



RF-BM-S01 and RF-BM-S01A CC254X Series

Bluetooth Low Energy Module

Version 1.0

Shenzhen RF-star Technology Co., Ltd.

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1 Device Overview

1.1 Module Series

There is a series of RF-BM-S01(A) Bluetooth Low Energy modules. All of them are based on TI CC254X (CC2540 and CC2541) SoC series. Because the CC254X series ICs are compatible in package, pins, and peripherals, those modules are pin-to-pin compatible with each other as well.

Table 1. Module Series of RF-BM-S01(A)

Model	Antenna Output Mode	Chip Model	TX Power	FLASH	RAM	Peripherals
S01	PCB onboard	CC2540	+4 dBm	256 KB	8 KB	USB, PWM, ADC, IR, WATCHDOG
S01A	PCB onboard	CC2541	0 dBm	256 KB	8 KB	I2C, PWM, ADC, IR, WATCHDOG

1.2 Description

RF-BM-S01 and RF-BM-S01A are Bluetooth Low Energy (BLE) module based on TI CC254X series, an 8051 core BLE System-on-Chip (SoC). This PCB module integrates a 32 MHz crystal, a 32.768 kHz crystal, an LC balun, an RF matching filter, and a meander line PCB antenna. It is pre-programmed with the BLE 4.2 stack and an application communication protocol. Very low-power sleep modes are available. Short transition times between operating modes further enable low power consumption. RF-BM-S01 is pin-compatible with the RF-BM-S01A in SMT package, if the USB is not used on the RF-BM-S01 and the I²C/extra I/O is not used on the RF-BM-S01A. Compared to the RF-BM-S01, the RF-BM-S01A provides lower RF current consumption. The RF-BM-S01A does not have the USB interface of the RF-BM-S01, and provides lower maximum output power in TX mode. The RF-BM-S01A also adds a HW I²C interface.

1.3 Key Features

- RF
 - Bluetooth low energy 4.0 compatible protocol stack for single-mode
 - Excellent link budget (up to 97 dBm), Enabling long-range applications without external front end
 - Accurate Digital Received Signal-Strength Indicator (RSSI)
- Microcontroller
 - High-performance and low-power 8051 microcontroller core
 - In-system-programmable flash of 256 KB
 - 8-KB SRAM
- Peripherals
 - 12 Bit ADC with eight channels and configurable resolution
 - Integrated high-power op-amp and ultra-low power comparator

- General-purpose timers (one 16-bits, two 8-bits)
- 19 General-purpose I/O pins
- 32 kHz sleep timer with capture
- Two powerful USARTs with support for several serial protocols
- IR generation Circuitry
- AES security coprocessor
- Battery monitor and temperature sensor
- RF-BM-S01:
 - Full speed USB interface
 - Each CC2540 contains a unique 48-bit IEEE address
- RF-BM-S01A:
 - I²C interface
 - 2 I/O pins have LED driving capabilities
- Low Power
 - Active mode RX down to 19.6 mA
 - Active mode TX (-6 dBm): 24 mA
 - Power mode 1 (3- μ s wake-up): 235 μ A
 - Power mode 2 (sleep timer on): 0.9 μ A
 - Power mode 3 (external interrupts): 0.4 μ A
 - Wide supply voltage range (2 V ~ 3.6 V)
 - Full RAM and register retention in all power modes
- Dimension: 17.4 mm × 13.7 mm SMT Package

1.4 Applications

- 2.4-GHz Bluetooth low energy system
- Mobile phone accessories
- Sports and leisure equipment
- Consumer electronics
- Human interface devices
- Keyboard, mouse
- Remote control
- USB dongles
- Health care and medical
- Smart lighting

1.5 Functional Block Diagram

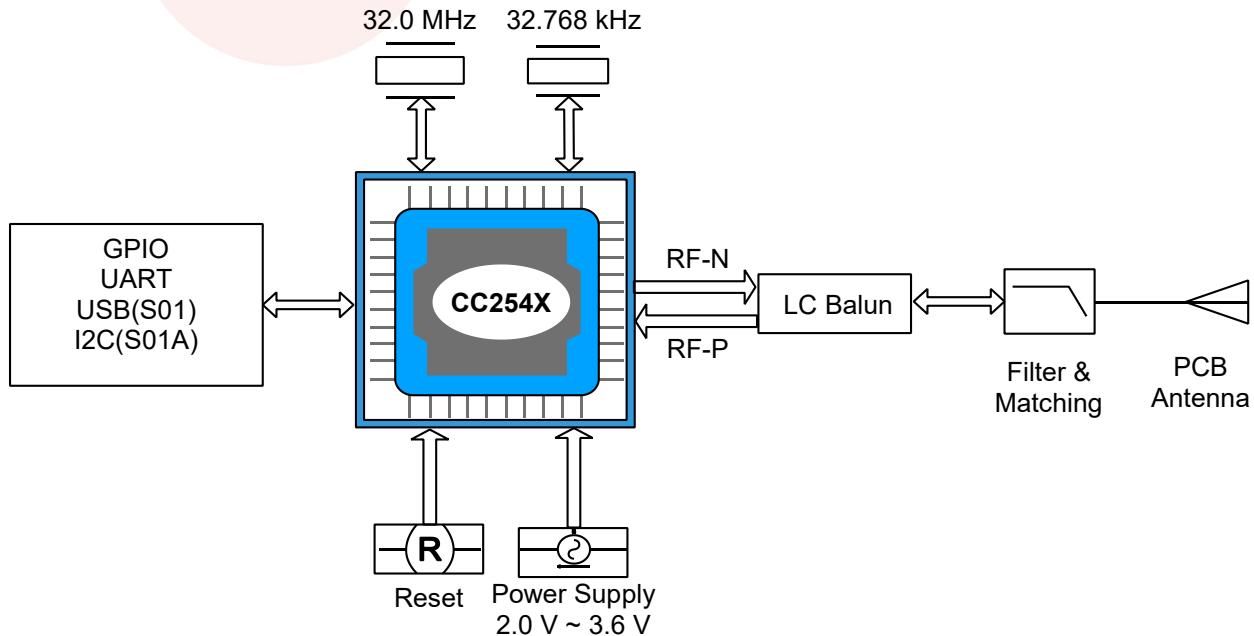


Figure 1. Functional Block Diagram of RF-BM-S01(A)

1.6 Part Number Conventions

The part numbers are of the form of RF-BM-S01(A) where the fields are defined as follows:

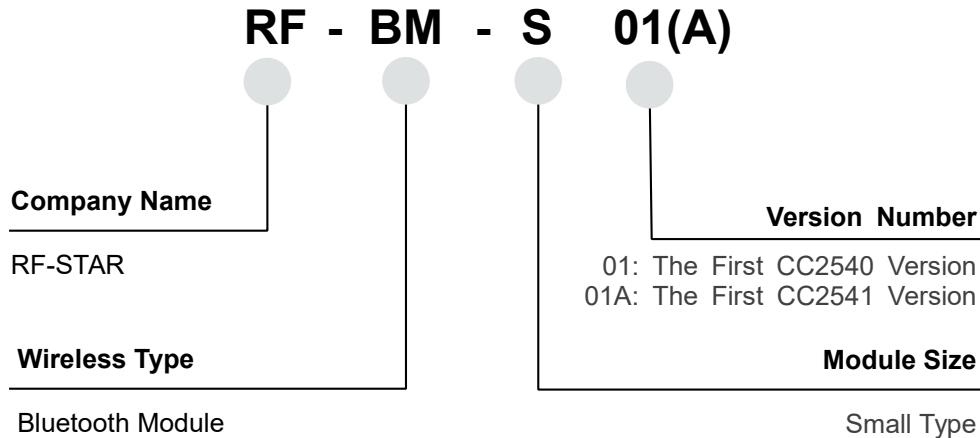


Figure 2. Part Number Conventions of RF-BM-S01(A)

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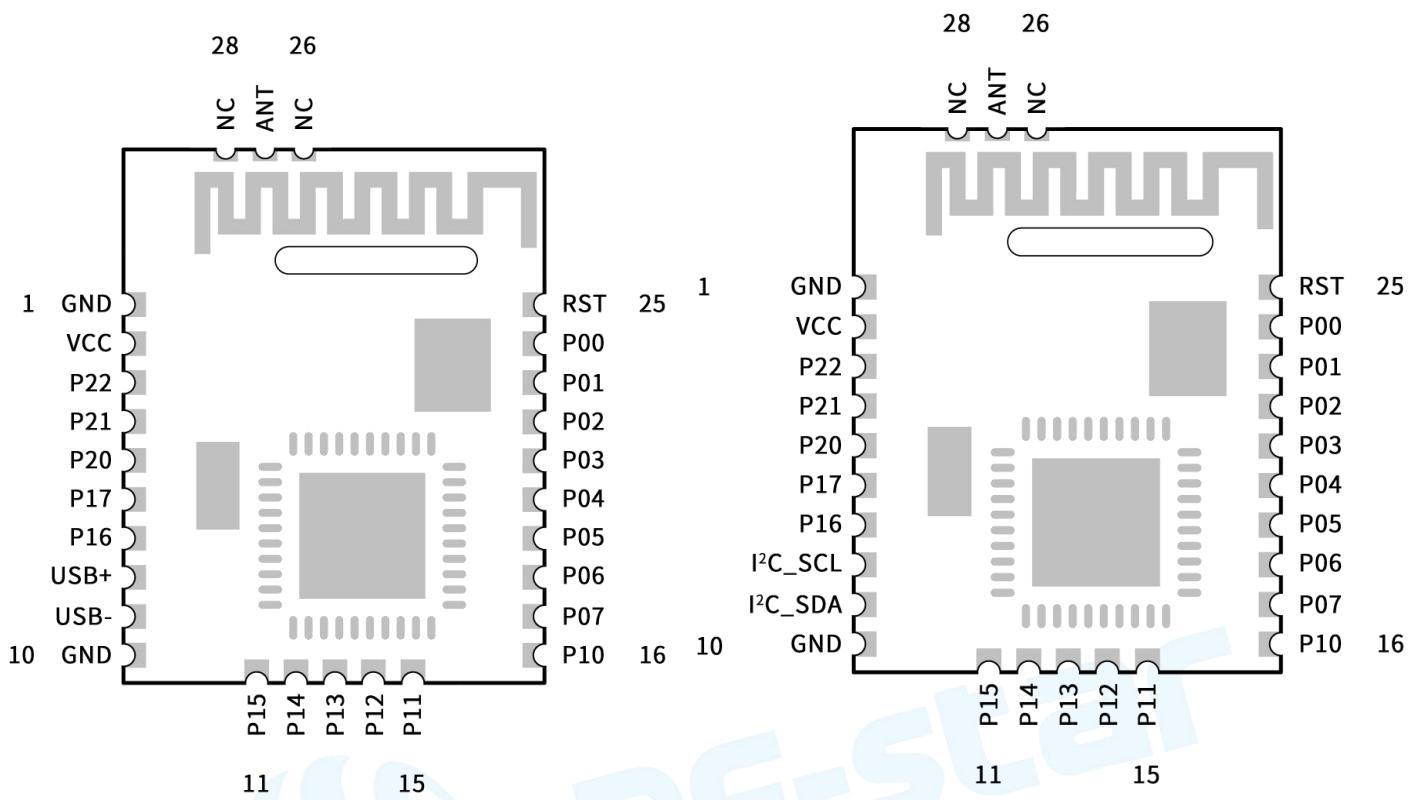


2 Module Configuration and Functions

2.1 Module Parameters

Table 2. Parameters of RF-BM-S01(A)

Chipset	RF-BM-S01: CC2540 RF-BM-S01A: CC2541
Supply Power Voltage	2.0 V ~ 3.6 V, recommended to 3.3 V
Frequency	2402 MHz ~ 2480 MHz
Transmit Power	RF-BM-S01: -23.0 dBm ~ +4.0 dBm RF-BM-S01A: -23.0 dBm ~0 dBm
Receiving Sensitivity (low gain mode)	-87 dBm
Receiving Sensitivity (high gain mode)	-93 dBm
GPIO	19
Crystal	32 MHz, 32.768 kHz
RAM	8 KB
Flash	256 KB
Package	SMT Packaging (1.27-mm half-hole pitch stamp stick)
Frequency Error	±20 kHz
Dimension	17.4 mm x 13.7 mm x 1.7 mm
Type of Antenna	PCB antenna
Operating Temperature	-40 °C ~ +85 °C
Storage Temperature	-40 °C ~ +125 °C
RX Current	19.6 mA
TX Current (-6 dBm)	24.0 mA
Power mode 1 (3-μs wake-up)	235 μA
Power mode 2 (sleep timer on)	0.9 μA
Power mode 3 (external interrupts)	0.4 μA



2.2 Module Pin Diagram

RF-BM-S01

RF-BM-S02A

Figure 3. Pin Diagram of RF-BM-S01(A)

3.3 Pin Functions

Table 3. Pin Functions of RF-BM-S01(A)

Pin	Name	Chip Pin	Pin Type	Description
1	GND	-	GND	Ground
2	VCC	-	VCC	Power supply: 2.0 V ~ 3.6 V
3	P22	P2.2	I/O	DEBUG_DC
4	P21	P2.1	I/O	DEBUG_DD
5	P20	P2.0	I/O	
6	P17	P1.7	I/O	
7	P16	P1.6	I/O	
8	USB_P	USB+	I/O	USB_P (For RF-BM-S01)
	I2C_SCL	I2C_SCL	I/O	I ² C_SCL (For RF-BM-S01A)

9	USB_N	USB-	I/O	USB_N (For RF-BM-S01)
	I2C_SDA	I2C_SDA	I/O	I ² C_SDA (For RF-BM-S01A)
10	GND	GND	GND	Ground
11	P15	P1.5	I/O	
12	P14	P1.4	I/O	
13	P13	P1.3	I/O	
14	P12	P1.2	I/O	
15	P11	P1.1	I/O	
16	P10	P1.0	I/O	
17	P07	P0.7	I/O	
18	P06	P0.6	I/O	
19	P05	P0.5	I/O	
20	P04	P0.4	I/O	
21	P03	P0.3	I/O	
22	P02	P0.2	I/O	
23	P01	P0.1	I/O	
24	P00	P0.0	I/O	
25	RESET	RST	RESET	Reset, active low.
26	NC	-	NC	
27	ANT	-	ANT	External antenna
28	NC	-	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-S01(A)

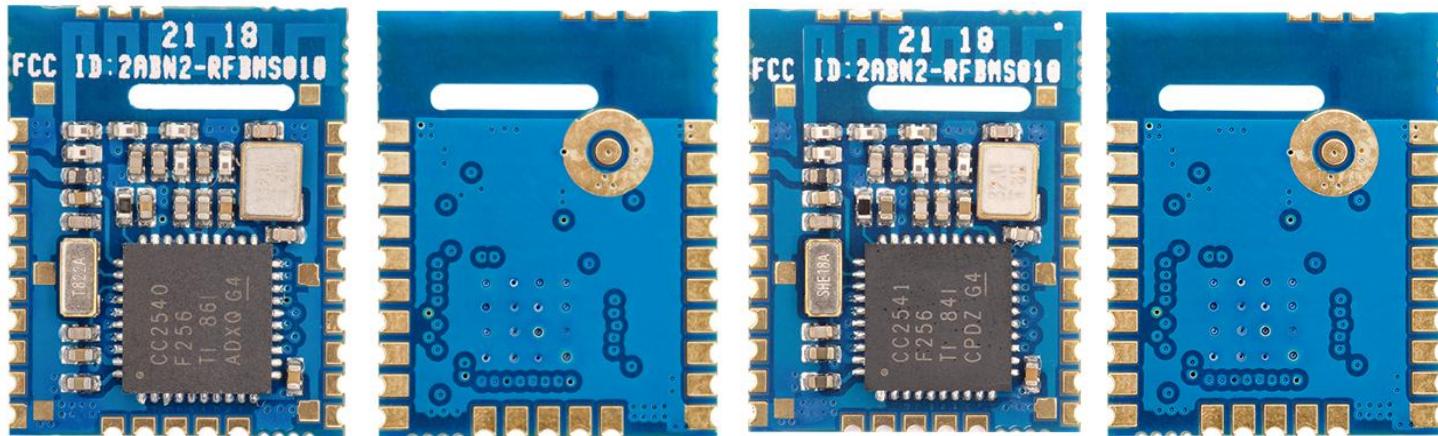
Items	Condition	Min.	Typ.	Max.	Unit
Operating Supply Voltage	Battery Mode	2.0	3.3	3.6	V
Operating Temperature	/	-40	+25	+85	°C
Environmental Hot Pendulum	/	-20		+20	°C/min

3.2 Handling Ratings

Table 5. Handling Ratings of RF-BM-S01(A)

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			±750		V

4 Application, Implementation, and Layout



4.1 Module Photos

RF-BM-S01

RF-BM-S01A

Figure 4. Photos of RF-BM-S01(A)

4.2 Recommended PCB Footprint

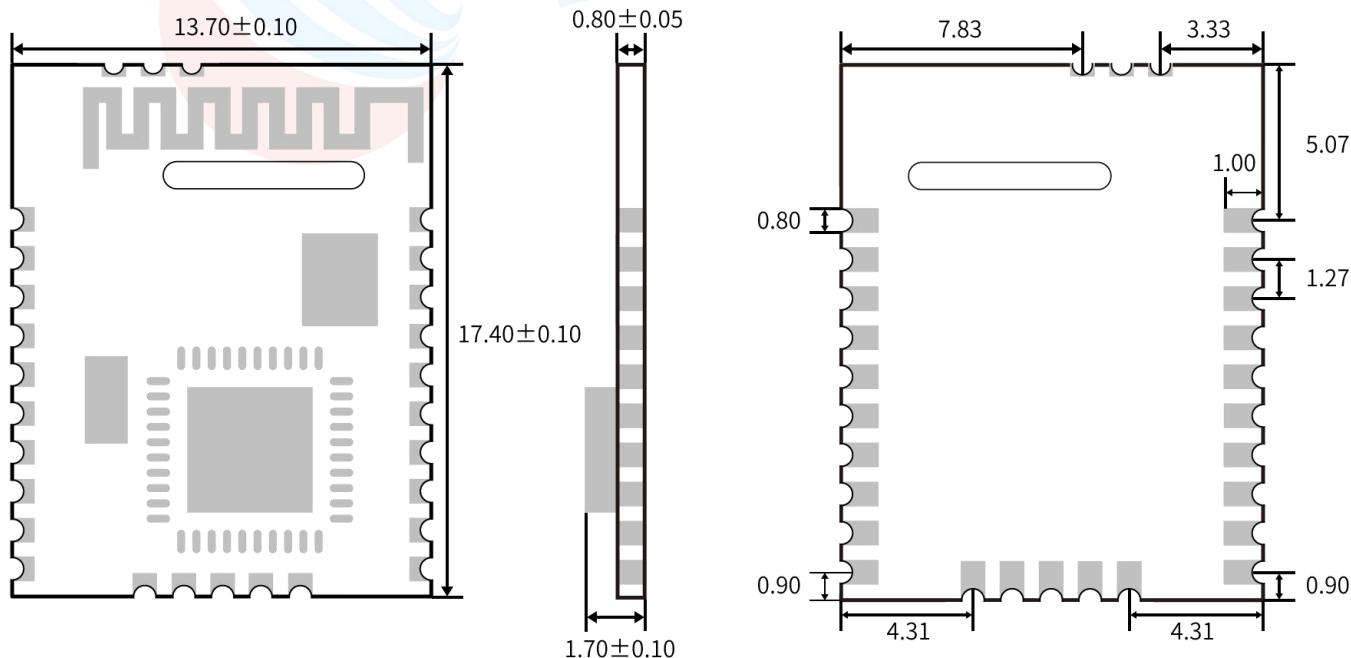


Figure 5. Recommended PCB Footprint of RF-BM-S01(A) (mm)

4.3 Schematic Diagram

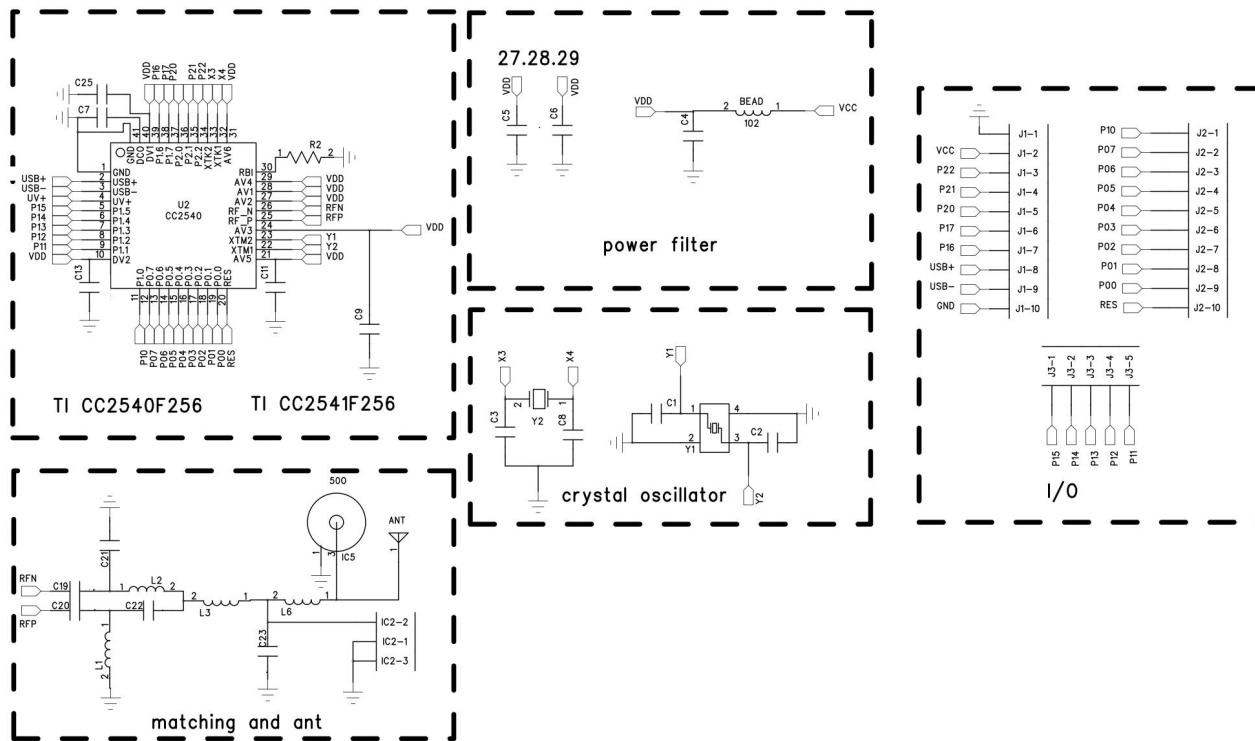
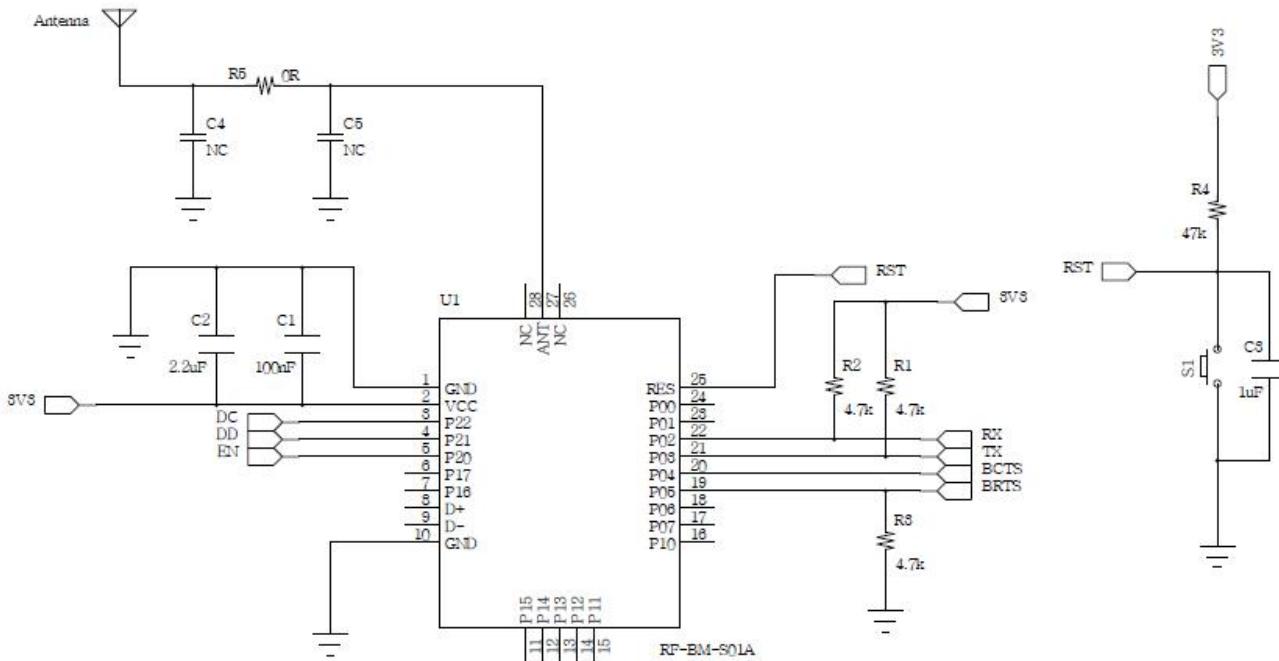


Figure 6. Schematic Diagram of RF-BM-S01(A)

4.4 Reference Design



Note: EN low active.

Figure 7. Reference Design of RF-BM-S01(A)

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.

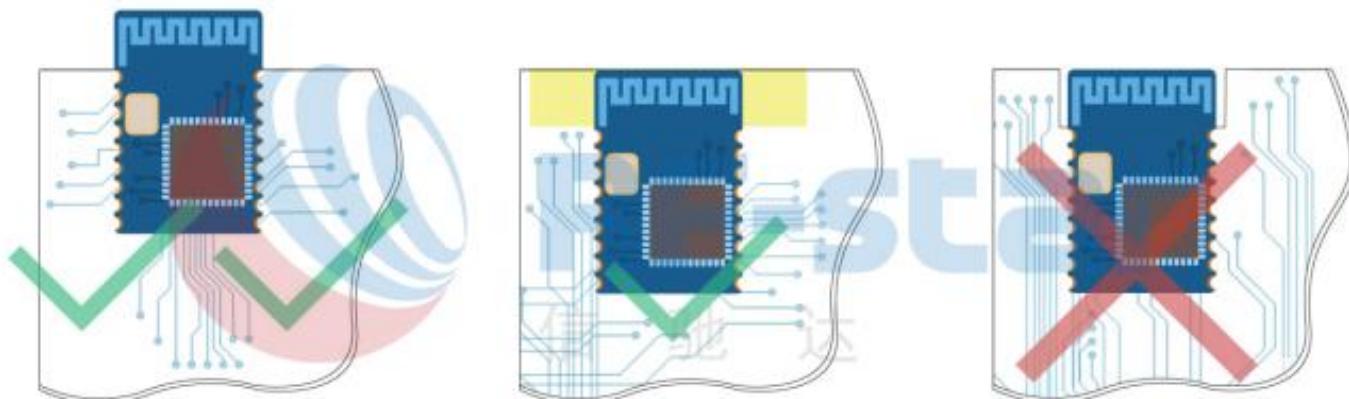


Figure 8. Recommendation of Antenna Layout

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 °C.

Table 6. 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 °C	150 °C
Max. Preheating Temperature (T_{max})	150 °C	200 °C
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 °C/s	Max. 3 °C/s
Liquid Temperature (T_L)	183 °C	217 °C
Time above Liquidus (t_L)	60 s ~ 90 s	30 s ~ 90 s
Peak Temperature (T_p)	220 °C ~ 235 °C	230 °C ~ 250 °C
Average Descend Rate (T_p to T_{\max})	Max. 6 °C/s	Max. 6 °C/s
Time from 25 °C to Peak Temperature (t_2)	Max. 6 minutes	Max. 8 minutes
Time of Soldering Zone (t_p)	20±10 s	20±10 s

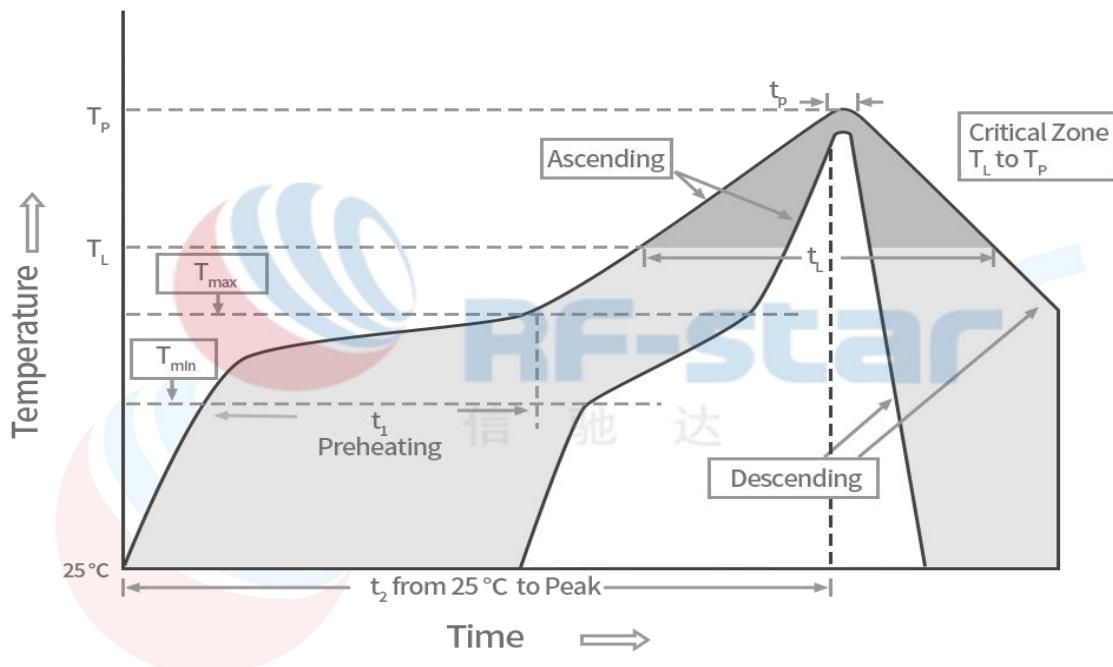


Figure 9. Recommended Reflow for Lead-Free Solder

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.

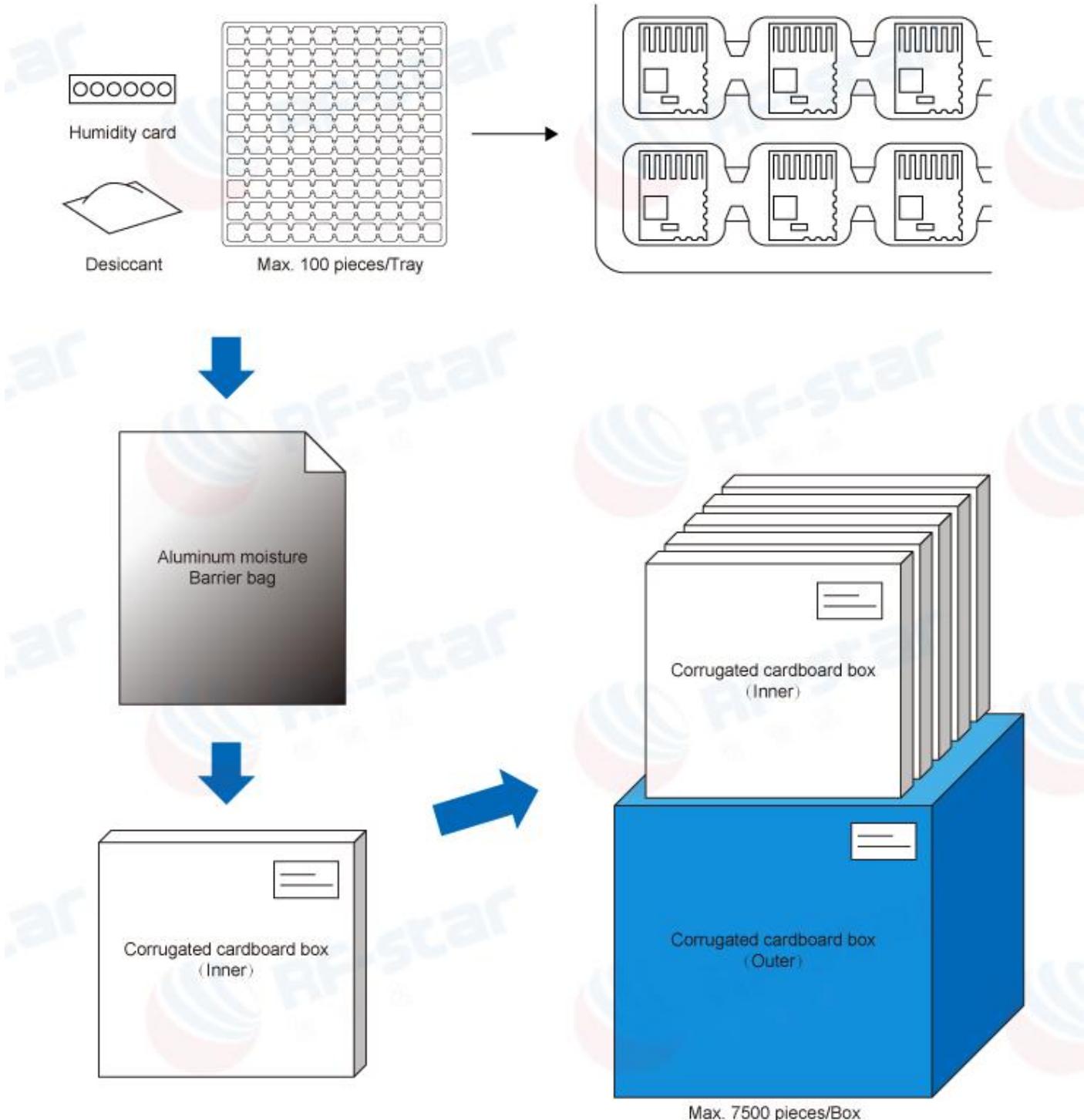


Figure 10. Default Package by Tray

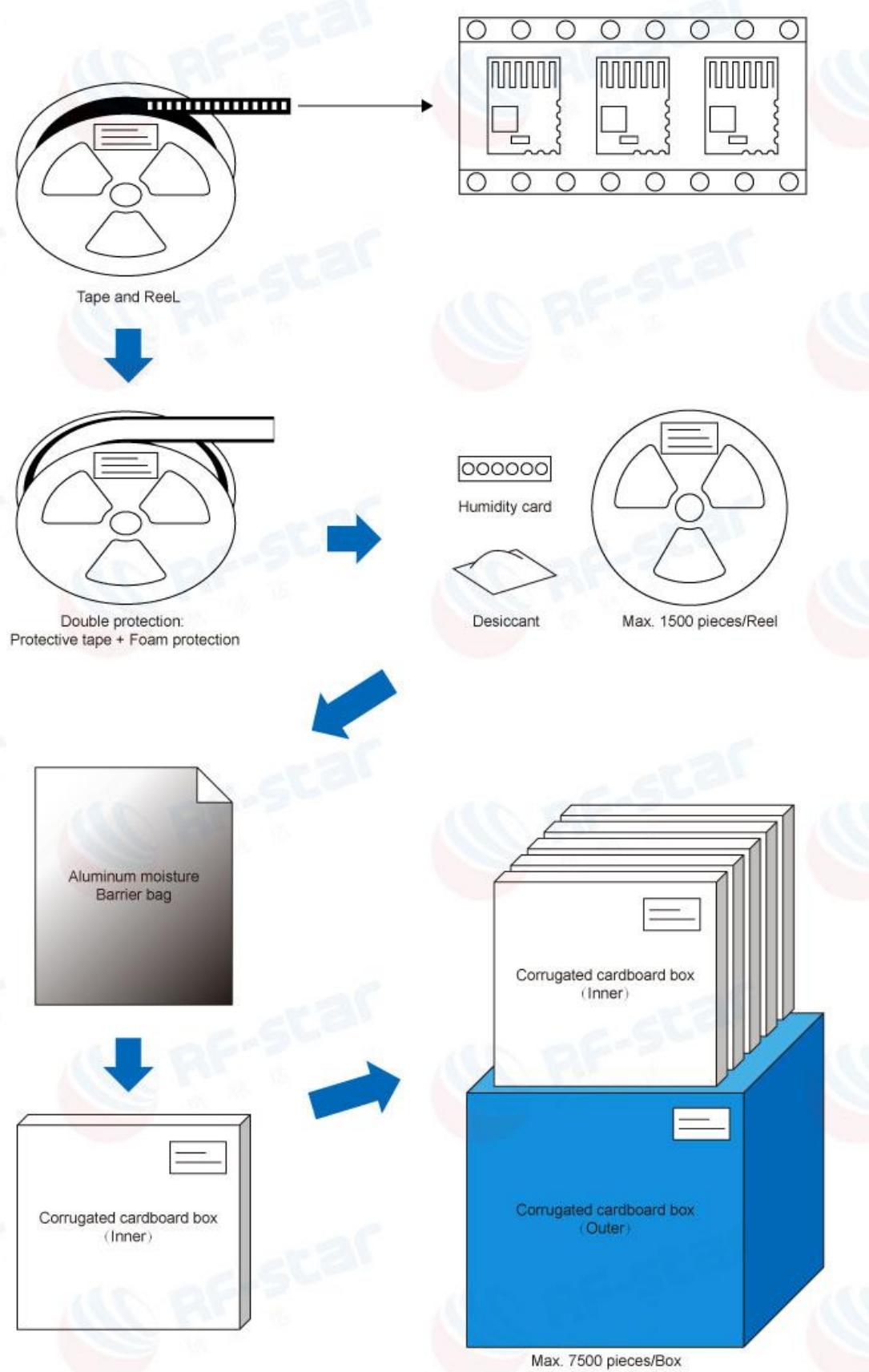


Figure 11. Package by Tape & Reel

6 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 ID: 2BMN5BTM1

6.2 IC and HVIN

IC:33343-BTM1

HVIN: RF-BM-S01A

6.3 Statement for FCC & IC

FCC regulatory compliance statement

§15.19 Statement

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.

§15.21 Information to user

Warning: changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

- List of applicable FCC rules:

47 CFR Part 15.247

- List of applicable IC rules:

RSS-247

- Summarize the specific operational use conditions

This module can be used in IOT devices, the input voltage to the module is nominally 3.3V.

- Limited module procedures

This module is a single module.

- Trace antenna designs

The antenna is not a trace antenna.

- RF exposure considerations

This Module complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with a minimum distance of 20cm between the radiator and your body. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

- Antennas

If you desire to increase antenna gain and either change antenna type or use same antenna type certified, a Class II permissive change application is required to be filed by us, or you (host manufacturer) can take responsibility through the change in FCC ID (new application) procedure followed by a Class II permissive change application.

- Label and compliance information

Please notice that if the FCC identification number is not visible when the module is installed inside another device, then the outside of the device into which the module is installed must also display a label referring to the enclosed module. This exterior label can use wording such as the following: "Contains FCC ID: 2BMN5BTM1" any similar wording that expresses the same meaning may be used.

§ 15.19 Labelling requirements shall be complied on end user device.

Labelling rules for special device, please refer to §2.925, § 15.19 (a)(5) and relevant KDB publications. For E-label, please refer to §2.935.

- Information on test modes and additional testing requirements

The OEM integrator is responsible for ensuring that the end-user has no manual instruction to remove or install module.

The module is limited to installation in mobile application, a separate approval is required for all other operating configurations, including portable configurations with respect to §2.1093 and difference antenna configurations.

- FCC other Parts, Part 15B Compliance Requirements for Host product manufacturer

This modular transmitter is only FCC authorized for the specific rule parts listed on our grant, host product manufacturer is responsible for compliance to any other FCC rules that apply to the host not covered by the modular transmitter grant of certification.

Host manufacturer in any case shall ensure host product which is installed and operating with the module is in compliant with Part 15B requirements.

Please note that For a Class B or Class A digital device or peripheral, the instructions furnished the user manual of the end-user product shall include statement set out in §15.105 Information to the user or such similar statement and place it in a prominent location in the text of host product manual. Original texts as following:

For Class B

Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This

equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.*
- Increase the separation between the equipment and receiver.*
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.*
- Consult the dealer or an experienced radio/TV technician for help.*

ISED Compliance Statements

This device contains licence-exempt transmitter(s)/receiver(s) that comply with Innovation, Science and Economic Development Canada's licence-exempt RSS(s). Operation is subject to the following two conditions:

- (1) This device may not cause interference.
- (2) This device must accept any interference, including interference that may cause undesired operation of the device.

L'émetteur/récepteur exempt de licence contenu dans le présent appareil est conforme aux CNR d'Innovation, Sciences et Développement économique Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes:

- (1) L'appareil ne doit pas produire de brouillage;
- (2) L'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Please notice that if the IC identification number is not visible when the module is installed inside another device, then the outside of the device into which the module is installed must also display a label referring to the enclosed module. This exterior label can use wording such as the following: "Contains IC: 33343-BTM1" any similar wording that expresses the same meaning may be used.

L'étiquette d'homologation d'un module d'Innovation, Sciences et Développement économique Canada devra être posée sur le produit hôte à un endroit bien en vue, en tout temps. En l'absence d'étiquette, le produit hôte doit porter une étiquette sur laquelle figure le numéro d'homologation du module d'Innovation, Sciences et Développement économique Canada, précédé du mot « contient », ou d'une formulation similaire allant dans le même sens et qui va comme suit: Contient IC: 33343-BTM1 est le numéro d'homologation du module.

RF Exposure Compliance

This equipment complies with FCC/IC RSS-102 radiation exposure limits set forth for an uncontrolled environment. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter. This equipment should be installed and operated with minimum distance 20cm between the radiator and your body.

Cet équipement est conforme aux limites d'exposition aux radiations IC CNR-102 établies pour un environnement non contrôlé. Cet émetteur ne doit pas être colocalisé ou fonctionner en conjonction avec une autre antenne ou un autre émetteur. Cet équipement doit être installé et utilisé avec une distance minimale de 20cm entre le radiateur et votre corps.

7 Revision History

Date	Version No.	Description
2018.01.23	V1.0	The initial version is released.
2018.02.07	V1.0	Update module picture.
2018.02.26	V1.0	Update module operating and storage temperature range.

2018.08.02	V1.0	Update company address.
2023.05.26	V1.0	Update MSL level. Update the Shenzhen office address.
2024.12.30	V1.0	Updated the certificate

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

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