RF-TI1352B1 CC1352R SimpleLink^{TM} High-Performance Sub-1G + 2.4 G Dual-band Module

Version 1.0

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1 Device Overview

1.1 Description

RF-TI1352B1 is an RF module based on TI lower-power SoC CC1352R. It integrates a 48 MHz and a 32.768 kHz crystal, a 256 kB ROM, a 352 kB Flash, and two IPEXs to guarantee the external antenna connection. Its ARM® Cortex®-M4F core application processor can operate at extremely low current at flexible power modes. It features small size, robust connection distance, and rigid reliability. It supports Sub GHz and 2.4 GHz multi-protocol and can be preprogrammed with a serial interface communication protocol for Thread, ZigBee, BLE5.2 and TI 15.4-Stack (Sub 1GHz). 1.27-mm pitch stamp stick package for easy assembling and cost-effective PCB design.

1.2 Key Features

- RF Section
  - Bluetooth 5.2 Low Energy
  - ZigBee, Thread
  - IEEE 802.15.4
  - IPv6-nabld smart objects (6LoWPAN)
  - MIOTY®
  - Wireless M-Bus
  - Wi-SUN®
  - KNX RF
  - Amazon Sidewalk
  - Proprietary systems
  - SimpleLink™ TI 15.4-Stack (Sub-1 GHz)
  - Dynamic Multiprotocol Manager (DDM) driver
- TX power:
  - Up to +5 dBm (2.4 GHz) with temperature compensation
  - Up to +14 dBm (Sub-1 GHz) with temperature compensation
- Excellent receiver sensitivity
  - -121 dBm @ Sub-1 GHz (SimpleLink Long-range Mode)
  - -110 dBm @ Sub-1 GHz (50 kbps)
  - -105 dBm for Bluetooth 125 kbps (LE coded PHY)

- 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
  - 2-pin cJTAG and JTAG debugging
  - Supports OTA upgrade
- Memory
  - 352 kB of in-system programmable flash
  - 256 kB of ROM for protocols and library functions
  - 8 kB of Cache SRAM
  - 80 kB of ultra-low leakage SRAM
- Ultra-low power sensor controller with 4KB of SRAM
  - Sample, store, and process sensor data
  - Operation independent from system CPU
  - Fast wake-up for low-power operation
- Rich Peripherals
  - 28 GPIOs, digital peripherals 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, MICROWIRE, TI)

- I²C

- I²S

- 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

- TCXO support

• Dimension: 26.5 mm × 16.8 mm × 2.2 mm

1.3 Applications

• Home automation

• Smart plug and metering

• Home appliances

• Sensor nodes

• Security systems

• Industrial control

• Wearables

• Building automation

• Sensor networks

• Medical devices

• Gaming controller
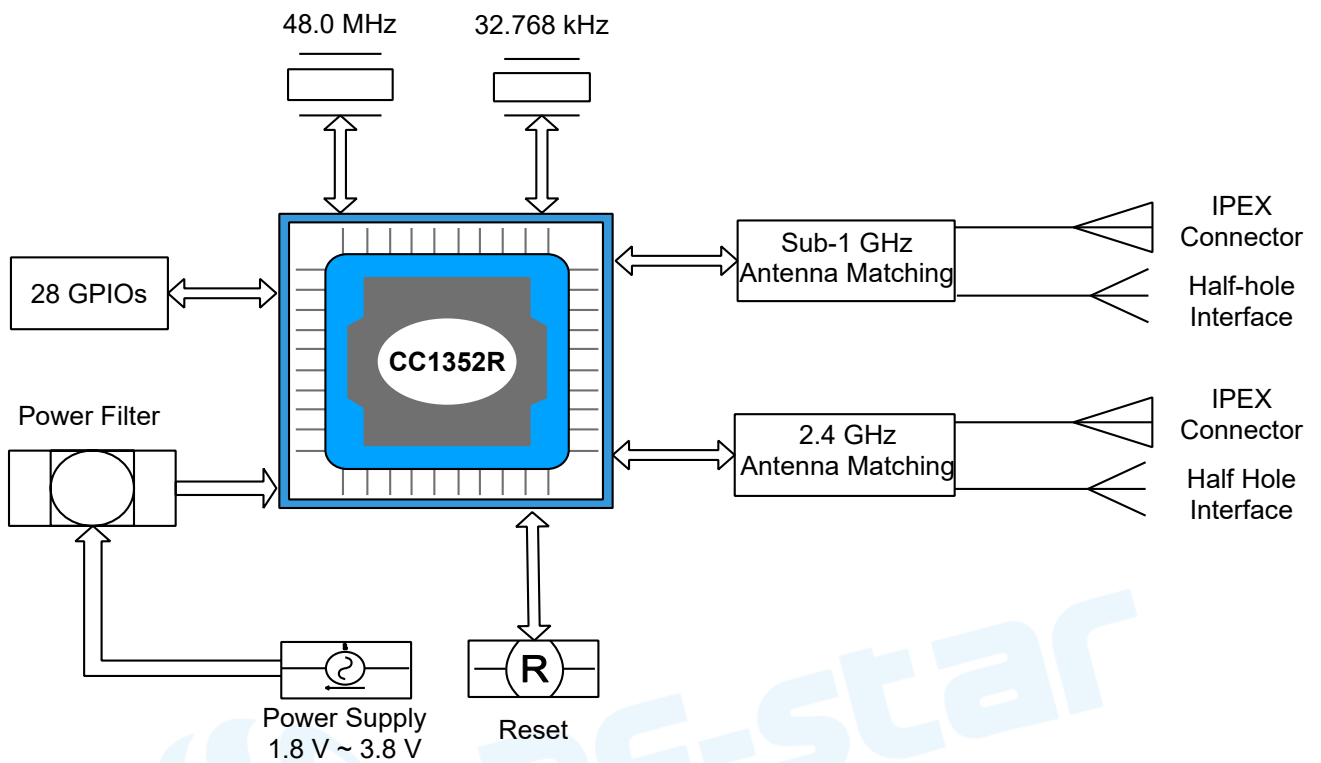
• Remote controls

1.4 Functional Block Diagram

Figure 1. Functional Block Diagram of RF-TI1352B1

1.5 Part Number Conventions

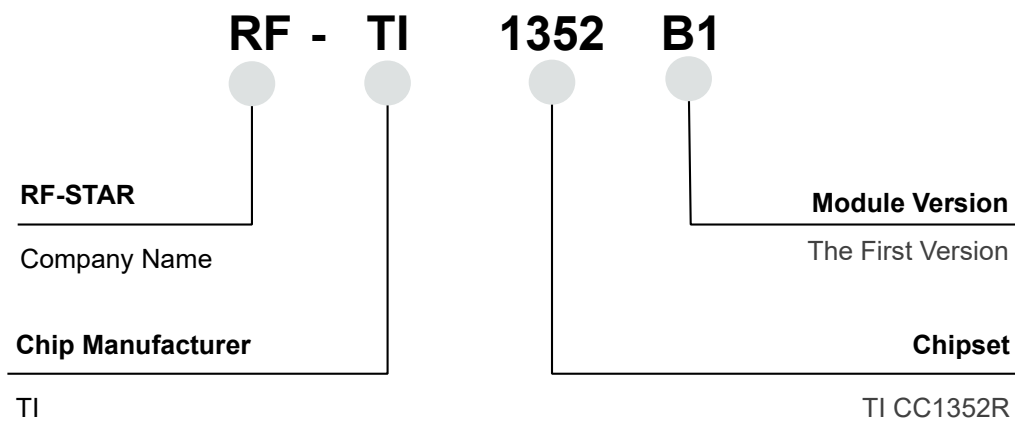The part numbers are of the form of RF-TI1352B1 where the fields are defined as follows:

Figure 2. Part Number Conventions of RF-TI1352B1

Table of Contents

2 Module Configuration and Functions

2.1 Module Parameters

Table 1. Parameters of RF-TI1352B1

Chipset	CC1352R
Supply Power Voltage	1.8 V ~ 3.8 V, 3.3 V is recommended
Frequency	Sub-1 GHz: 868 MHz ~ 928 MHz 2.4 GHz: 2402 MHz ~ 2480 MHz
Maximum Transmit Power	+14.0 dBm @ Sub-1 GHz +5.0 dBm @ 2.4 GHz
Receiving Sensitivity	-121 dBm @ Sub-1 GHz (Long-range Mode) -110 dBm @ Sub-1 GHz (50 kbps) -104 dBm @ Sub-1 GHz (100 kbps) -97 dBm @ Bluetooth 5.0 (1 Mbps) -92 dBm @ Bluetooth 5.0 (2 Mbps) -105 dBm @ Bluetooth 5.0 (125 kbps LE Coded PHY)
GPIO	28
Flash	352 kB
ROM	256 kB
SRAM	88 kB

Power Consumption	RX current: 5.8 mA @3.6 V, 868 MHz
	
	            6.9 mA @3.0 V, 2.4 GHz
	
	TX current: 8.0 mA @ 0 dBm, 3.6 V, 868 MHz
	
	         24.9 mA @ +14 dBm, 3.6 V, 868 MHz
	
	       7.1 mA @ 0 dBm, 3.0 V, 2.4 GHz
	MCU 48 MHz (CoreMark): 2.9 mA (60 µA/MHz)
	Sensor Controller: 30.1 µA @ low power mode, 2 MHz, running infinite loop
	
	       808 µA @ active mode, 24 MHz, running infinite loop
	
	Standby mode: 0.85 µA
	
	Sleep Mode: 150 nA

Support Protocol	Thread, Zigbee®, Bluetooth® 5.2 Low Energy, IEEE 802.15.4g, IPv6-enabled smart objects, (6LoWPAN), MIOTY®, Wireless M-Bus, Wi-SUN®, KNX RF, Amazon Sidewalk, proprietary systems, SimpleLink™ TI 15.4-Stack (Sub-1

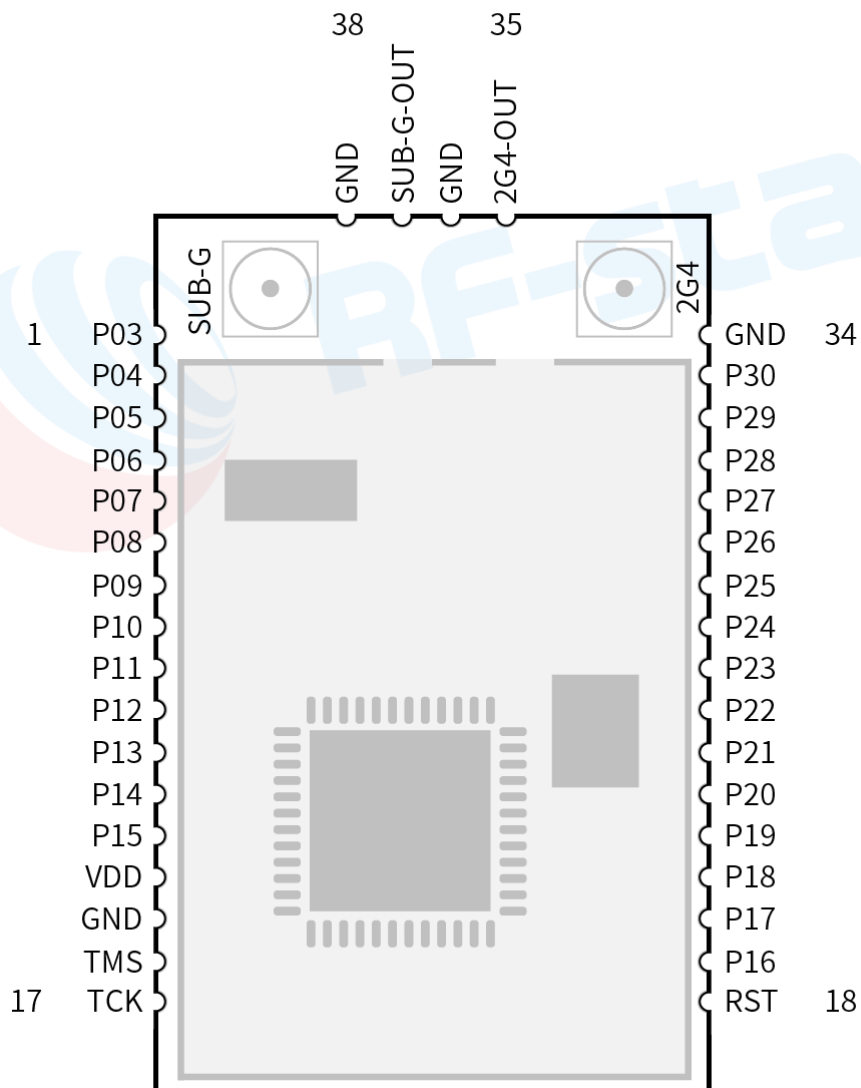|	GHz)
Crystal	48 MHz, 32.768 kHz
Package	SMT packaging (1.27-mm half-hole pitch stamp stick)
Dimension	26.5 mm × 16.8 mm × 2.2 mm
Type of Antenna	IPEX connector, half-hole ANT pin
Operating Temperature	-40 ℃ ~ +85 ℃
Storage Temperature	-40 ℃ ~ +125 ℃

2.2 Module Pin Diagram

Figure 3. Pin Diagram of RF-TI1352B1

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3.3 Pin Functions

Table 2. Pin Functions of RF-TI1352B1

Pin	Name	Chip Pin	Function	Description
1	P03	DIO_3	Digital	GPIO
2	P04	DIO_4	Digital	GPIO
3	P05	DIO_5	Digital	GPIO, high-drive capability
4	P06	DIO_6	Digital	GPIO, high-drive capability
5	P07	DIO_7	Digital	GPIO, high-drive capability
6	P08	DIO_8	Digital	GPIO
7	P09	DIO_9	Digital	GPIO
8	P10	DIO_10	Digital	GPIO
9	P11	DIO_11	Digital	GPIO
10	P12	DIO_12	Digital	GPIO
11	P13	DIO_13	Digital	GPIO
12	P14	DIO_14	Digital	GPIO
13	P15	DIO_15	Digital	GPIO
14	VDD	VDDS	VDD	Power Supply: 1.8 V ~ 3.8 V, recommend to 3.3 V
15	GND	GND	GND	Ground
16	TMS	JTAG_TMSC	Digital	JTAG TMSC, high-drive capability
17	TCK	JTAG_TCKC	Digital	JTAG TCKC
18	RST	RESET_N	Digital	Reset, active low. Internal pullup.
19	P16	DIO_16	Digital	GPIO, JTAG_TDO, high-drive capability
20	P17	DIO_17	Digital	GPIO, JTAG_TDI, high-drive capability
21	P18	DIO_18	Digital	GPIO
22	P19	DIO_19	Digital	GPIO
23	P20	DIO_20	Digital	GPIO
24	P21	DIO_21	Digital	GPIO
25	P22	DIO_22	Digital	GPIO

26	P23	DIO_23	Digital or Analog	GPIO, analog capability
27	P24	DIO_24	Digital or Analog	GPIO, analog capability
28	P25	DIO_25	Digital or Analog	GPIO, analog capability
29	P26	DIO_26	Digital or Analog	GPIO, analog capability
30	P27	DIO_27	Digital or Analog	GPIO, analog capability
31	P28	DIO_28	Digital or Analog	GPIO, analog capability
32	P29	DIO_29	Digital or Analog	GPIO, analog capability
33	P30	DIO_30	Digital or Analog	GPIO, analog capability
34	GND	GND	Ground	Ground
35	2G4-OUT		RF Out	2.4 GHz antenna pin out
36	GND	GND	Antenna Ground	Antenna Ground
37	SUB-OUT		RF Out	Sub 1GHz antenna pin out
38	GND	GND	Ground	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-TI1352B1

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-TI1352B1

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

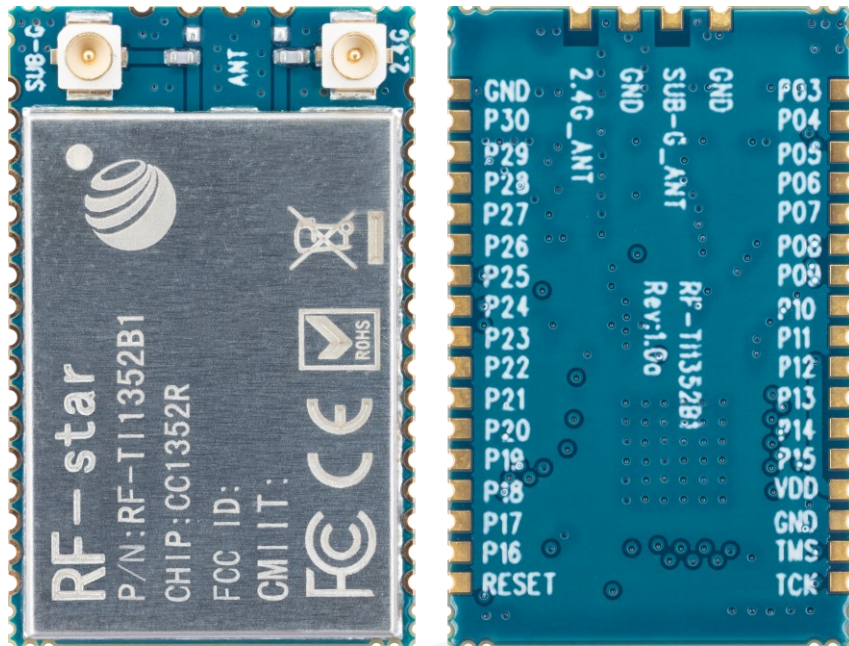# 4 Application, Implementation, and Layout

4.1 Module Photos

Figure 4. Photos of RF-TI1352B1

4.2 Recommended PCB Footprint

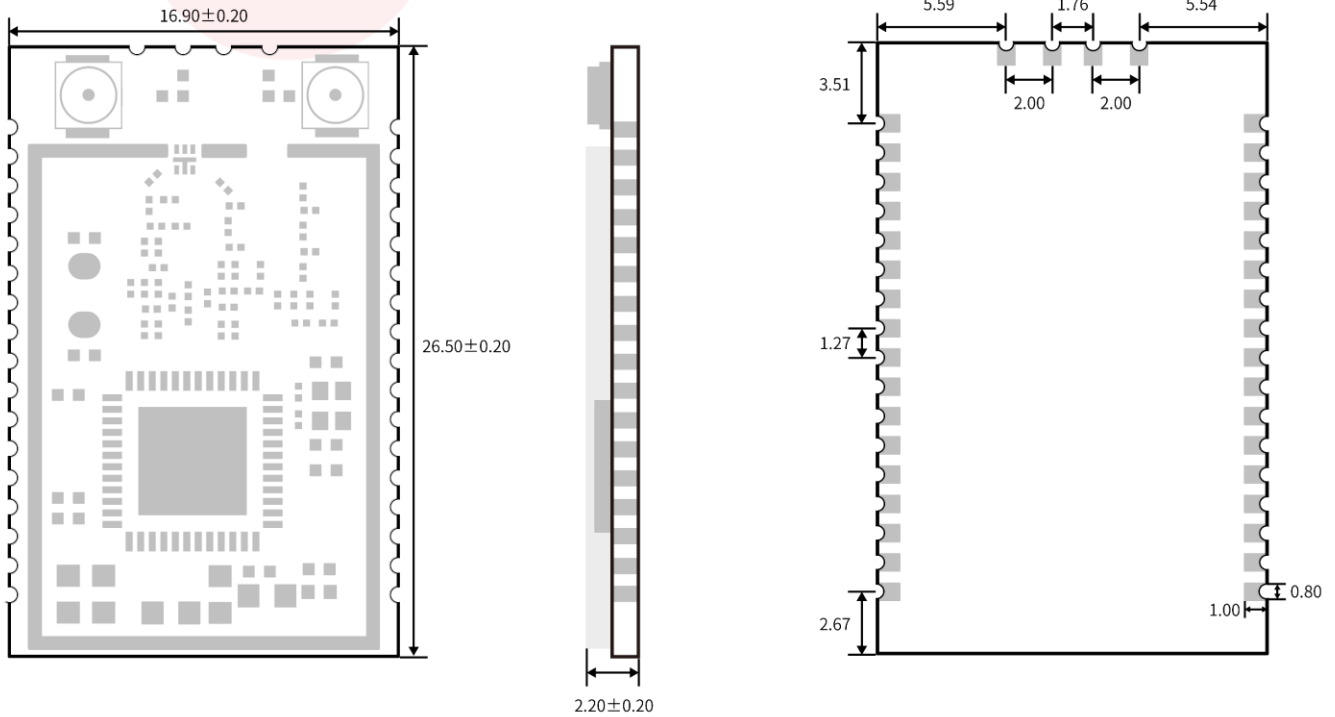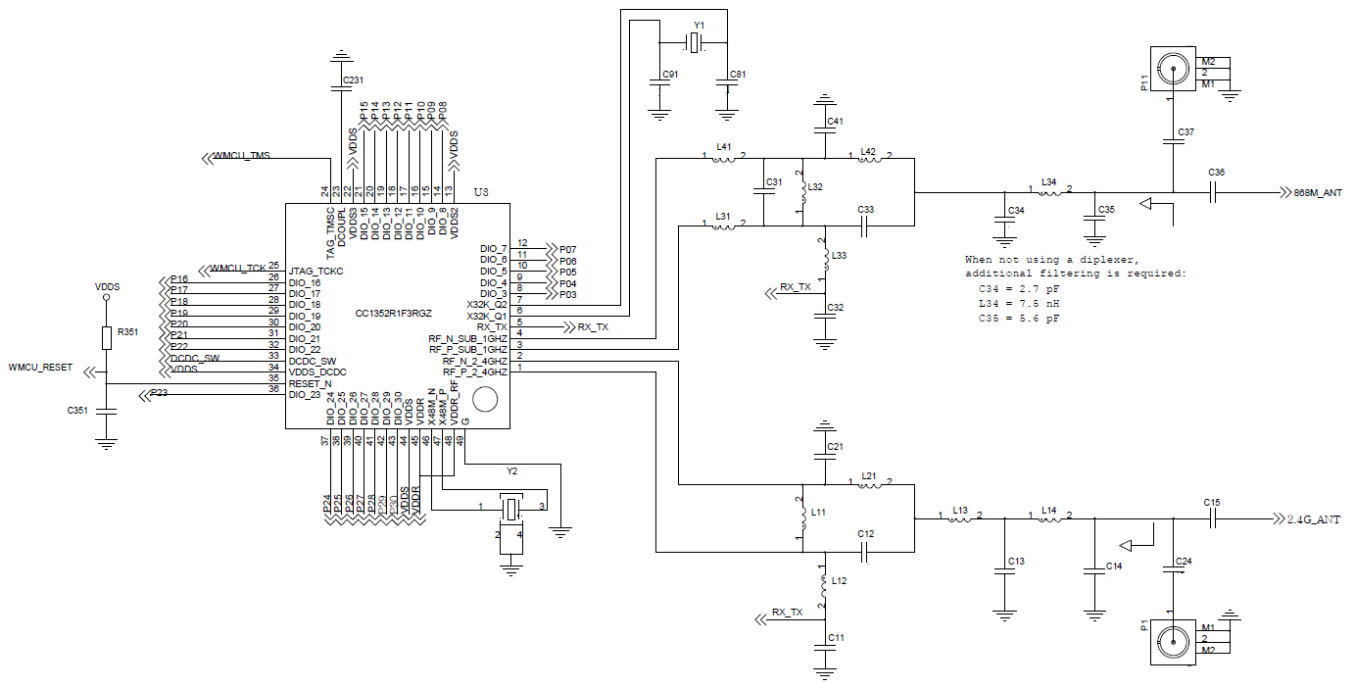Figure 5. Recommended PCB Footprint of RF-TI1352B1

4.3 Schematic Diagram

Figure 6. Schematic Diagram of RF-TI1352B1
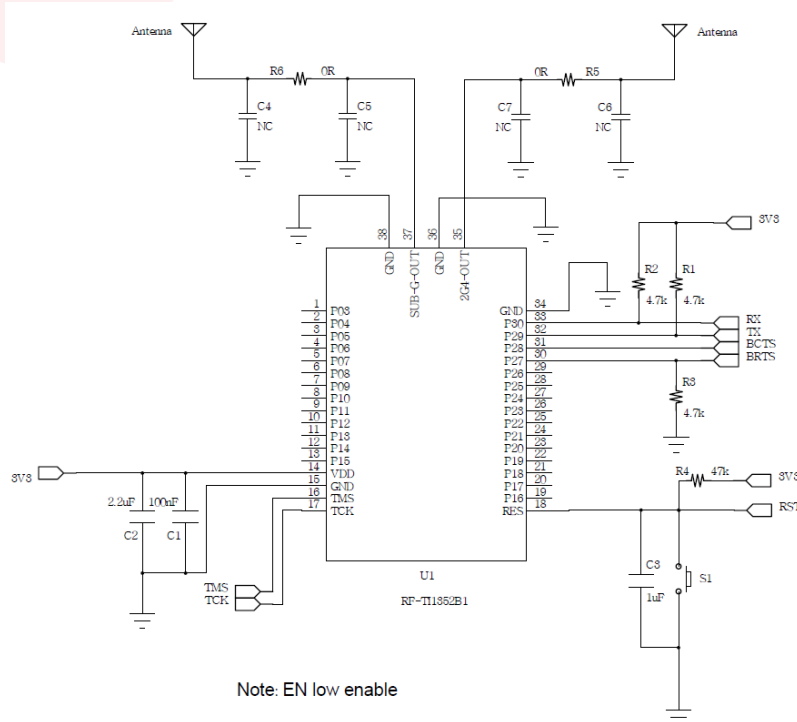
4.4 Reference Design

Note: EN low enable

Figure 7. Reference Design of RF-TI1352B1

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 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.
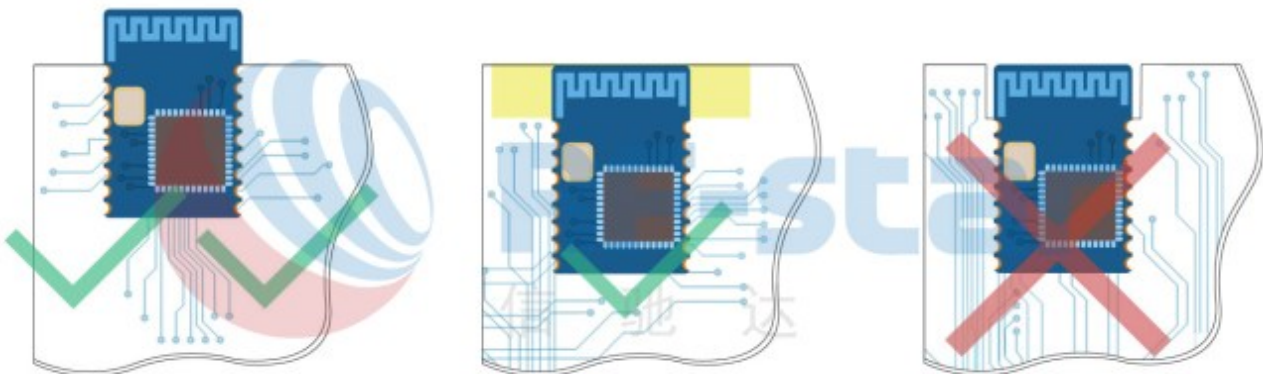

Figure 8. Recommendation of Antenna Layout

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

4.5.2 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.
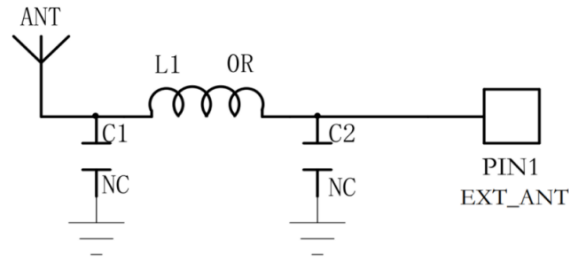
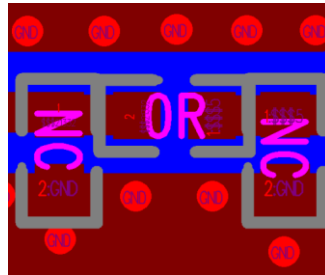Figure 9. Reference Design of the External Antenna

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.
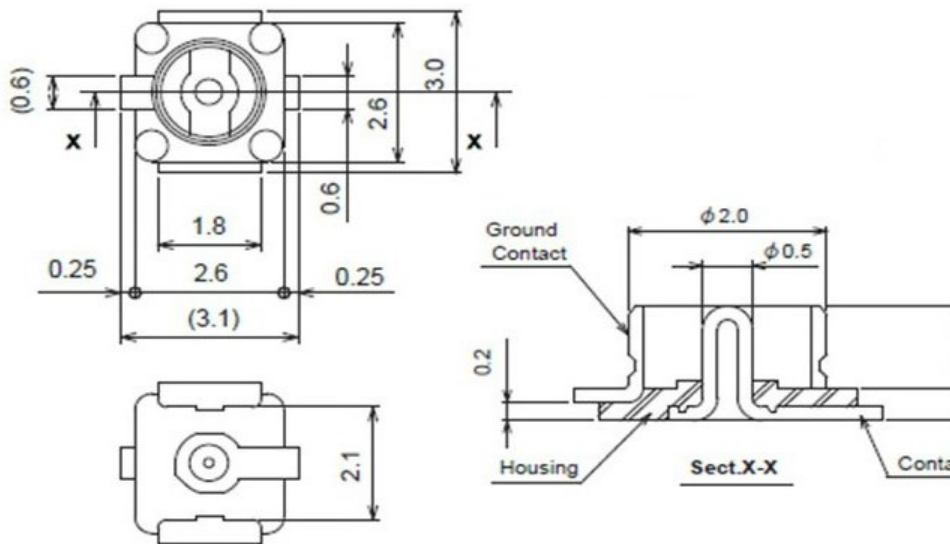

Figure 11. SI9000 Impedance Calculation Diagram

4.5.3 IPEX Connector Specification

RF-TI1352B1 module is integrated the IPEX version 1 antenna seat, the specification of the antenna seat is as follows:

Figure 12. Specification of Antenna Seat

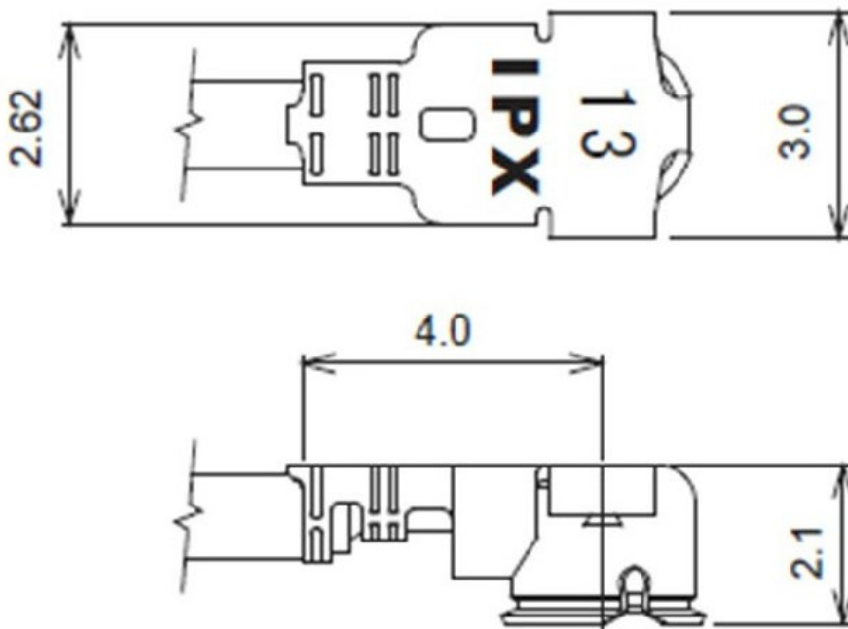The specification of the IPEX wire end is as follows:

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 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.

4.7.2 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 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.

4.7.3 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 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
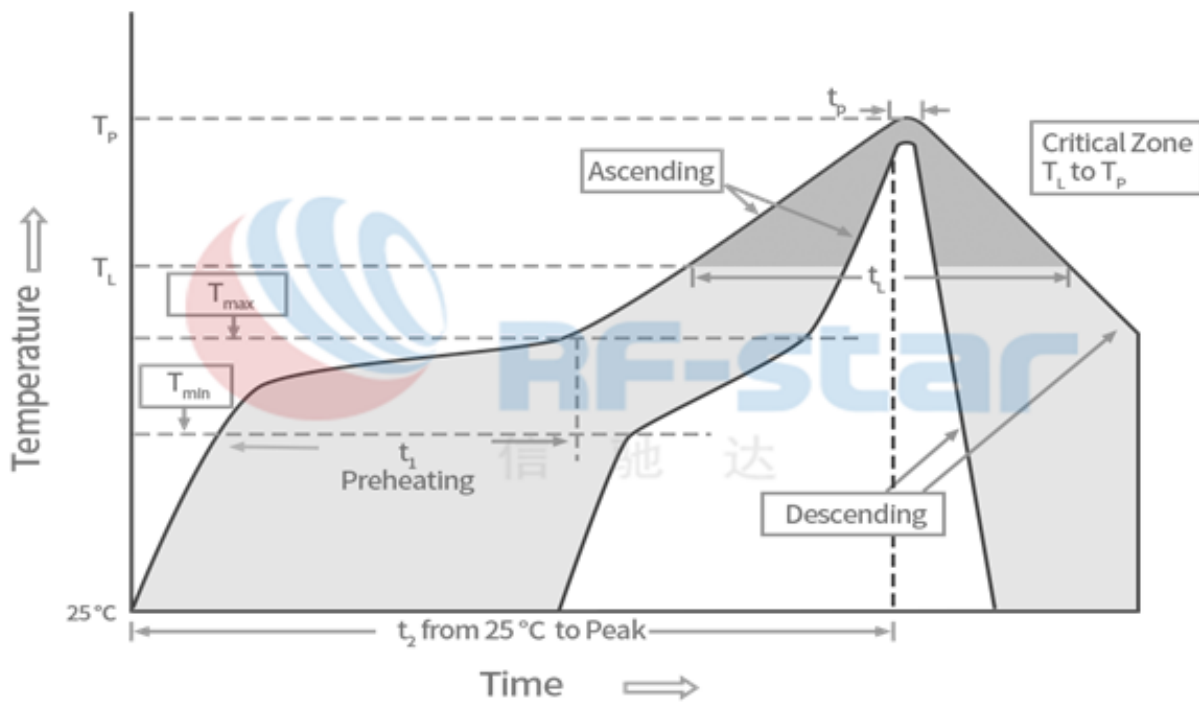
Figure 14. Recommended Reflow for Lead-Free Solder

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.
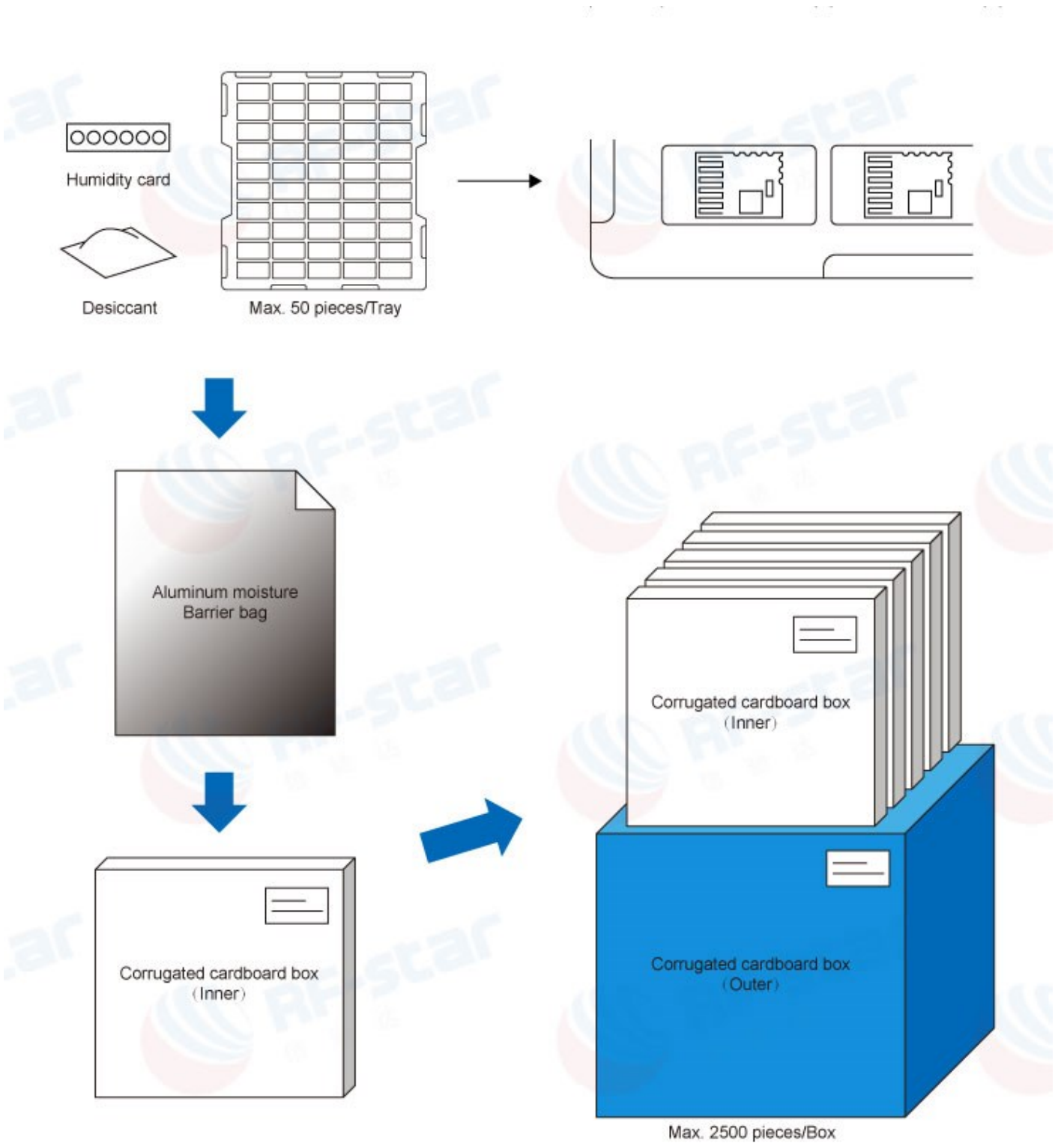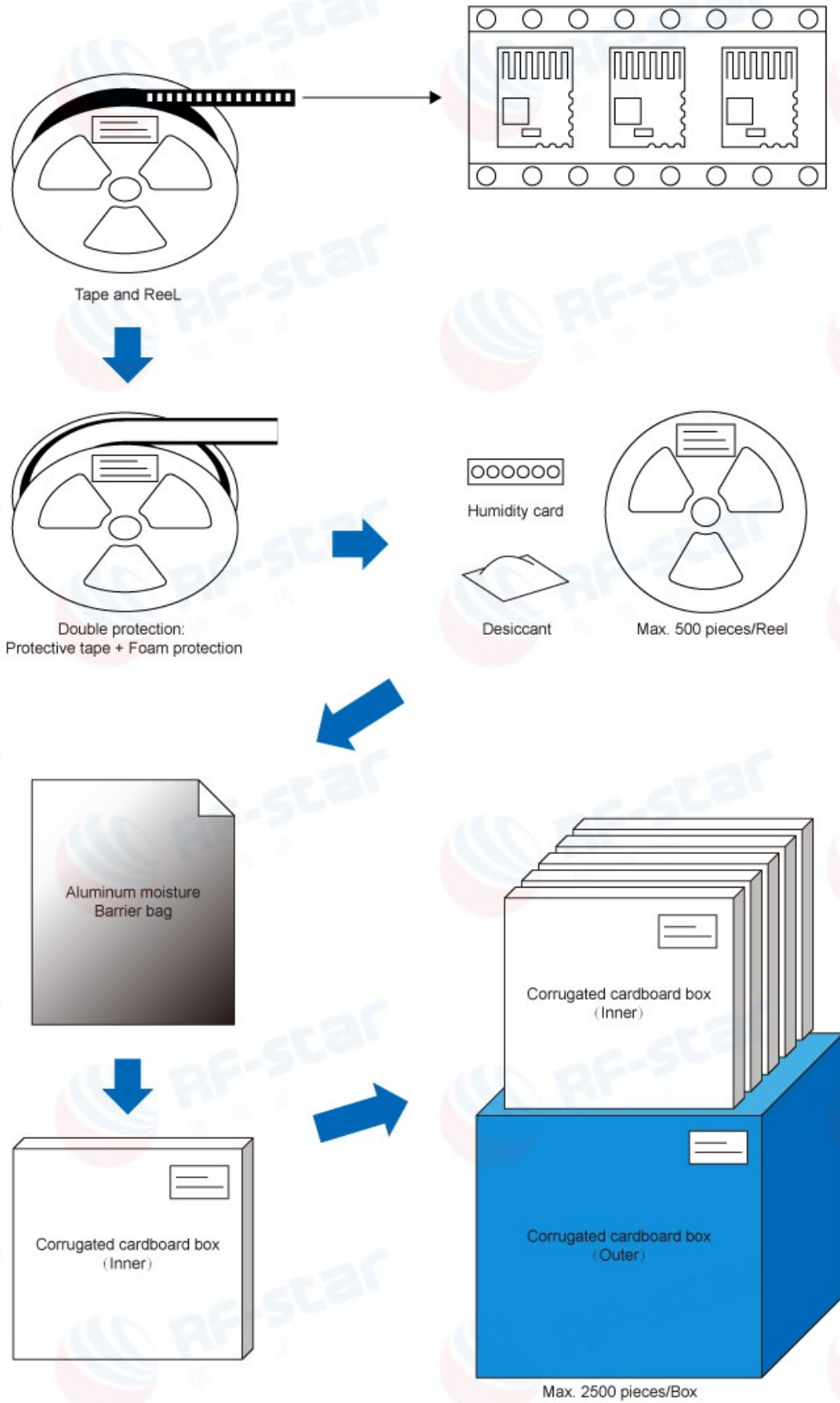

Figure 15. Default Package by Tray

Figure 16. Package by Tape & Reel

6 Revision History

Date	Version No.	Description
2019.06.24	V1.0	The Initial version is released.
2020.04.14	V1.0	Add antenna specification. Update module PCB Footprint diagram.
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.

7 Contact Us

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