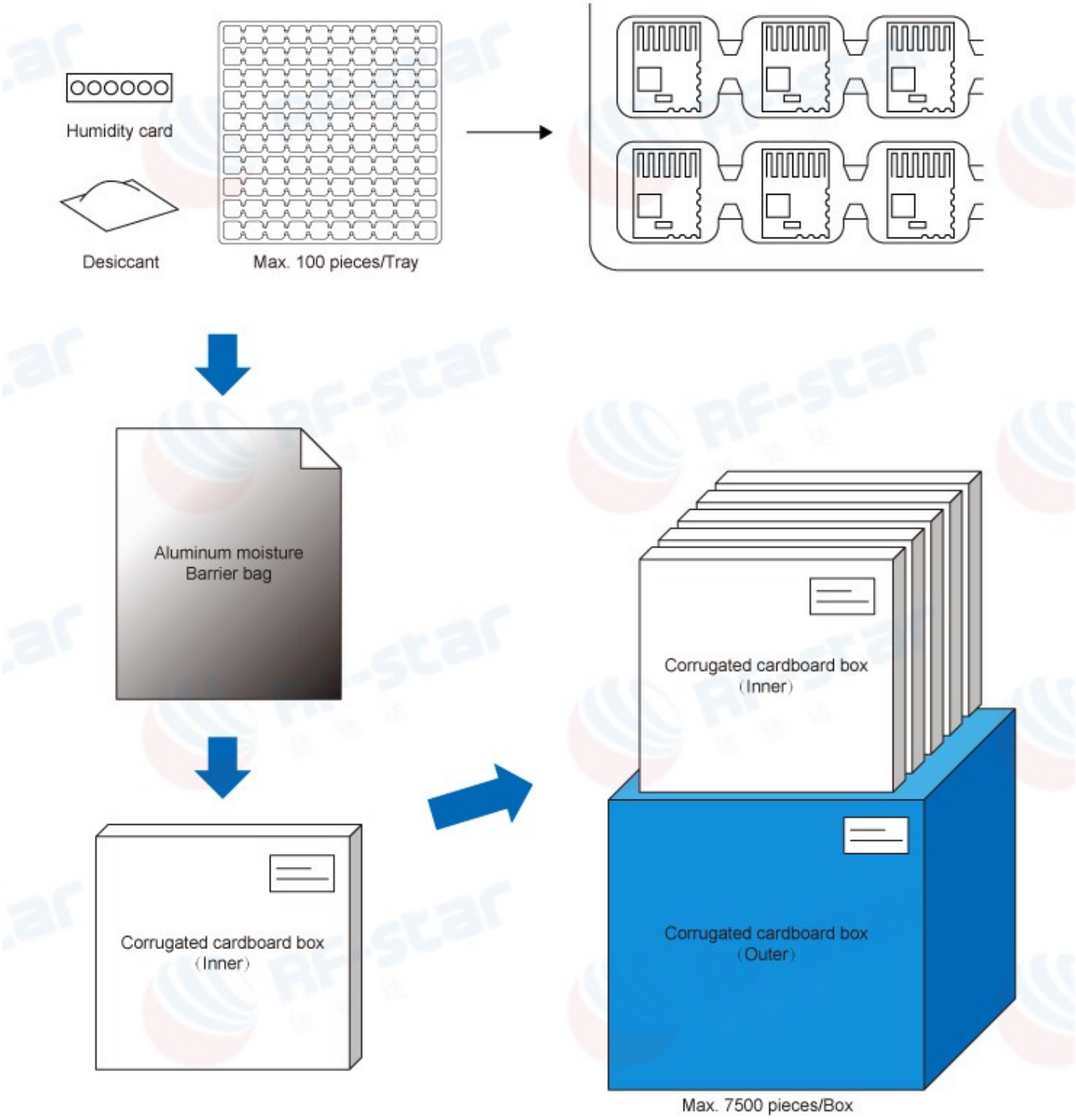


Figure 13. Default Package by Tray

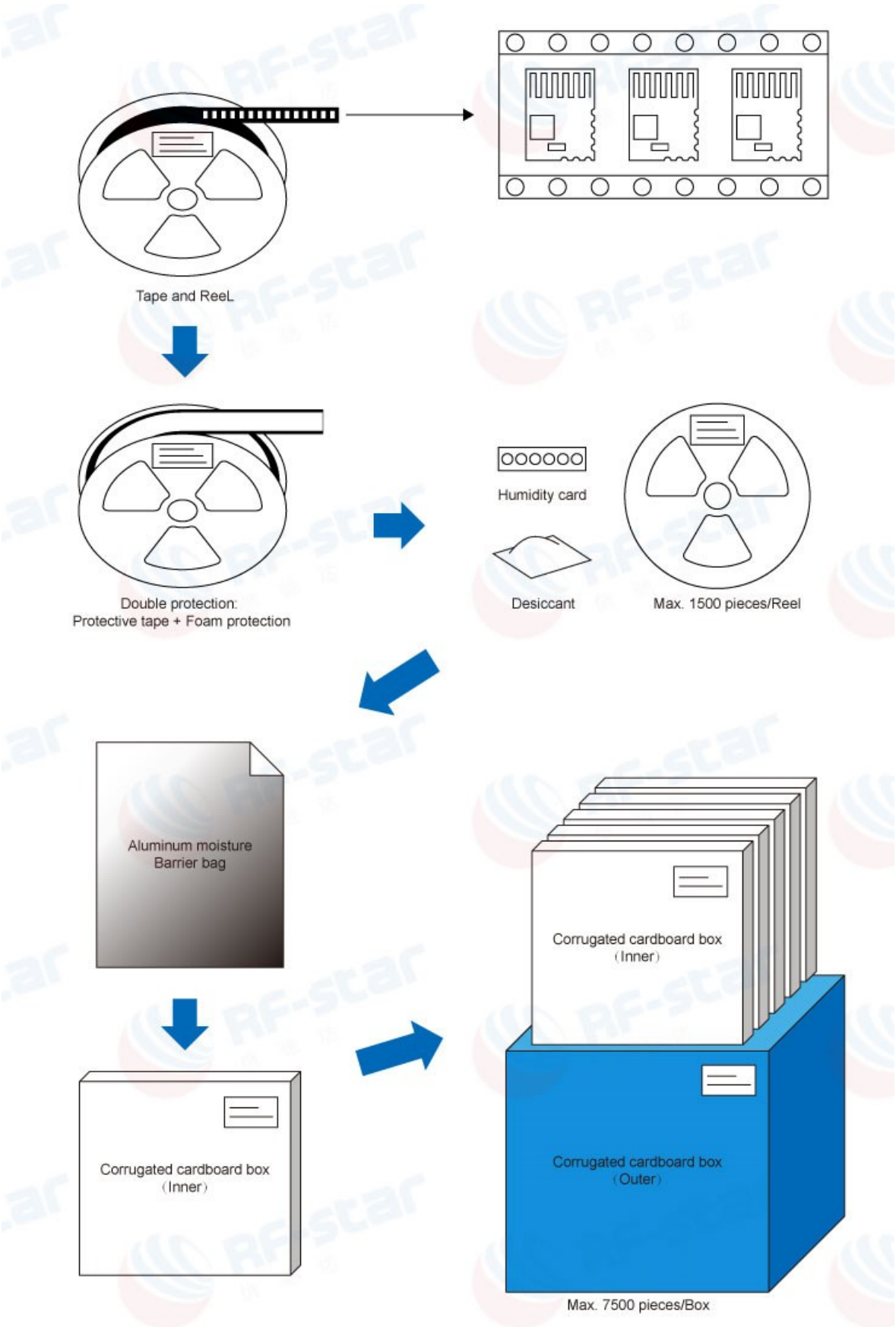


Figure 14. Package by Tape & Reel

6 Certification

5.1 SRRC

SRRC CMIIT ID: 2019DP5829

Figure 15. SRRC Certificate of RF-BM-4044B4

6 Revision History

Date	Version No.	Description
2018.01.23	V1.0	The initial version is released.
2018.04.25	V1.1	Update module parameters.
2018.08.02	V1.1	Update 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.

7 Contact Us

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