



# **RF-BM-2652P3 CC2652P SimpleLink™ Multiprotocol 2.4 GHz Wireless Module with Integrated Power Amplifier and Flash**

**Version 1.0**

Shenzhen RF-star Technology Co., Ltd.

May 25<sup>th</sup>, 2023

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## 1 Device Overview

### 1.1 Description

RF-BM-2652P3 is an RF module based on TI lower-power CC2652P SoC, which is a multiprotocol 2.4 GHz wireless module supporting Thread, Zigbee®, Matter, Bluetooth® 5.3 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 a 48 MHz crystal and a 32.768 kHz crystal, 352 KB of in-system Programmable Flash and an external flash of 1 MB, 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. And the module enables long-range and low-power applications using integrated +20 dBm high-power amplifier with best-in-class transmit current consumption at 85 mA. It features small size, robust connection distance, and rigid reliability.

### 1.2 Key Features

- RF Section
  - Bluetooth 5.3 Low Energy
  - ZigBee, Thread, Matter
  - IEEE 802.15.4
  - IPv6-enabled smart objects (6LoWPAN)
  - Proprietary systems
  - SimpleLink™ TI 15.4-Stack (2.4 GHz)
  - Dynamic Multiprotocol Manager (DMM) driver
- TX power: up to +20 dBm with temperature compensation
- Excellent receiver sensitivity
  - -105 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 JTAG and JTAG debugging
  - Support OTA upgrade
- Memory
  - 352 KB of in-system programmable flash + external 1 MB 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
  - 23 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<sup>2</sup>C

- I<sup>2</sup>S
- 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
  - On-chip buck DC/DC converter
- Dimension: 24.0 mm × 16.0 mm × 2.1 mm
- Certificates:
  - FCC
  - CE
  - RoHS

### 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

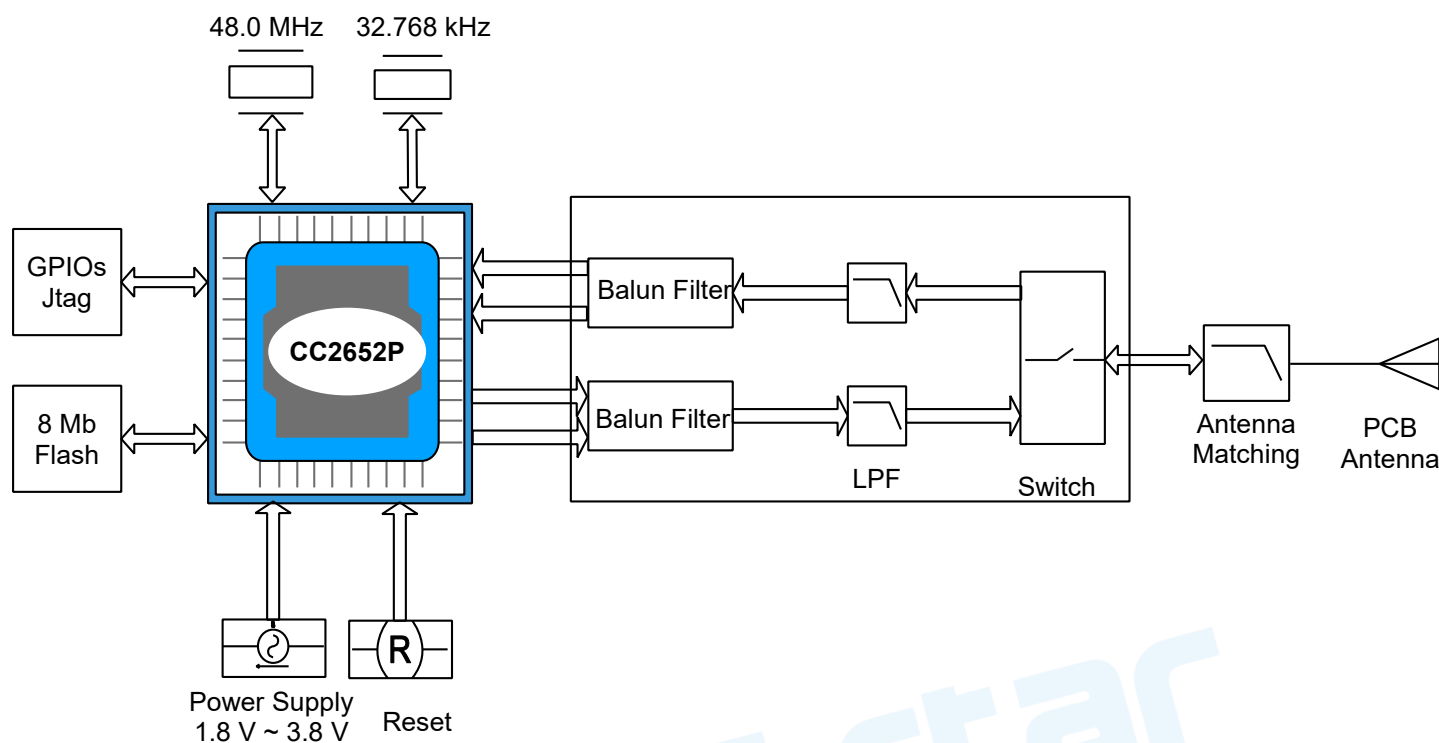


Figure 1. Functional Block Diagram of RF-BM-2652P3

## 1.5 Part Number Conventions

The part numbers are of the form of RF-BM-2652P3 where the fields are defined as follows:

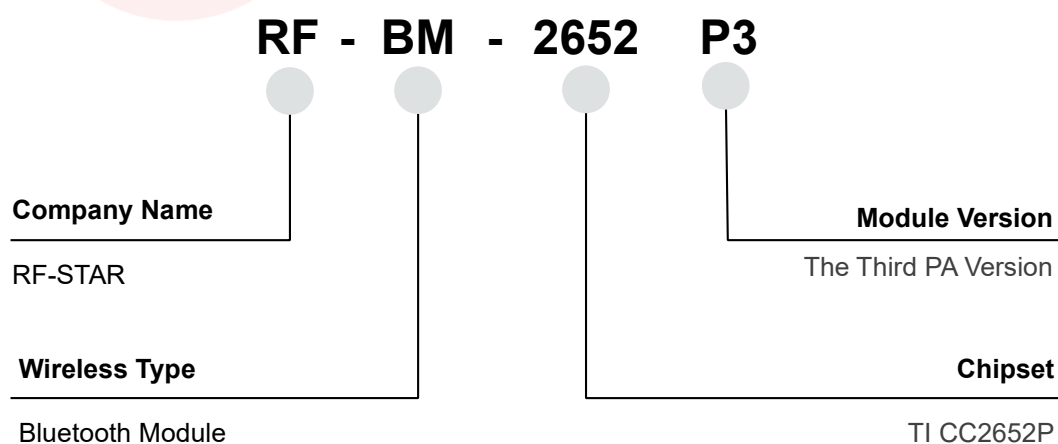


Figure 2. Part Number Conventions of RF-BM-2652P3

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## 2 Module Configuration and Functions

### 2.1 Module Parameters

Table 1. Parameters of RF-BM-2652P3

|                        |   |
|------------------------|---|
| Chipset                | CC2652P   |
| Supply Power Voltage   | 1.8 V ~ 3.8 V, 3.3 V is recommended   |
| Frequency              | 2402 MHz ~ 2480 MHz   |
| Maximum Transmit Power | +20.0 dBm   |
| Receiving Sensitivity  | -100 dBm @ 802.15.4 (2.4 GHz)<br>-105 dBm @ Bluetooth 125 kbps (LE Coded PHY)   |
| GPIO                   | 11  |
| Flash                  | 352 KB + 1 MB   |
| ROM                    | 256 KB  |
| SRAM                   | 88 KB   |
| Power Consumption      | RX current: 6.9 mA<br>TX current: 7.3 mA @ 0 dBm<br>9.6 mA @ 5 dBm<br>22 mA @ 10 dBm<br>85 mA @ 20 dBm<br>MCU 48 MHz (CoreMark): 3.4 mA (71 $\mu$ A/MHz)<br>Sensor Controller: 30.1 $\mu$ A @ Low Power-Mode, 2 MHz, running infinite loop<br>808 $\mu$ A @ Active-Mode, 24 MHz, running infinite loop<br>Standby: 0.94 $\mu$ A<br>Shutdown: 150 nA |
| Support Protocol       | Thread, ZigBee, Matter, BLE5.3, IEEE 802.15.4, 6LoWPAN, proprietary systems, SimpleLink™ TI 15.4 stack (2.4 GHz)  |
| Flash                  | 1 MB + 352 kB   |
| Crystal                | 48 MHz, 32.768 kHz  |
| Package                | SMT packaging (1.27-mm half-hole pitch stamp stick)   |
| Dimension              | 24.0 mm × 16.0 mm × 2.2 mm  |
| Type of Antenna        | PCB antenna   |
| Operating Temperature  | -40 °C ~ +85 °C   |
| Storage Temperature    | -40 °C ~ +125 °C  |

## 2.2 Module Pin Diagram

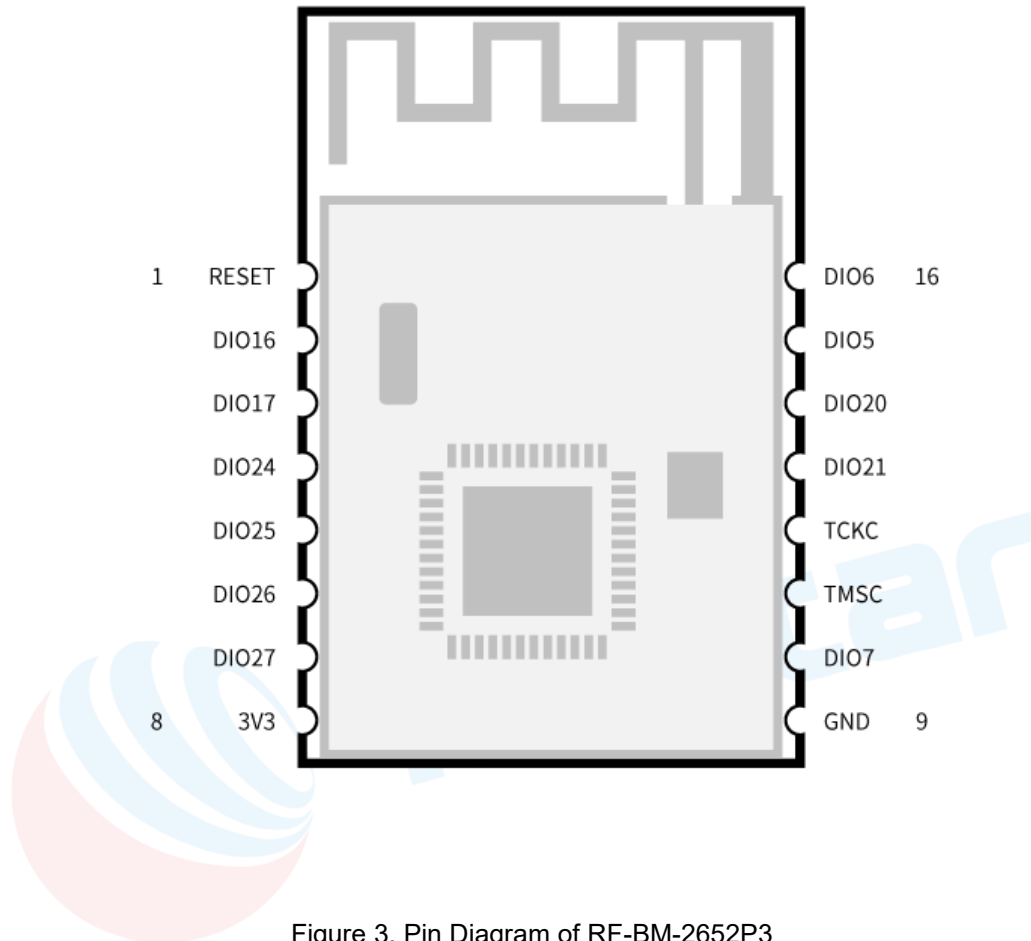


Figure 3. Pin Diagram of RF-BM-2652P3

## 2.3 Pin Functions

Table 2. Pin Diagram of RF-BM-2652P3

| Pin | Name  | Chip Pin | Function          | Description                                       |
|-----|-------|----------|-------------------|---|
| 1   | RESET | RESET_N  |                   | Reset, active low. Internal pullup.               |
| 2   | DIO16 | DIO_16   | Digital           | GPIO, JTAG_TDO, high-drive capability             |
| 3   | DIO17 | DIO_17   | Digital           | GPIO, JTAG_TDI, high-drive capability             |
| 4   | DIO24 | DIO_24   | Digital or Analog | GPIO, analog capability                           |
| 5   | DIO25 | DIO_25   | Digital or Analog | GPIO, analog capability                           |
| 6   | DIO26 | DIO_26   | Digital or Analog | GPIO, analog capability                           |
| 7   | DIO27 | DIO_27   | Digital or Analog | GPIO, analog capability                           |
| 8   | 3V3   | 3V3      | -                 | Power supply: 1.8 V ~ 3.8 V, recommended to 3.3 V |



|    |           |           |         |                                  |
|----|-----------|-----------|---------|----------------------------------|
| 9  | GND       | GND       | GND     | Ground                           |
| 10 | DIO7      | DIO_7     | Digital | GPIO, high-drive capability      |
| 11 | JTAG_TMSC | JTAG_TMSC | Digital | JTAG TMSC, high-drive capability |
| 12 | JTAG_TCKC | JTAG_TCKC | Digital | JTAG TCKC                        |
| 13 | DIO21     | DIO_21    | Digital | GPIO                             |
| 14 | DIO20     | DIO_20    | Digital | GPIO                             |
| 15 | DIO5      | DIO_5     | Digital | GPIO, high-drive capability      |
| 16 | DIO6      | DIO_6     | Digital | GPIO, high-drive capability      |



## 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-2652P3

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

### 3.2 Handling Ratings

Table 4. Handling Ratings of RF-BM-2652P3

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

### 3.3 PA Output Control

The PA of the CC2652P switches the RF switch by controlling the output of DIO28 and DIO29, and then switches the PA and non-PA RF output to realize the control of the transmission power range.

Table 3. RF Control Truth Table

| Power                  | DIO28 (Output) | DIO29 (Output) |
|------------------------|----------------|----------------|
| +5 dBm ~ + 20 dBm (PA) | 0              | 1              |
| < 5 dBm                | 1              | 0              |

## 4 Application, Implementation, and Layout

### 4.1 Module Photos

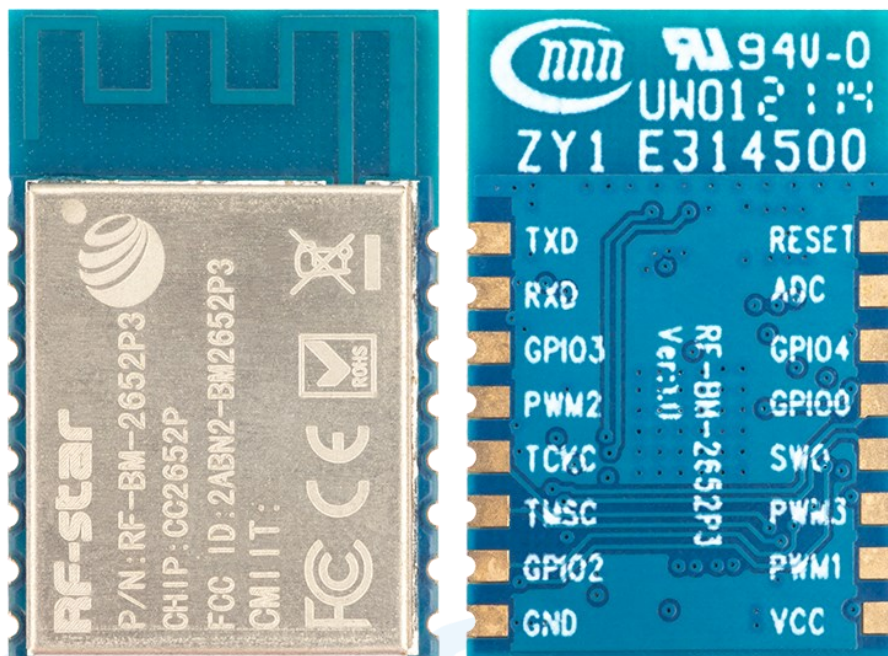


Figure 3. Photos of RF-BM-2652P3

### 4.2 Recommended PCB Footprint

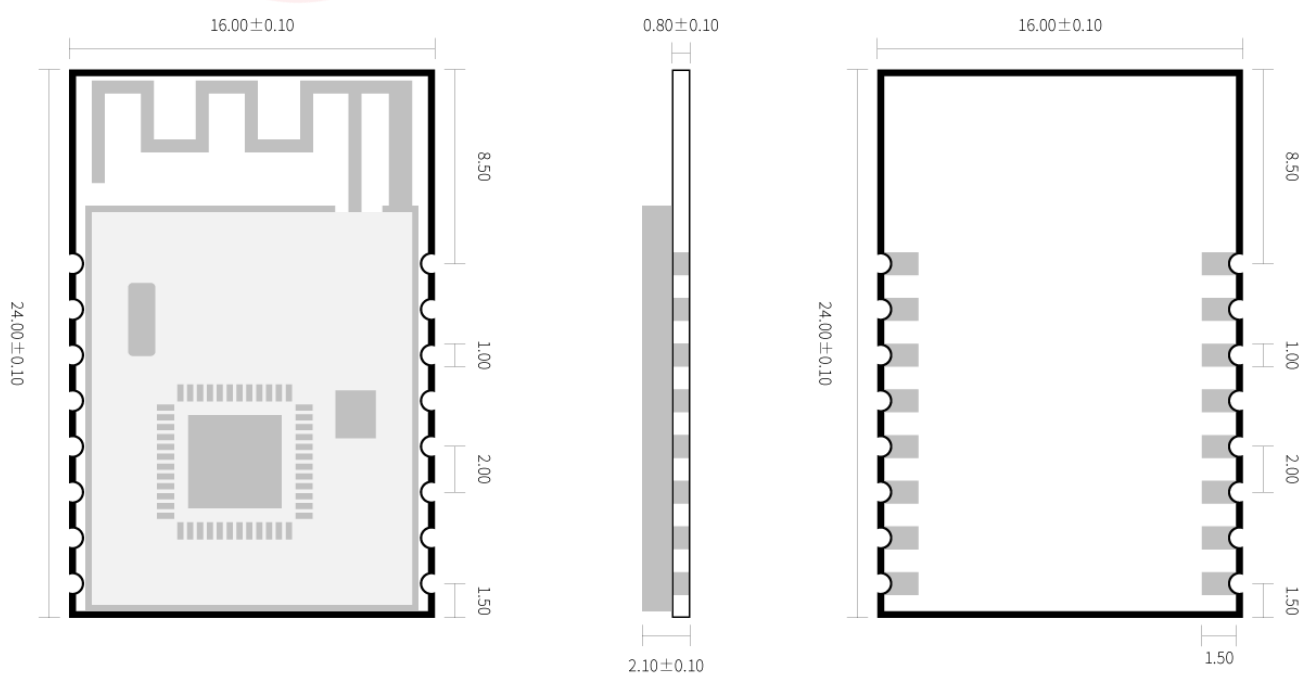


Figure 4. Recommended PCB Footprint of RF-BM-2652P3

## 4.3 Schematic Diagram

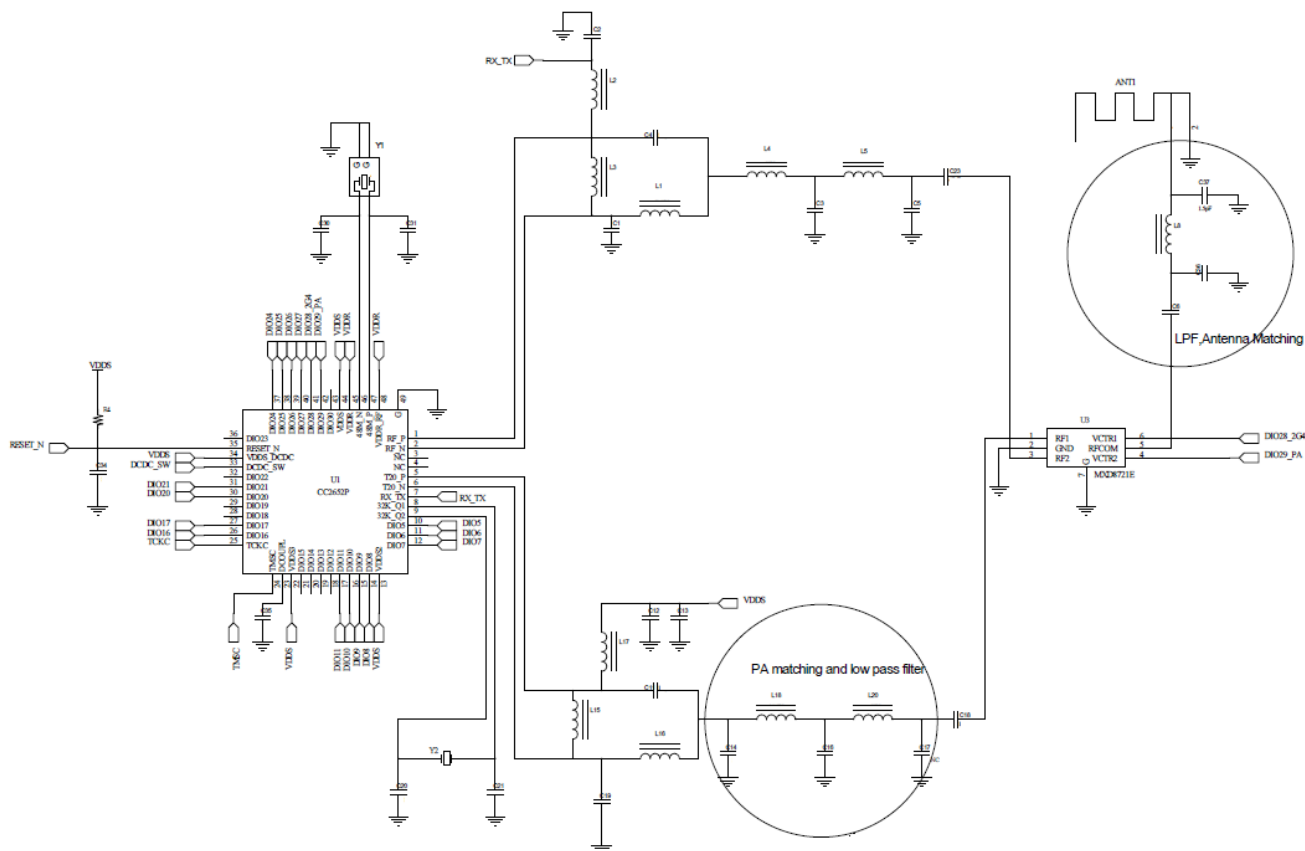


Figure 5. Schematic Diagram of RF-BM-2652P3

## 4.4 Antenna

### 4.4.1 Antenna Design Recommendation

1. The antenna installation structure has a great influence on the module performance. It is necessary to ensure that 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.

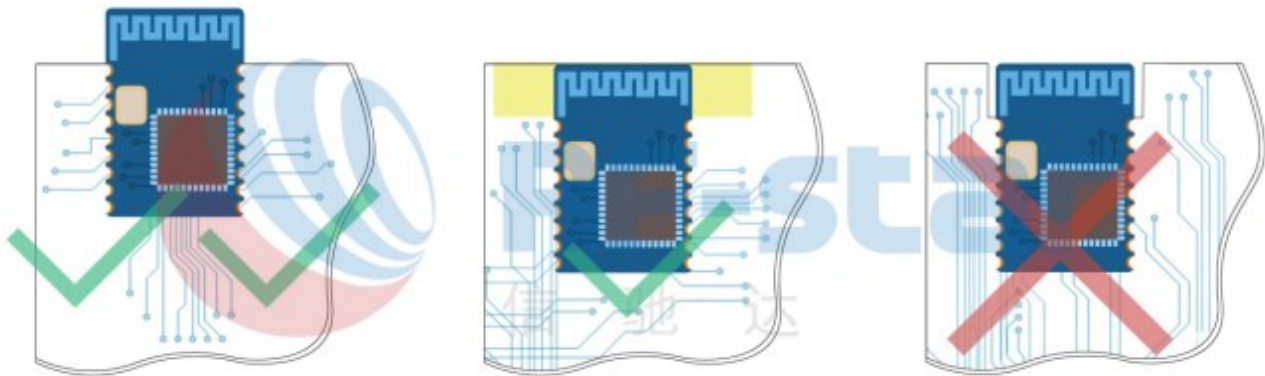


Figure 4. Recommendation of Antenna Layout

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

#### 4.5 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.

## **4.6 Trouble Shooting**

### **4.6.1 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.

### **4.6.2 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.

### **4.6.3 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.

- The unsatisfactory power supply may also cause garbled. It is necessary to ensure the power supply's reliability.
- If the extension wire or feeder wire is of poor quality or too long, the bit error rate will be high.

#### 4.7 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:

- According to the anti-static measures, bare hands are not allowed to touch modules.
- Modules must be placed in anti-static areas.
- 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.

#### 4.8 Soldering and Reflow Condition

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

Table 5. Temperature Table of Soldering and Reflow

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

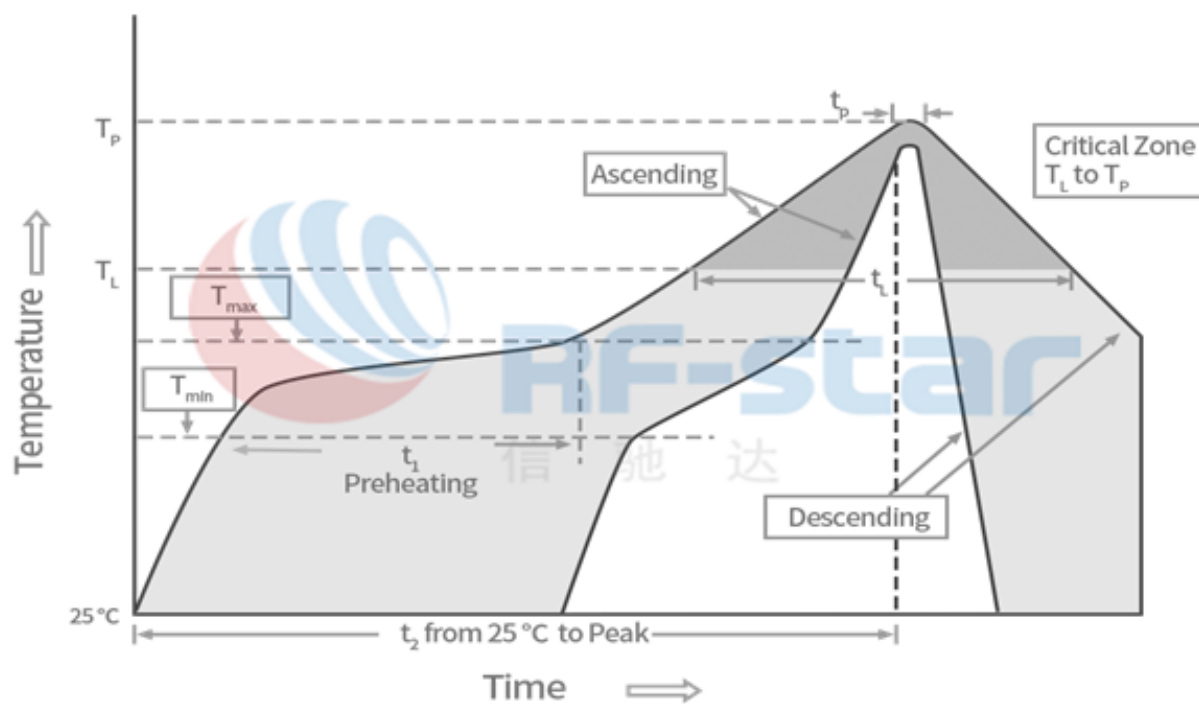


Figure 5. Recommended Reflow for Lead-Free Solder



## 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.

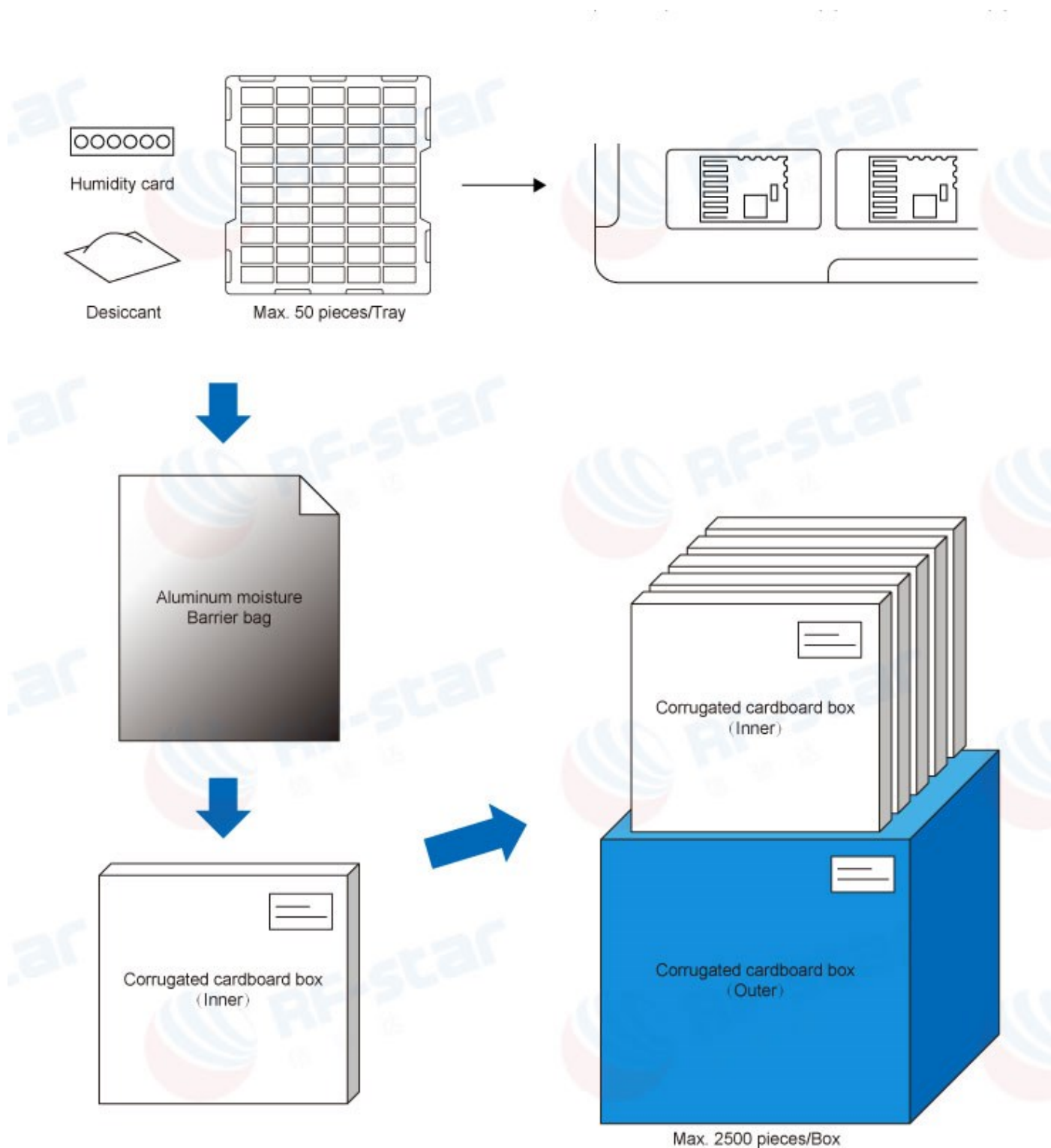


Figure 6. Default Package by Tray

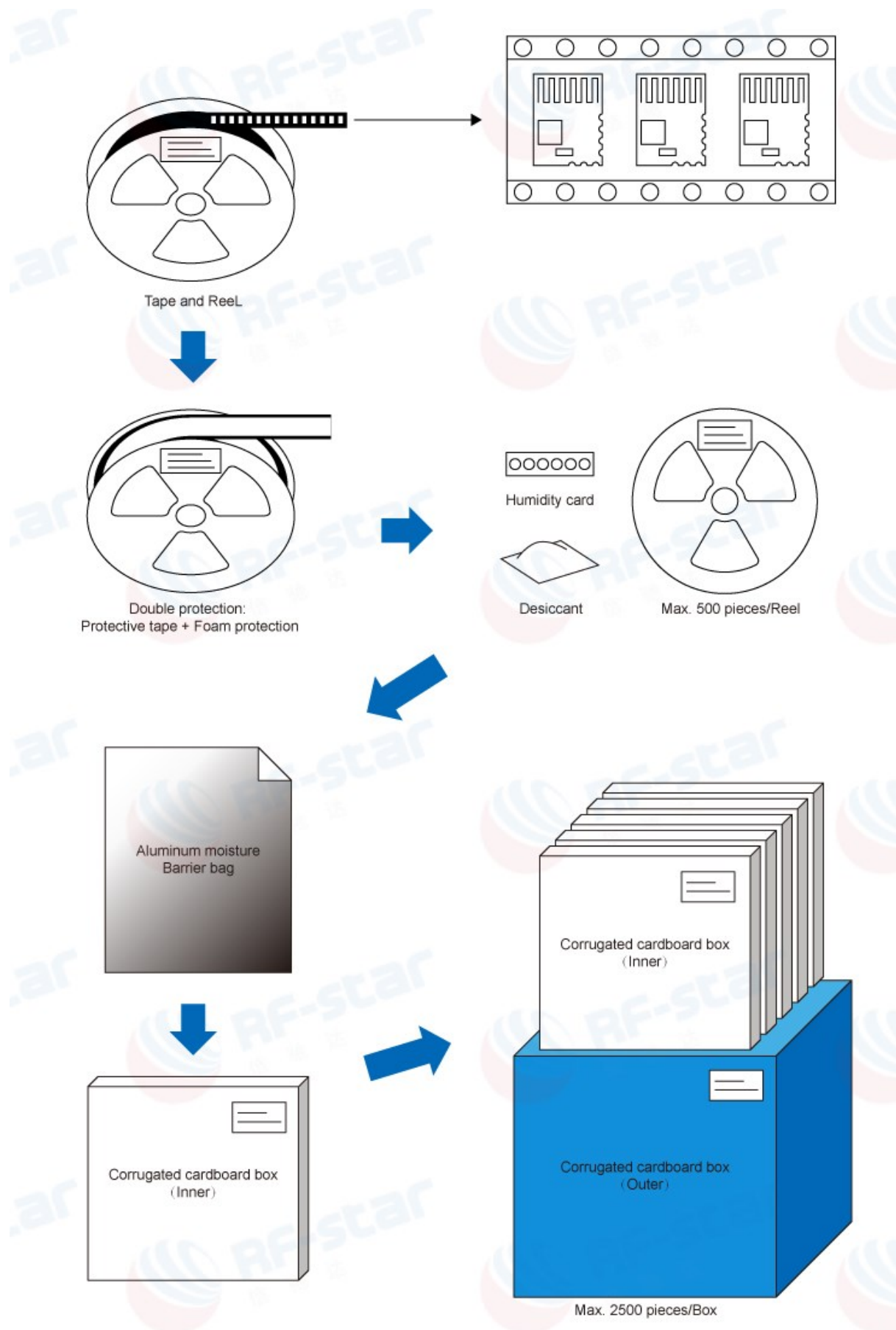


Figure 7. Package by Tape & Reel

## 6 Certification

### 6.1 FCC

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 Identifier: 2ABN2-2652P3

**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: 08/04/2021  
Application Dated: 08/04/2021

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

Attention: Anso woo

**NOT TRANSFERABLE**

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

FCC IDENTIFIER: 2ABN2-2652P3  
Name of Grantee: ShenZhen RF-STAR Technology CO., LTD

Equipment Class: Digital Transmission System  
Notes:  
Module Type: BT module  
Module Model: Single Module

| Grant Notes | FCC Rule Parts | Frequency Range (MHz) | Output Power (Watt) | Frequency Tolerance | Emission Designator |
|-------------|----------------|-----------------------|---------------------|---------------------|---------------------|
| 15C         | 15C            | 2400.0 - 2480.0       | 0.001875            |                     |                     |
| 15C         | 15C            | 2400.0 - 2480.0       | 0.001250            |                     |                     |

Output power listed is conducted

Figure 8. FCC Certificate

### 6.2 CE

**Declaration of Conformity**

The submitted sample of the following equipment has been tested for CE marking according to the following European Directives: the RED Directive 2014/53/EU.

Applicant name & Address: ShenZhen RF-star Technology Co., Ltd.  
Room 601, Block C, Skyworth Building, High-tech Park, Nanshan District, Shenzhen, Guangdong, China

Manufacturer name & Address: ShenZhen RF-star Technology Co., Ltd.  
Room 601, Block C, Skyworth Building, High-tech Park, Nanshan District, Shenzhen, Guangdong, China

Product: BT module

Model/Type reference: RF-BM-2652P3

Trade name: RF-star

Order No.: BLA-EMC-202106-A92

| Essential Requirements | Applied Specifications/Standards   | Documentary Evidence   |
|------------------------|--|--|
| Art 3.1 (a) Health     | EN 62479-2020  | Test Report<br>BLA-EMC-202106-A9204                          |
| Art 3.1 (a) Safety     | EN IEC 62368-1-2020  | Test Report<br>BLA-202106-A15                                |
| Art 3.1 (b) EMC        | ETSI EN 301 485-4 V2.2.3 (2019-11);<br>ETSI EN 301 489-17 V3.2.4 (2020-09) | Test Report<br>BLA-EMC-202106-A9201                          |
| Art 3.2 Radio          | ETSI EN 300328 V2.2.2 (2018-07)  | Test Report<br>BLA-EMC-202106-A9202;<br>BLA-EMC-202106-A9203 |

This certification has been granted to the applicant based on the results of the tests performed by laboratory of Shenzhen of Technical Service (Shenzhen) Co., Ltd. on the sample of the above-mentioned product in accordance with the provisions of the relevant specific standards and the product is in conformity with the essential requirements of Article 3 (3) (b) 2 of Directive 2014/53/EU. The CE mark on shown below can be used, under the responsibility of the manufacturer, after completion of an EC Declaration of Conformity and compliance with all relevant EC Directives.

**CE**

Shenzhen of Technical Service (Shenzhen) Co., Ltd.  
Building C No. 107, Software Road, Shennan Town, Nanshan District,  
Shenzhen, Guangdong Province, China  
Tel: +86-755-22054521  
Email: shenzhen@szrfstar.com  
www.szrfstar.com

Figure 9. CE Certificate

## 6.3 RoHS

RoHS Report No.:C210630006001-1

**CPST**  

**Test Report** No. C210630006001-1 Date: Jul 06, 2021 Page 1 of 9

Applicant: Shenzhen RF-star Technology Co., Ltd.  
 Applicant address: Room 601, Block C, Skyworth Building, High-tech Park, Nanshan District, Shenzhen, Guangdong, China

The following samples were submitted and identified on behalf of the clients as

Sample Name: BT module  
 Model: RF-BM-2652P3  
 Manufacturer: Shenzhen RF-star Technology Co., Ltd.  
 Manufacturer Address: Room 601, Block C, Skyworth Building, High-tech Park, Nanshan District, Shenzhen, Guangdong, China  
 CPST Internal Reference No.: C210630006  
 Sample Received Date: Jun 30, 2021  
 Sample Quantity: 02 pcs  
 Test Period: Jun 30, 2021 to Jul 06, 2021  
 Test Method: Please refer to next page(s).  
 Test Result: Please refer to next page(s).

Signature and Stamp of  
 Eurores (Dongguan) Consumer Products Testing Service Co., Ltd.

WRITTEN BY:   
 Chen Xiao Ting, Silvia  
 Report writer

REVIEWED BY:   
 Liu Xiao Fang, Sunshine  
 Report Reviewer

APPROVED BY:   
 Pan Jian Ding, Will  
 Technical Supervisor

Note: This Test Report shall be issued if it is not identical with the sample used for testing. Only responsible for the tested samples, issued if identified, signed and sealed. This report is not a certificate of conformity, and it is not a guarantee of the quality of the product. Any unauthorized alteration, forgery or falsification of the content of this report is prohibited. The report is valid only for the purpose of the test. The report is not a certificate of conformity, and it is not a guarantee of the quality of the product. Any unauthorized alteration, forgery or falsification of the content of this report is prohibited. The report is valid only for the purpose of the test.

 400 111 8218 Eurores (Dongguan) Consumer Products Testing Service Co., Ltd. Tel: 0512-180337788 Fax: 0512-180337788 Email: service@cpst.com  
 Room 1002, No. 12, East of Huadu Avenue, Huadu, Dongguan, Guangdong, China. Postcode: 523300

Figure 10. RoHS Certificate

## 7 Revision History

| Date       | Version No. | Description  |
|------------|-------------|--|
| 2021.02.02 | V1.0        | The initial version is released.                           |
| 2023.05.25 | V1.0        | Update MSL version.<br>Update the Shenzhen office address. |

Note:

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