RF-BM-2652RB2 CC2652RB SimpleLink™ Multiprotocol 2.4 GHz Wireless Module

Version 1.0

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1 Device Overview

1.1 Description

RF-BM-2652RB2 is an RF module based on TI lower-power CC2652RB SoC, which is the industry's first multiprotocol 2.4 GHz wireless crystal-less microcontroller (MCU) with integrated TI Bulk Acoustic Wave (BAW) resonator technology supporting Thread, Zigbee®, Bluetooth® 5.2 Low Energy, IEEE 802.15.4, IPv6-enabled smart objects (6LoWPAN), proprietary systems, including the TI 15.4-Stack (2.4 GHz), and concurrent multiprotocol through a Dynamic Multiprotocol Manager (DMM) driver. It integrates 352 kB of in-system Programmable Flash, 256 kB ROM, 8 kB of Cache SRAM, 80 kB of ultra-low leakage SRAM. Its ARM® Cortex®-M4F core application processor can operate at an extremely low current at flexible power modes. It features small size, robust connection distance, and rigid reliability. RF-BM-2652RB2 integrates the chip antenna, the compact size and all accessible pins make the module more convenient for application and development.

1.2 Key Features

- RF Section
  - Bluetooth 5.2 Low Energy
  - ZigBee, Thread
  - IEEE 802.15.4
  - IPv6-nabld smart objects (6LoWPAN)
  - Proprietary systems
  - SimpleLink™ TI 15.4-Stack (2.4 GHz)
  - Dynamic Multiprotocol Manager (DDM) driver
- TX power: up to +5 dBm with temperature compensation
- Excellent receiver sensitivity
  - -102 dBm for Bluetooth 125 kbps (LE coded PHY)
  - -100 dBm for 802.15.4 (2.4 GHz)
- Wide Operation Range
  - 1.8 V to 3.8 V single power supply
  - Operating temperature: -40 °C to +85 °C
  - Storage temperature: -40 °C to +125 °C
- Microcontroller
  - Powerful 48 MHz ARM® Cortex®-M4F processor
  - EEBMC CoreMark® score: 148
  - 2-pin cJTAG and JTAG debugging
  - Support OTA upgrade
- Memory
  - 352 kB of in-system programmable flash
  - 256 kB of ROM for protocols and library functions
  - 8 kB of cache SRAM (Alternatively available as general-purpose RAM)
  - 80 kB of ultra-low leakage SRAM. The SRAM is protected by parity to ensure high reliability of operation.
- Ultra-low power sensor controller with 4 KB of SRAM
  - Sample, store, and process sensor data
  - Operation independent from system CPU
  - Fast wake-up for low-power operation
- Rich Peripherals
  - 31 GPIOs, digital peripheral pins can be routed to any GPIOs
  - 4 × 32-bit or 8 × 16-bit general-purpose timers
  - 12-bit ADC, 200 kSamples/s, 8 channels
  - 2 × comparators with internal reference DAC (1 × continuous time, 1 × ultra-low power)
  - Programmable current source
  - 2 × UART
  - 2 × SSI (SPI, Microwave, TI)
  - I^2C
  - I^2S

- Real-time clock (RTC)
- Capacitive sensing, up to 8 channels
- Integrated temperature and battery monitor

• Security Enablers
- AES 128-bit and 256-bit Crypto accelerator
- ECC and RSA public key hardware accelerator
- SHA2 accelerator (full suite up to SHA-512)
- True random number generator (TRNG)

• External system
- Integrated bulk acoustic wave (BAW) resonator generating accurate clock with fast startup time of 80 μs for system and RF
- On-chip buck DC/DC converter

• Dimension: 16.0 mm × 16.0 mm × 2.0 mm

1.3 Applications

- 2400 to 2480 MH ISM and SRD systems with down to 4 kHz of receive bandwidth
- Home and building automation
- Building security system
- HVAC system
- Gateway
- IP network camera
- Fire safety system
- Smart grid
- Automatic meter reading
- Industrial transport
- Wireless sensor networks
- Factory automation and control
- Wireless healthcare applications
- Energy harvesting applications
- Asset tracking and management
- Electronic Shelf Label (ESL)
- Wired networking
- Small business router
- Portable electronics
- Set-top box
- Connected peripherals
- Keyboard and keypads
- Home theater & entertainment
- Electronic and robotic toys
- Wearables

1.4 Functional Block Diagram

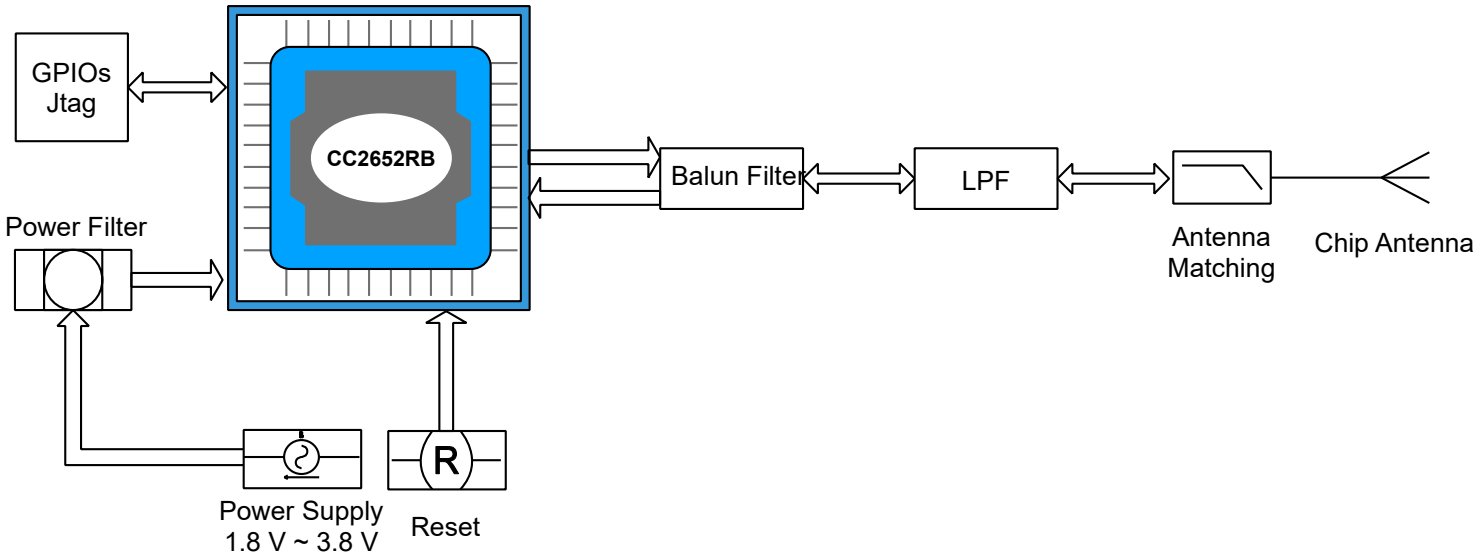

Figure 1. Functional Block Diagram of RF-BM-2652RB2

1.5 Part Number Conventions

The part numbers are of the form of RF-BM-2652RB2 where the fields are defined as follows:

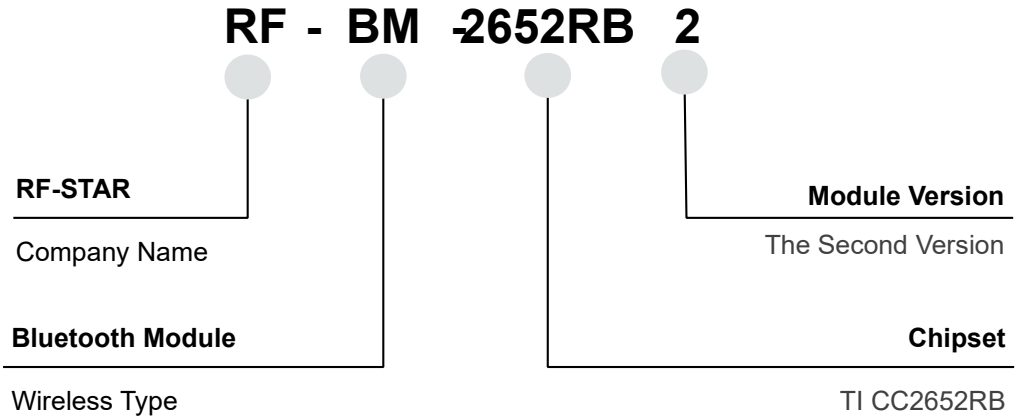

Figure 2. Part Number Conventions of RF-BM-2652RB2

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2 Module Configuration and Functions

2.1 Module Parameters

Table 1. Parameters of RF-BM-2652RB2

Chipset	CC2652RB
Supply Power Voltage	1.8 V ~ 3.8 V, 3.3 V is recommended
Frequency	2402 MHz ~ 2480 MHz
Maximum Transmit Power	+5.0 dBm
Receiving Sensitivity	-100 dBm @ 802.15.4 (2.4 GHz) -102 dBm @ Bluetooth 125 kbps (LE Coded PHY)
GPIO	31
Flash	352 kB
ROM	256 kB
SRAM	88 kB
Power Consumption	RX current: 7.3 mA TX current: 7.9 mA @ 0 dBm 10.2 mA @ 5 dBm MCU 48 MHz (CoreMark): 3.4 mA (71 μA/MHz) Sensor Controller: 30.8 μA @ Low Power-Mode, 2 MHz, running infinite loop 808 μA @ Active-Mode, 24 MHz, running infinite loop Standby: 0.94 μA
Support Protocol	Bluetooth 5.2 Low Energy, ZigBee, Thread, IEEE 802.15.4, 6LoWPAN, SimpleLink™ TI 15.4 stack (2.4 GHz)
Package	BGA packaging (0.6 mm & 1.2 mm pitch)
Dimension	16.0 mm × 16.0 mm × 2.0 mm
Type of Antenna	Chip antenna
Operating Temperature	-40 ℃ ~ +85 ℃
Storage Temperature	-40 ℃ ~ +125 ℃

2.2 Module Pin Diagram

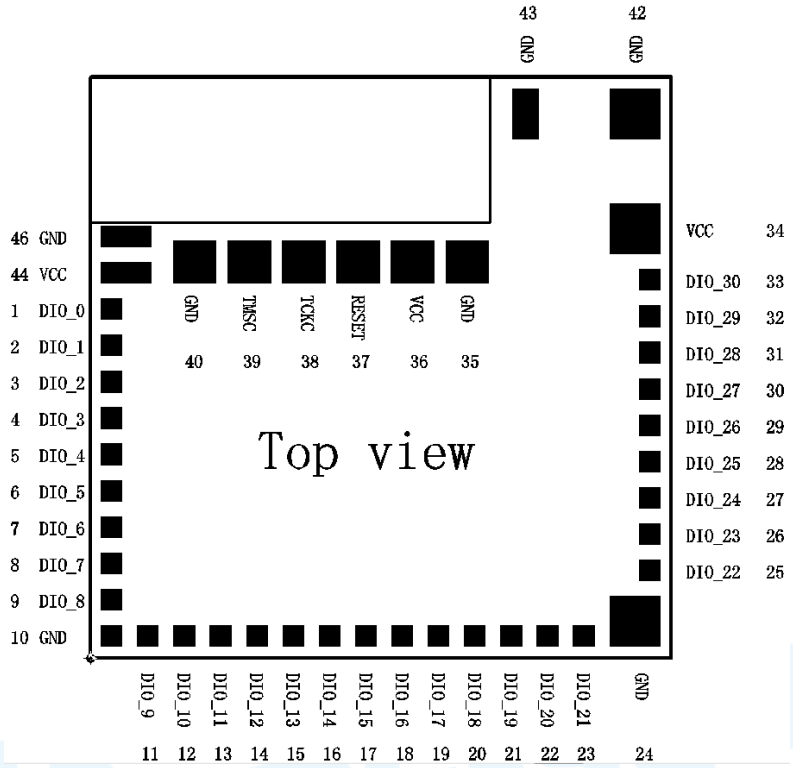

Figure 3. Pin Diagram of RF-BM-2652RB2

2.3 Pin Functions

Table 2. Pin Diagram of RF-BM-2652RB2

Pin	Name	Chip Pin	Function	Description
1	DIO_0	DIO_0	Digital	GPIO
2	DIO_1	DIO_1	Digital	GPIO
3	DIO_2	DIO_2	Digital	GPIO
4	DIO_3	DIO_3	Digital	GPIO
5	DIO_4	DIO_4	Digital	GPIO
6	DIO_5	DIO_5	Digital	GPIO, high-drive capability
7	DIO_6	DIO_6	Digital	GPIO, high-drive capability
8	DIO_7	DIO_7	Digital	GPIO, high-drive capability
9	DIO_8	DIO_8	Digital	GPIO
10	GND	GND	-	Ground
11	DIO_9	DIO_9	Digital	GPIO
12	DIO_10	DIO_10	Digital	GPIO

13	DIO_11	DIO_11	Digital	GPIO
14	DIO_12	DIO_12	Digital	GPIO
15	DIO_13	DIO_13	Digital	GPIO
16	DIO_14	DIO_14	Digital	GPIO
17	DIO_15	DIO_15	Digital	GPIO
18	DIO_16	DIO_16	Digital	GPIO, JTAG_TDO, high-drive capability
19	DIO_17	DIO_17	Digital	GPIO, JTAG_TDI, high-drive capability
20	DIO_18	DIO_18	Digital	GPIO
21	DIO_19	DIO_19	Digital	GPIO
22	DIO_20	DIO_20	Digital	GPIO
23	DIO_21	DIO_21	Digital	GPIO
24	GND	GND	GPIO	GPIO
25	DIO_22	DIO_22	GPIO	GPIO
26	DIO_23	DIO_23	GPIO or Analog	GPIO, analog capability
27	DIO_24	DIO_24	GPIO or Analog	GPIO, analog capability
28	DIO_25	DIO_25	GPIO or Analog	GPIO, analog capability
29	DIO_26	DIO_26	GPIO or Analog	GPIO, analog capability
30	DIO_27	DIO_27	GPIO or Analog	GPIO, analog capability
31	DIO_28	DIO_28	GPIO or Analog	GPIO, analog capability
32	DIO_29	DIO_29	GPIO or Analog	GPIO, analog capability
33	DIO_30	DIO_30	GPIO or Analog	GPIO, analog capability
34	VCC	VCC	VCC	Power supply: 1.8 V ~ 3.8 V, 3.3 V is recommended
35	GND	GND	-	Ground
36	VCC	VCC	-	-
37	RESET	RESET	RES	Reset, active low. Internal pullup.
38	JTAG_TCKC	JTAG_TCKC	Digital	JTAG TCKC
39	JTAG_TMSC	JTAG_TMSC	Digital	JTAG TMSC, high-drive capability
40	GND	GND	-	Ground
42	GND	GND	-	Ground
43	GND	GND	-	Ground
44	VCC	VCC	-	-
46	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-BM-2652RB2

Items	Condition	Min.	Typ.	Max.	Unit
Operating Supply Voltage	/	1.8	3.3	3.8	V
Operating Temperature	/	-40	+25	+85	℃

3.2 Handling Ratings

Table 4. Handling Ratings of RF-BM-2652RB2

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

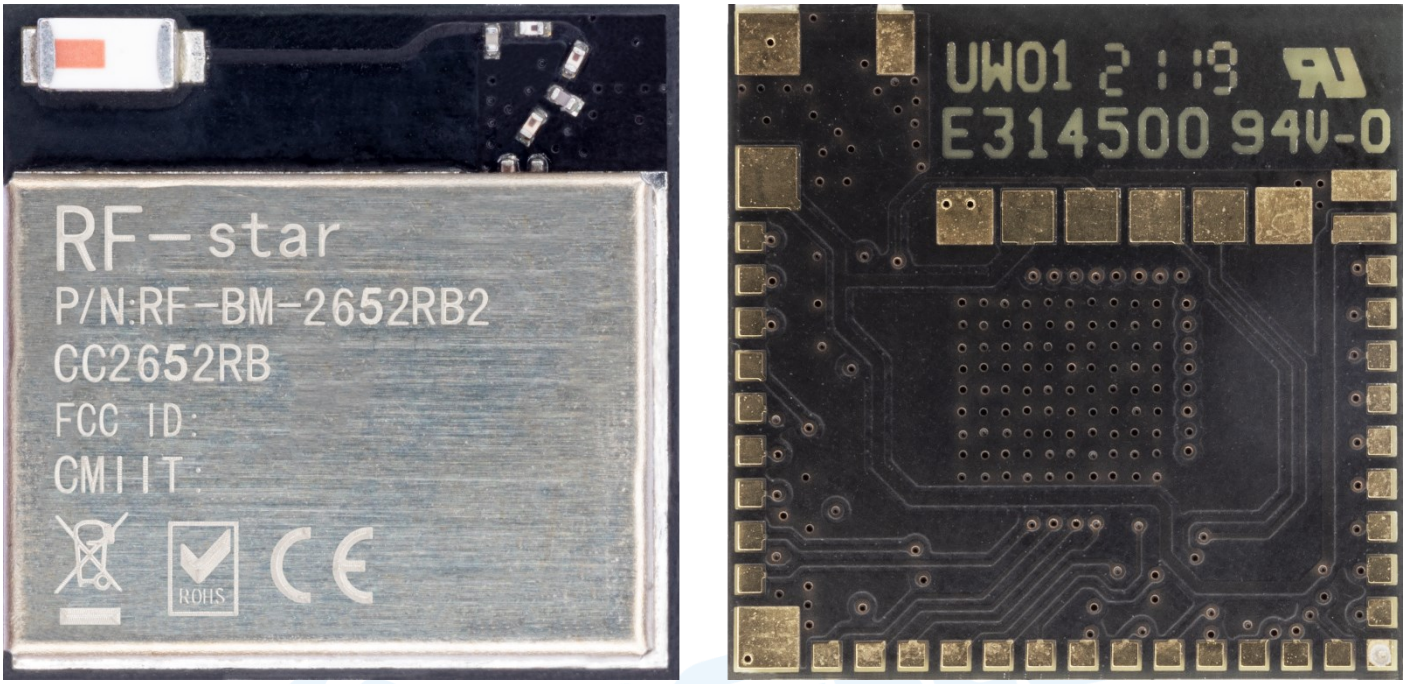

Figure 3. Photos of RF-BM-2652RB2

4.2 Recommended PCB Footprint

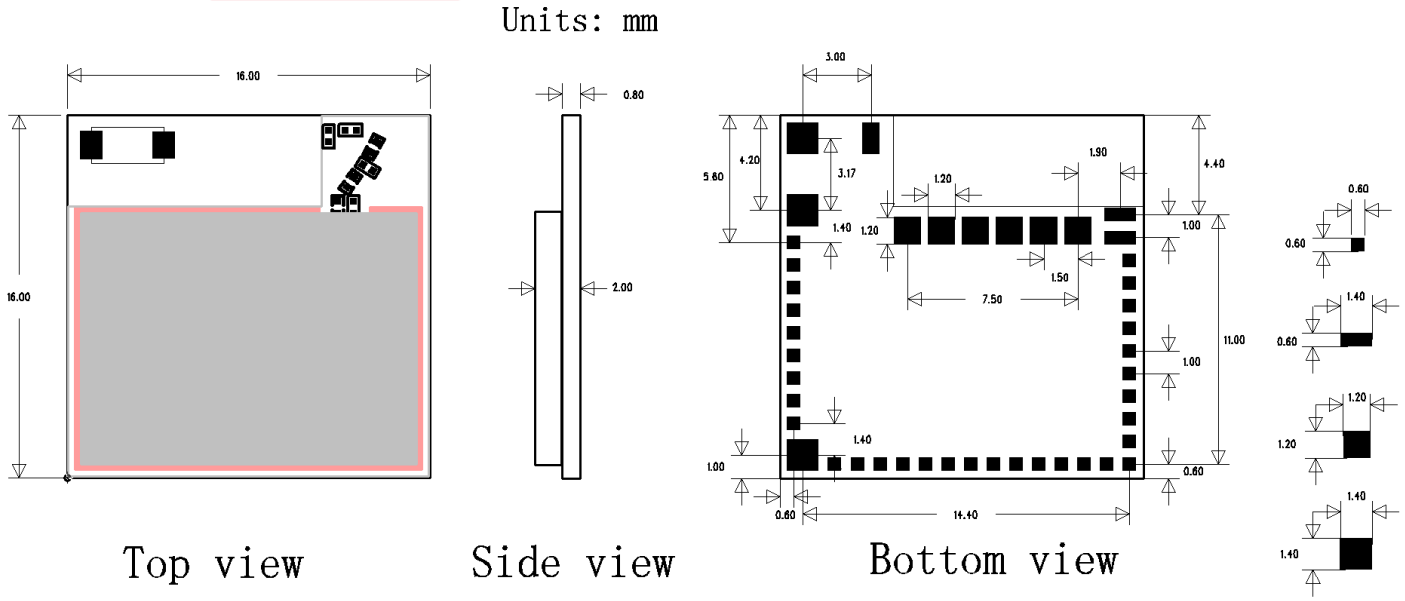

Figure 4. Recommended PCB Footprint of RF-BM-2652RB2

4.3 Schematic Diagram

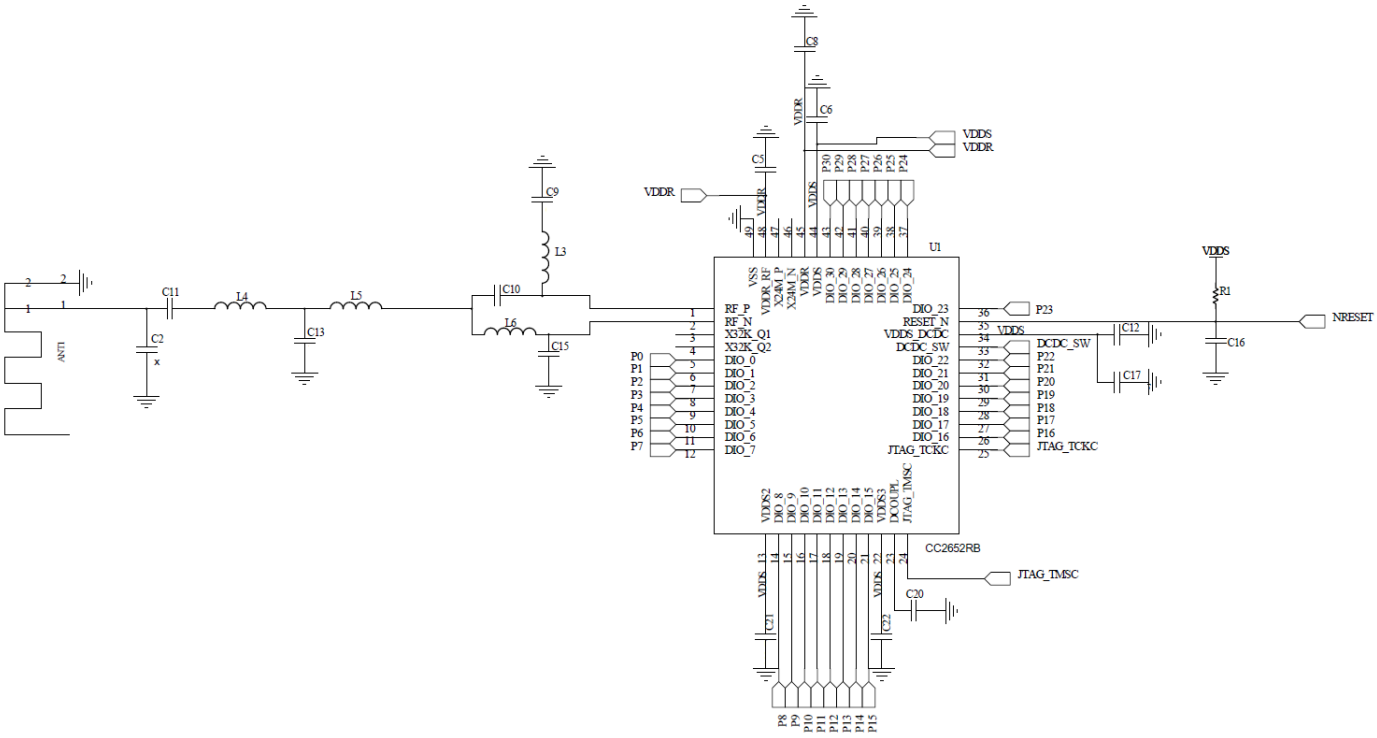

Figure 5. Schematic Diagram of RF-BM-2652RB2

4.4 Basic Operation of Hardware Design

1. It is recommended to offer the module with a DC stabilized power supply, a tiny power supply ripple coefficient and the 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 the stable power supply and no frequently fluctuated 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 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 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 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 degrees.

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.
9. 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.
10. The antenna must not be installed inside the metal case, which will cause the transmission distance to be greatly weakened.
11. The recommendation of antenna layout.

    The inverted-F antenna position on PCB is free space electromagnetic radiation. The location and layout of antenna is a key factor 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 the best to hollow out the antenna position in the following figure so as to ensure that S11 of the module is minimally affected.

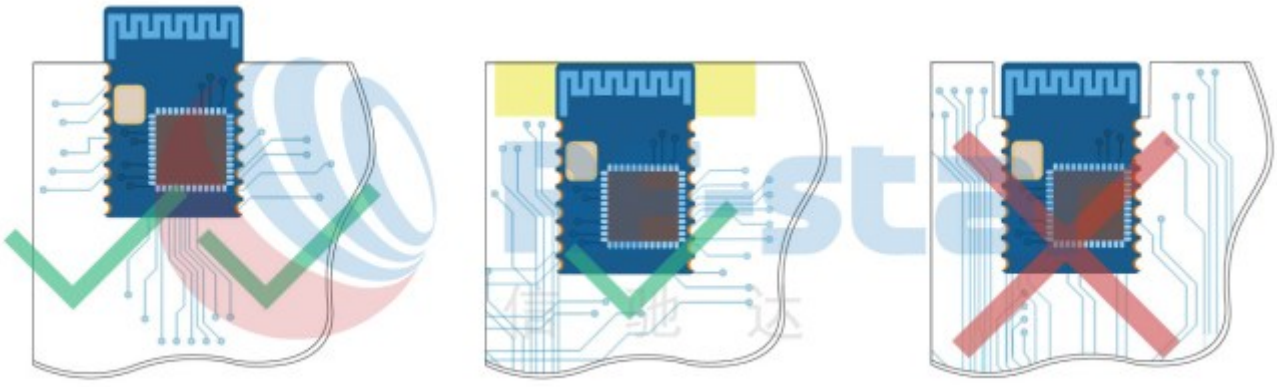

Figure 4. Recommendation of Antenna Layout

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

4.5 Trouble Shooting

4.5.1 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 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 seaside are poor.
3. The signal attenuation will be very obvious, if there is a metal near the antenna or the module is placed inside of the metal shell.
4. The incorrect power register set or the high data rate in an 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 module or the poor quality of antenna will affect the communication distance.

4.5.2 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 the stable power supply and no frequently fluctuated 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.

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

4.6 Electrostatics Discharge Warnings

The module will be damaged for the discharge of static. RF-star suggest 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 module, even causing the failure.

4.7 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

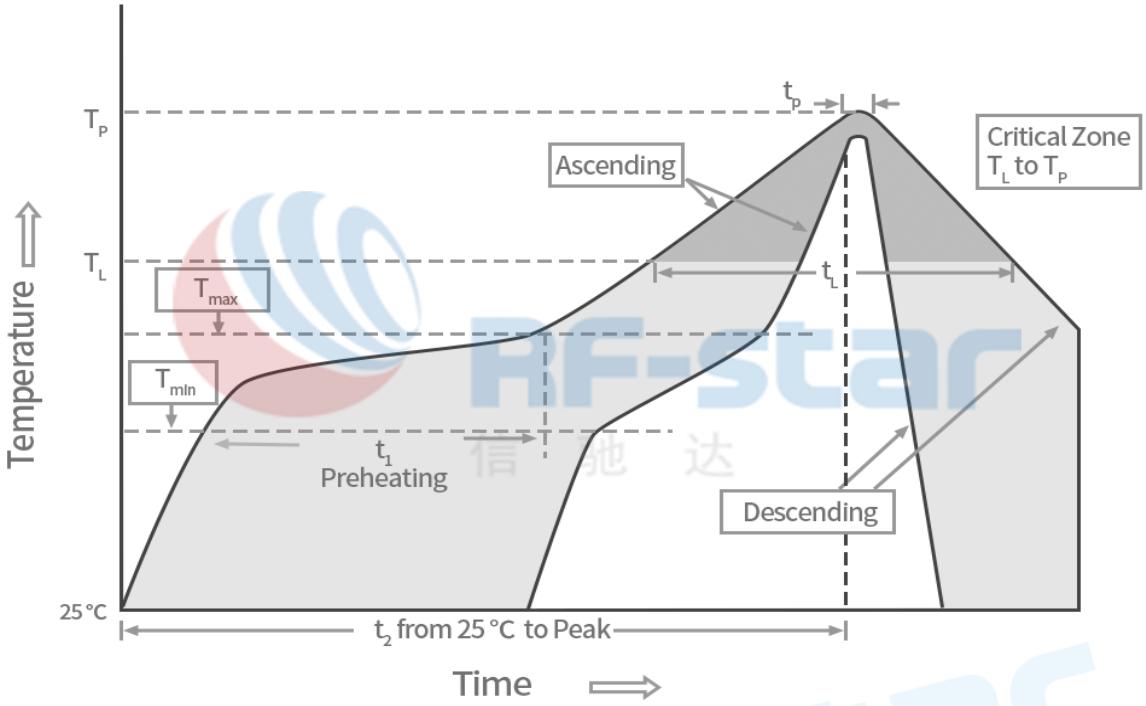

Figure 5. Recommended Reflow for Lead Free Solder

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.

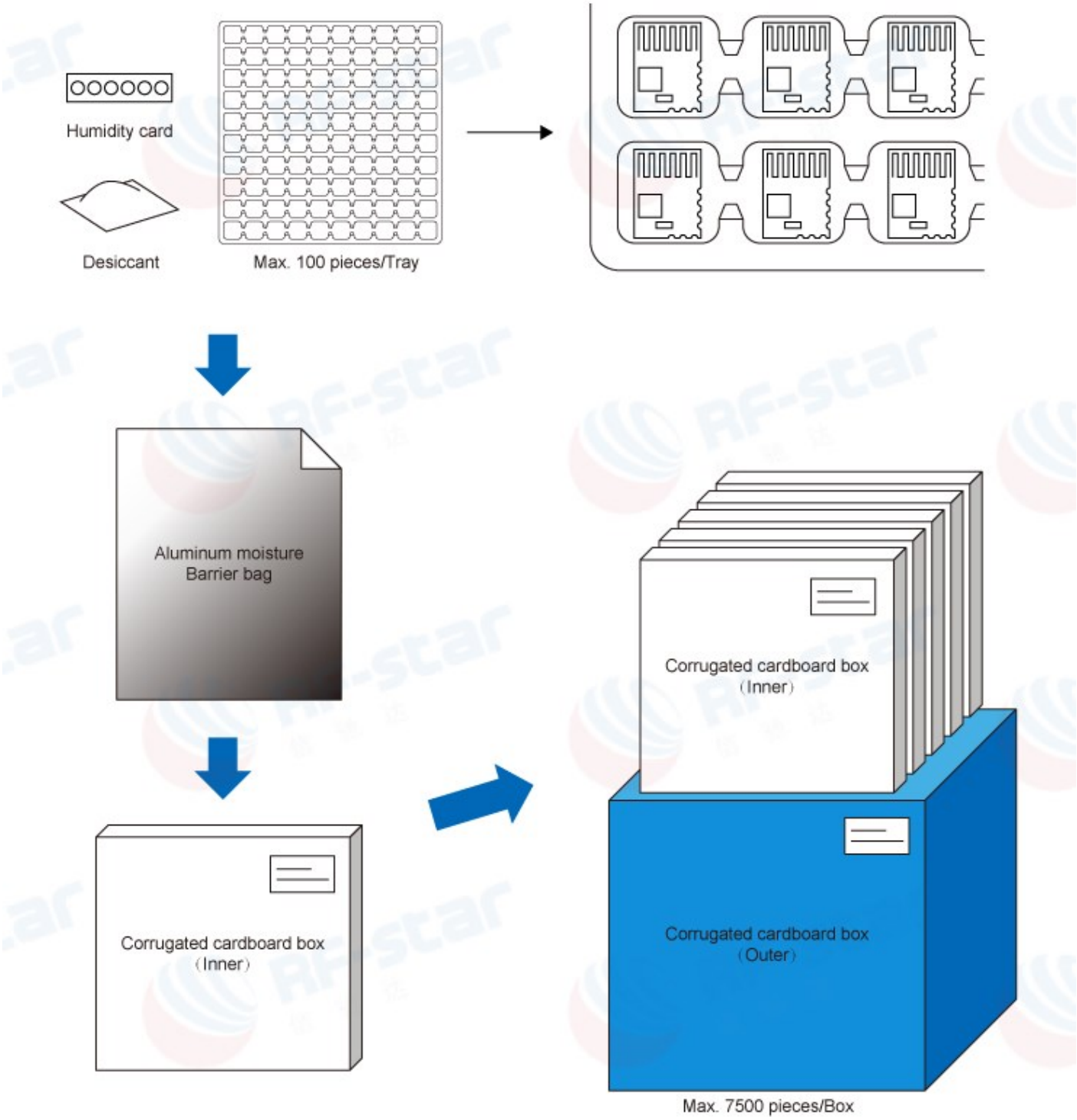

Figure 6. Default Package by Tray

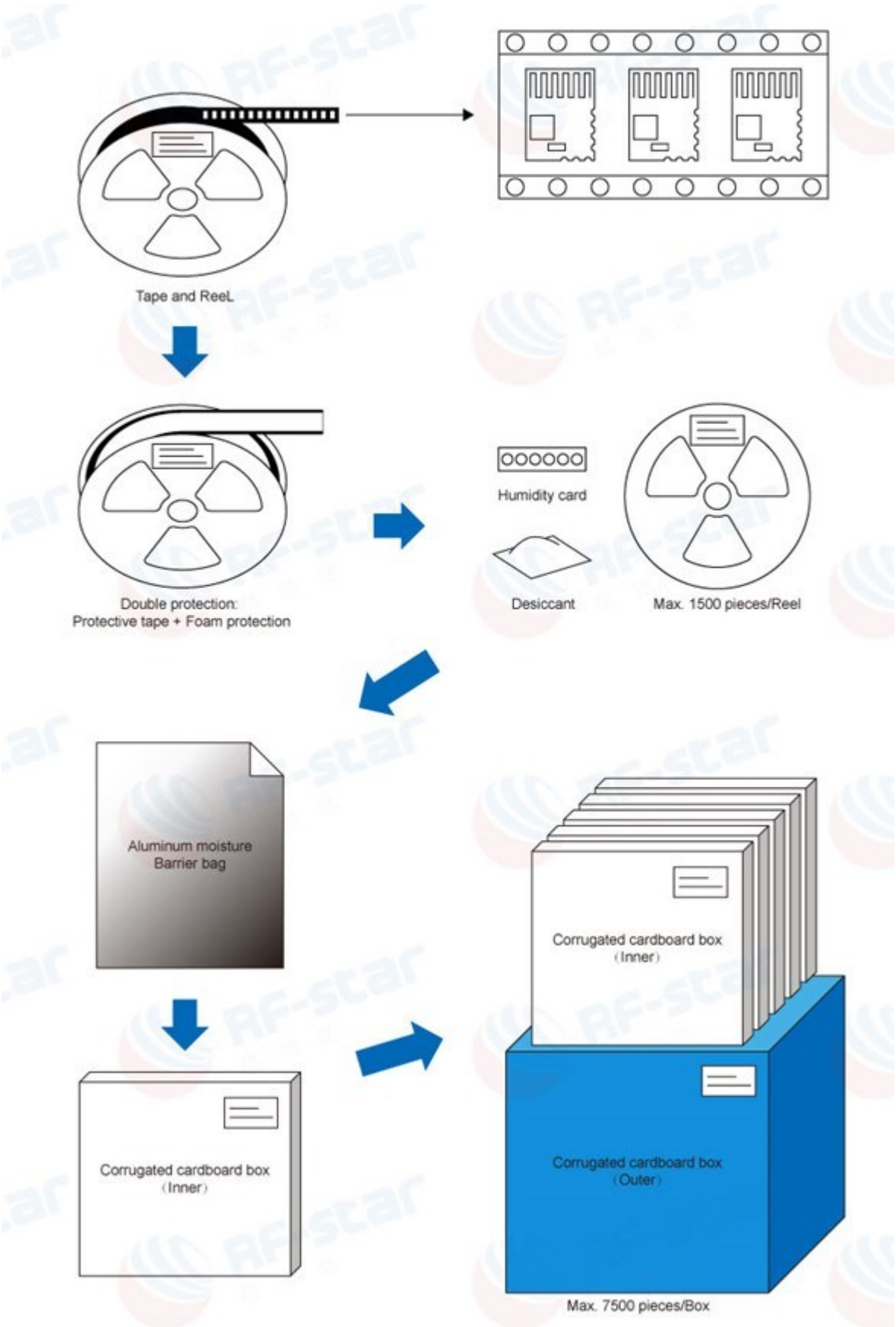

Figure 7. Package by Tape & Reel

5 Revision History

Date	Version No.	Description
2021.03.19	V1.0	The initial version is released.
2023.05.25	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.

6 Contact Us

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