RF-WM-20CMB1 RTL8720CM Ultra-Low-Power 2.4 GHz 802.11b/g/n WLAN Wi-Fi and BLE4.2 Module

Version 1.0

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1 Device Overview

1.1 Description

RF-WM-20CMB1 is an IoT wireless module based on Realtek Wi-Fi SoC RTL8720CM with Real-M300 (KM4) CPU. This module has on-chip 384 KB ROM, 256 KB RAM, 4 MB pSRAM and 2MB flash, a pin-out of peripherals of SDIO, SPI, UART, I²C, PWM, GDMA and GPIOs. It has integrated a 40 MHz crystal, three RF RF output modes (an onboard PCB antenna, an IPEX/U.FL connector and a half-hole interface) for wide coverage. It supports 2.4 GHz 802.11 b/g/n at 20 MHz channel bandwidth. The module supports STA, AP, and STA + AP concurrent modes, advanced security features include Wi-Fi WEP, WPA, WPA2, and WPS2 with MD5, SHA-1, SHA2-256, DES, 3DES, and AES security engines.

1.2 Key Features

- Wi-Fi Feature
  - 802.11b/g/n 1x1, 2.4 GHz
  - 802.11e QoS Enhancement (WMM)
  - 802.11i (WPA, WPA2). Open, shared key, and pair-wise key authentication services
  - Support low power TX/RX for short-range application
  - Support Wi-Fi WPS
  - Frame aggregation for increased MAC efficiency (A-MSDU, A-MPDU)
  - Low latency immediate High-Throughput Block Acknowledgement (HT-BA)
  - Long NAV for media reservation with CF-End for NAV release
  - Integrated balun, PA/LNA
- Bluetooth Low Energy
  - Bluetooth Low Energy (BLE4.2)
  - Support LE secure connections
  - Support LE scatternet
  - Support 1 Master/1Slave
- Memory
  - ROM: 384 KB
  - RAM: 256 KB
  - pSRAM: 4 MB
  - FLASH: 2 MB
- Secure
  - Secure boot
  - Wi-Fi WEP, WPA, WPA2, WPS
  - Crypto engine: MD5, SHA-1, SHA2-224, SHA2-256, HMAC, AES
- Peripheral interfaces
  - 3xUART, baud rate up to 4 MHz and all of them can configurable as log UART
  - 1xI2C, Max clock 400 Kbps
  - 1xSDIO 2.0 Device, up to 50 MHz
  - 1xSPI, Master clock up to 25 Mbps/Slave clock up to 5 Mbps
  - 8xPWM with configurable duration and duty cycle from 0 ~ 100%
  - 16xprogrammable GPIOs
  - 1 GDMA with 2 channels
- Dimension: 23 mm x 20 mm x 2.4 mm

1.3 Applications

- Cloud connectivity
- Home automation
- Home appliances
- Access control
- Security systems
- Smart energy

- Internet gateway
- Industrial control
- Smart plug
- Smart metering
- Wireless audio
- IP network sensor nodes

1.4 Functional Block Diagram

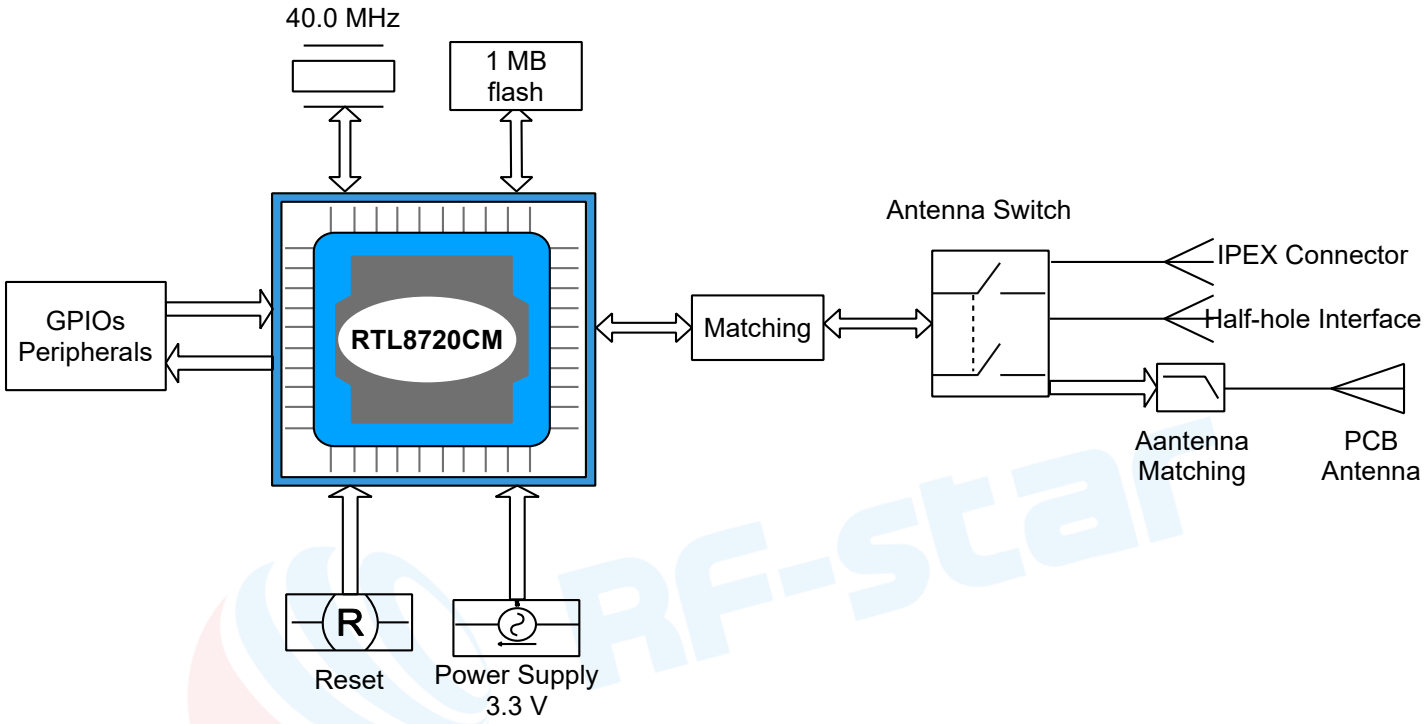

Figure 1. Functional Block Diagram of RF-WM-20CMB1

1.5 Part Number Conventions

The part numbers are of the form of RF-WM-20CMB1 where the fields are defined as follows:

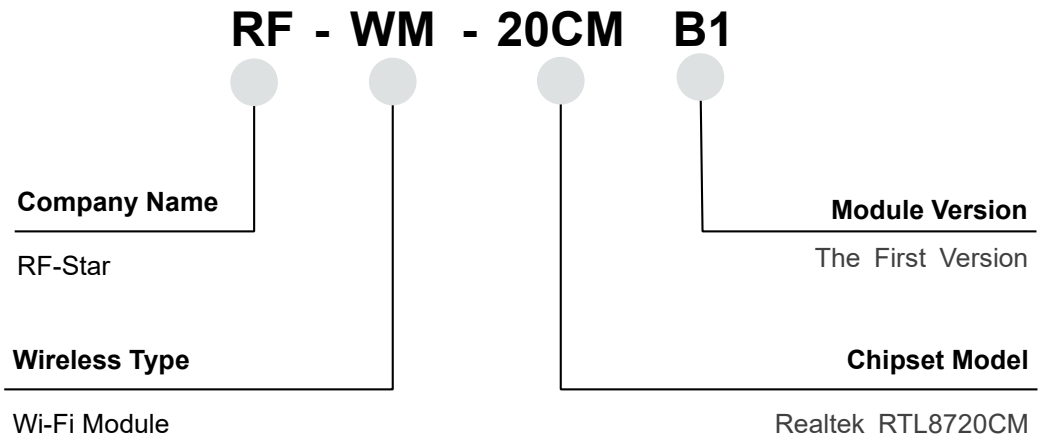

Figure 2. Part Number Conventions of RF-WM-20CMB1

Table of Contents

2 Module Configuration and Functions

2.1 Module Parameters

Table 1. Parameters of RF-WM-20CMB1

Chipset	Realtek RTL8720CM
Supply Power Voltage	2.3 V ~ 3.6 V, recommended to 3.3 V
Frequency	Wi-Fi: 2400 MHz ~ 2500 MHz BLE: 2402 MHz ~ 2480 MHz
TX power	Wi-Fi: 1 Mbps DSSS@802.11b: 21 dBm 11 Mbps DSSS@802.11b: 21 dBm 6 Mbps OFDM@802.11g: 19 dBm 54 Mbps OFDM@802.11g: 17 dBm HT20 MCS0@802.11n: 19 dBm HT20 MCS7@802.11n: 16 dBm BLE: 2.5 dBm ~ 6.5 dBm
RX Sensitivity	Wi-Fi: 1 Mbps DSSS@802.11b: -99.0 dBm 11 Mbps DSSS@802.11b: -901 dBm 6 Mbps OFDM@802.11g: -94.0 dBm 54 Mbps OFDM@802.11g: -76.5 dBm HT20 MCS0@802.11n: -93.5 dBm HT20 MCS7@802.11n: -74.0 dBm BLE: -100 dBm
Crystal	40 MHz
Package	SMT Packaging
Dimension	23.0 mm x 20.0 mm x 2.4 mm
Type of Antenna	PCB antenna / IPEX connector / Half-hole ANT interface
Operating Temperature	-20 ℃ ~ +85 ℃
Storage Temperature	-55 ℃ ~ +125 ℃

2.2 Module Pin Diagram

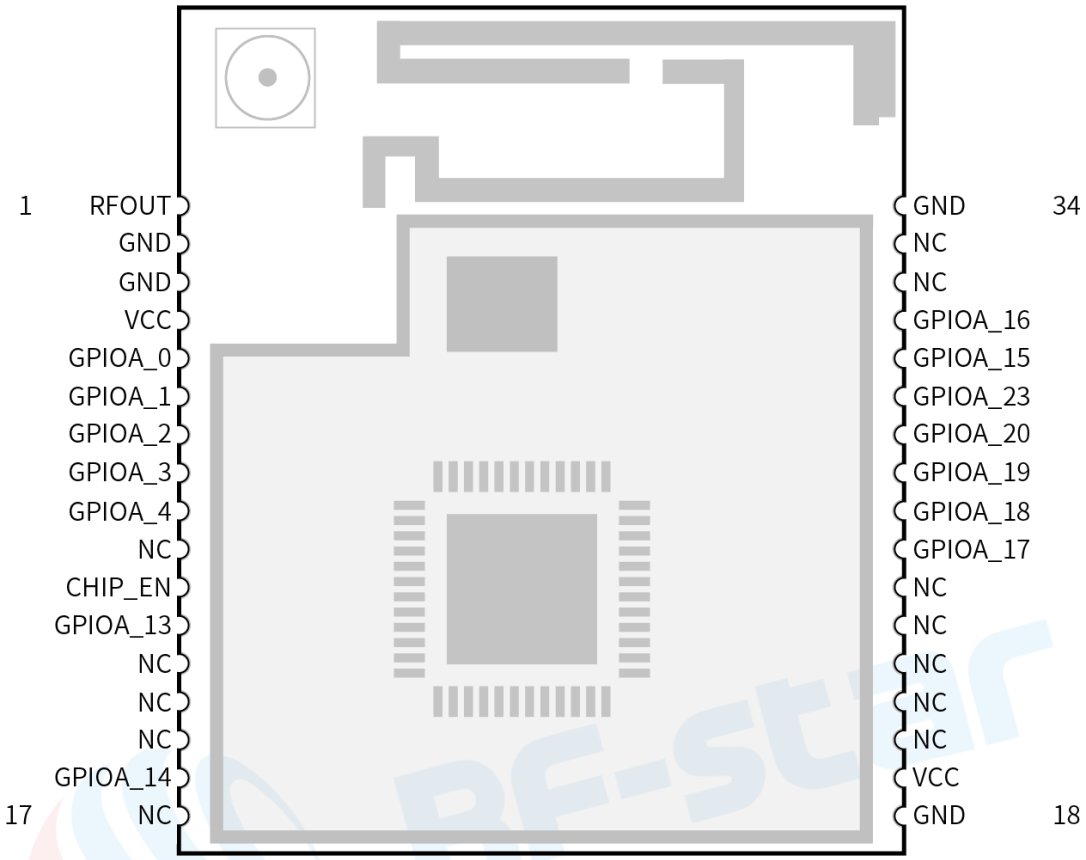

Figure 3. Pin Diagram of RF-WM-20CMB1

2.3 Pin Functions

Table 2. Pin Functions of RF-WM-20CMB1

Pin	Name	Description
1	RFOUT	RF signal output pin
2	GND	Ground
3	GND	Ground
4	VCC	3.3 V power supply
5	GPIOA_0	GPIO, JTAG CLK
6	GPIOA_1	GPIO, JTAG TMS
7	GPIOA_2	GPIO, JTAG TDO
8	GPIOA_3	GPIO, JTAG TDI
9	GPIOA_4	GPIO, JTAG TRST

10	NC	None connect
11	CHIP_EN	Chip EN pin can be as reset, for more details, pls refer to the minimum system
12	GPIOA_13	GPIO, UART RX
13	NC	None connect
14	NC	None connect
15	NC	None connect
16	GPIO_14	GPIO, UART TX
17	NC	None connect
18	GND	Ground
19	VCC	3.3 V power supply
20	NC	None connect
21	NC	None connect
22	NC	None connect
23	NC	None connect
24	NC	None connect
25	GPIOA_17	GPIO
26	GPIOA_18	GPIO
27	GPIOA_19	GPIO
28	GPIOA_20	GPIO
29	GPIOA_23	GPIO
30	GPIOA_15	GPIO, LOG UART RX
31	GPIOA_16	GPIO, LOG UART TX
32	NC	None connect
33	NC	None connect
34	GND	Ground

2.4 GPIO Pin Function

Table 3. GPIO Pin Function of RF-WM-20CMB1

Pin name	SPIC-Flash/SDIO	JTAG	UART	SPI/WL_LED	I2C	PWM
GPIOA_0		JTAG_CLK	UART1_IN			PWM[0]
GPIOA_1		JTAG_TMS	UART1_OUT	BT_LED		PWM[1]
GPIOA_2		JTAG_TDO	UART1_IN	SPI_CSn	I2C_SCL	PWM[2]
GPIOA_3		JTAG_TDI	UART1_OUT	SPI_SCL	I2C_SDA	PWM[3]
GPIOA_4		JTAG_TRST	UART1_CTS	SPI_MOSI		PWM[4]
GPIOA_7	SPI_M_CS			SPI_CSn		
GPIOA_8	SPI_M_CLK			SPI_SCL		
GPIOA_9	SPI_M_DATA[2]		UART0_RTS	SPI_MOSI		
GPIOA_10	SPI_M_ DATA[1]		UART0_CTS	SPI_MISO		
GPIOA_11	SPI_M_ DATA[0]		UART0_OUT		I2C_SCL	PWM[0]
GPIOA_12	SPI_M_ DATA[3]		UART0_IN		I2C_SDA	PWM[1]
GPIOA_13			UART0_IN			PWM[7]
GPIOA_14	SDIO_INT		UART0_OUT			PWM[2]
GPIOA_15	SD_D[2]		UART0_IN	SPI_CSn	I2C_SCL	PWM[3]
GPIOA_16	SD_D[3]		UART0_OUT	SPI_SCL	I2C_SDA	PWM[4]
GPIOA_17	SD_CMD					PWM[5]
GPIOA_18	SD_CLK		UART2_CTS			PWM[6]
GPIOA_19	SD_D[0]		UART2_RTS	SPI_MOSI	I2C_SCL	PWM[7]
GPIOA_20	SD_D[1]			SPI_MOSI	I2C_SDA	PWM[0]
GPIOA_23				LED_0		PWM[7]

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-WM-20CMB1

Items	Condition	Min.	Typ.	Max.	Unit
Operating Supply Voltage	Battery Mode	2.97	3.3	3.63	V
Operating Temperature	/	-20	+25	+85	℃
Environmental Hot Pendulum	/	-20		+20	℃/min

3.2 Handling Ratings

Table 5. Handling Ratings of RF-WM-20CMB1

Items	Condition	Min.	Typ.	Max.	Unit
Storage Temperature	Tstg	-55	+25	+125	℃
Human Body Model	HBM		4000		V
Moisture Sensitivity Level			3		
Charged Device Model			750		V

4 Application, Implementation, and Layout

4.1 Module Photos

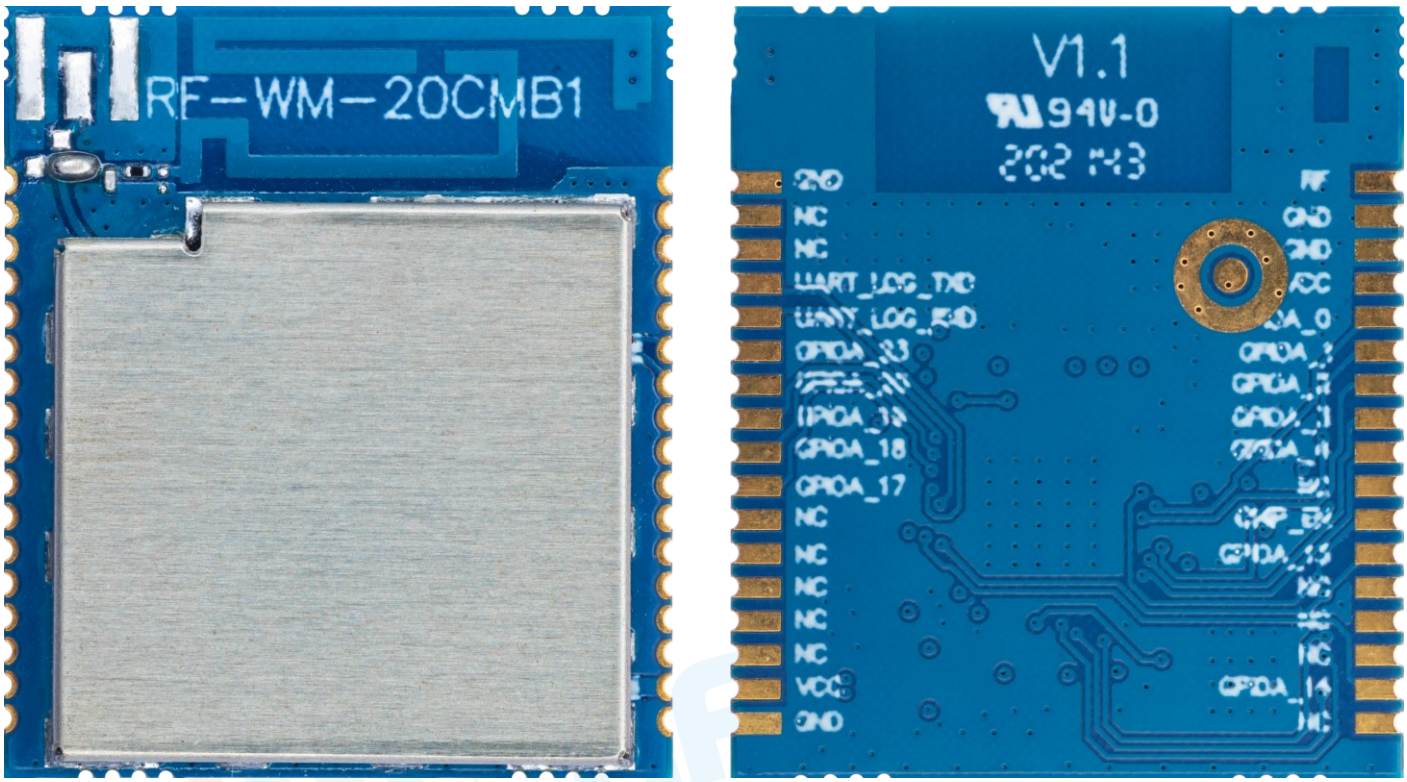

Figure 4. Photos of RF-WM-20CMB1

4.2 Recommended PCB Footprint

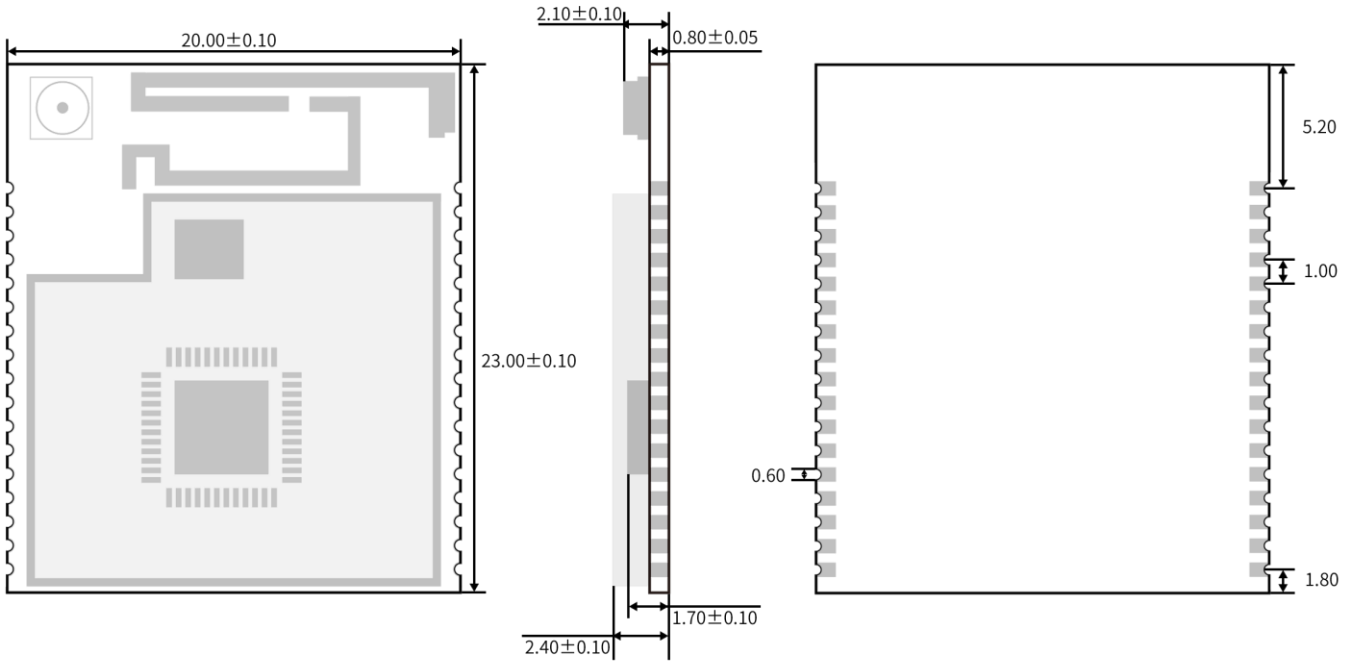

Figure 5. Recommended PCB Footprint of RF-WM-20CMB1 (mm)

4.3 Antenna

4.3.1 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.

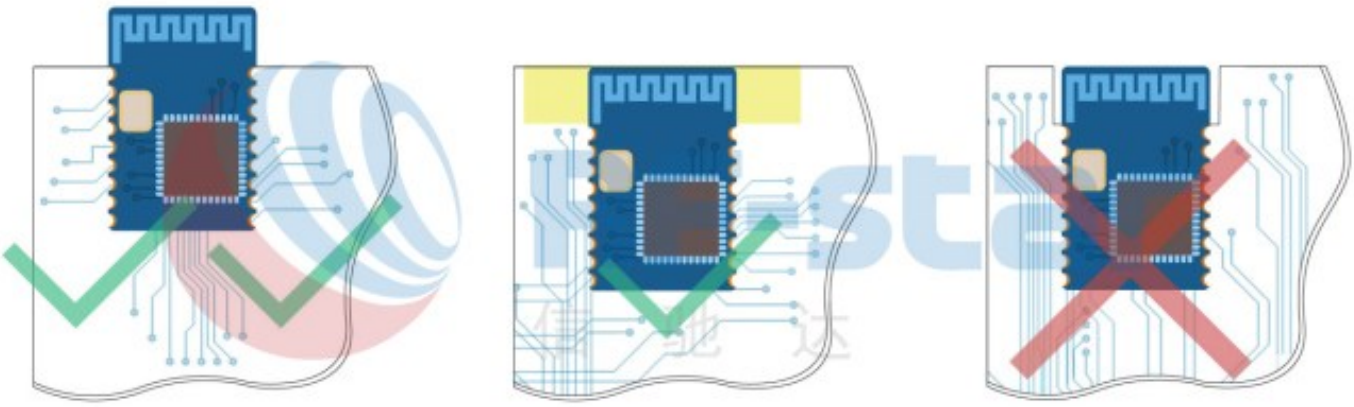

Figure 6. Recommendation of Antenna Layout

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

4.3.2 Antenna Output Mode Modification

1. RF-WM-20CMB1 has three antenna output modes. An onboard PCB antenna, a stamp half-hole output (ANT pin, see pin function table for details) and one IPEX connecter.

The default delivery is the ***onboard PCB antenna***. If you want to use the external antenna by the IPEX connector, pls solder a 0 R Resistor in the red rectangle. The location of the Resister is shown in the figure below.

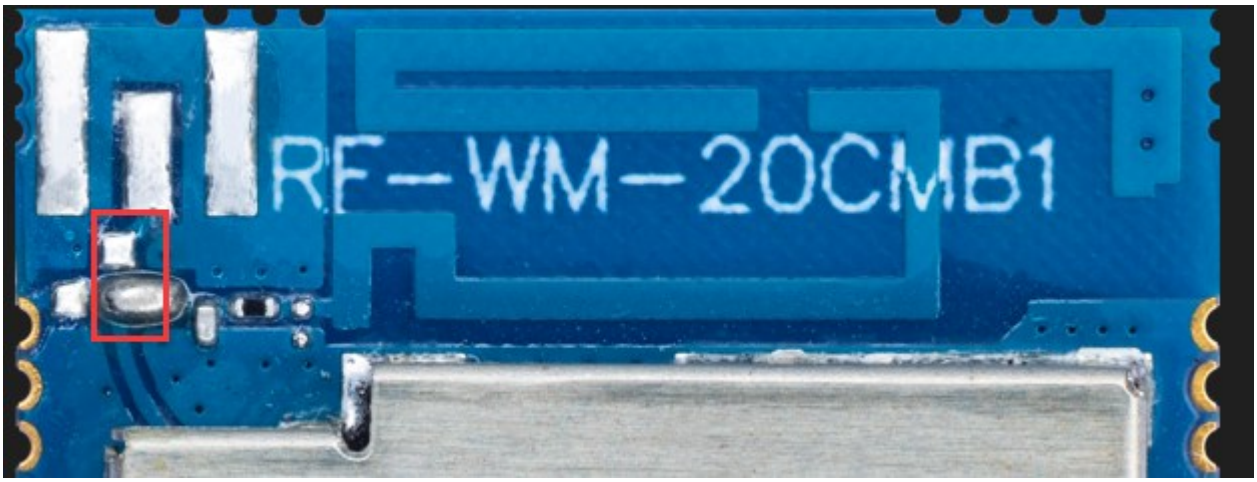

Figure 7. IPEX Antenna Output Mode of RF-WM-20CMB1

If you want to use the external antenna by the ANT pin, pls solder a 0 R Resistor in the red rectangle. The location of the Resister is shown in the figure below.

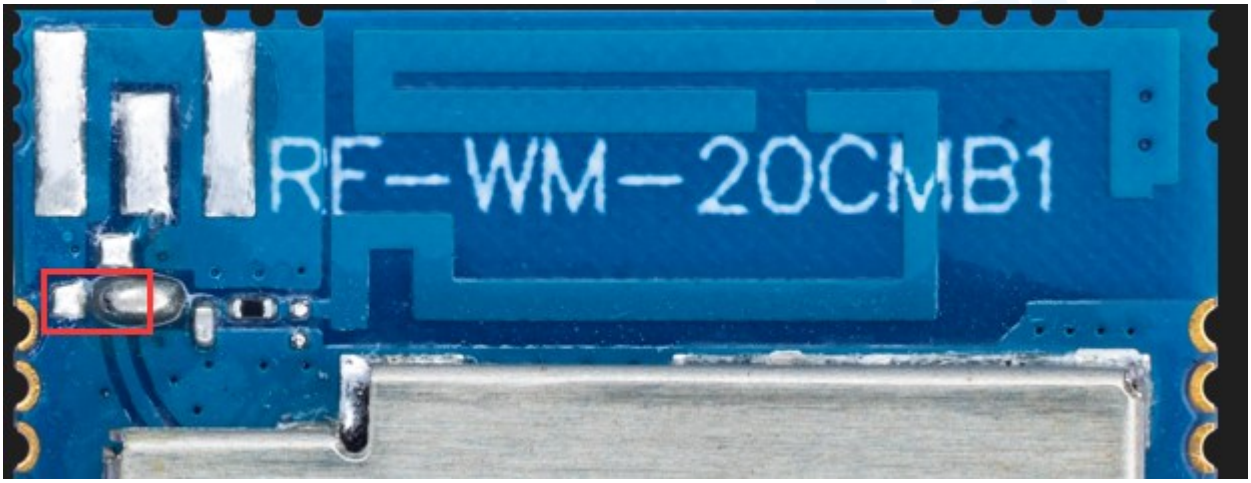

Figure 8. ANT Pin Antenna Output Mode of RF-WM-20CMB1

4.3.3 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.

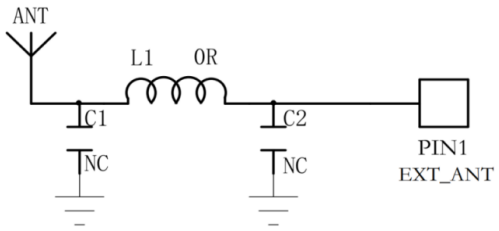

Figure 9. Reference Design of the External Antenna

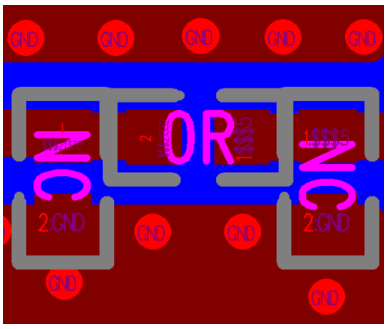

Figure 10. Reference Design of the External Antenna Traces

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.

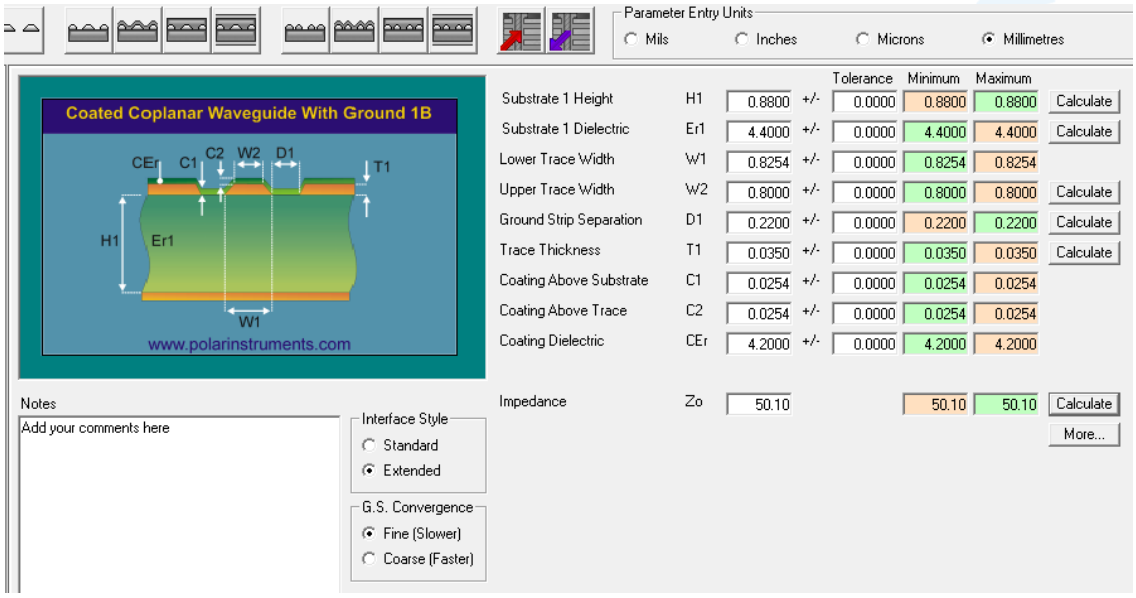

Figure 11. SI9000 Impedance Calculation Diagram

4.3.4 IPEX Connector Specification

RF-WM-20CMB1 module can be integrated with the IPEX version 1 antenna seat, the specification of the antenna seat is as follows:

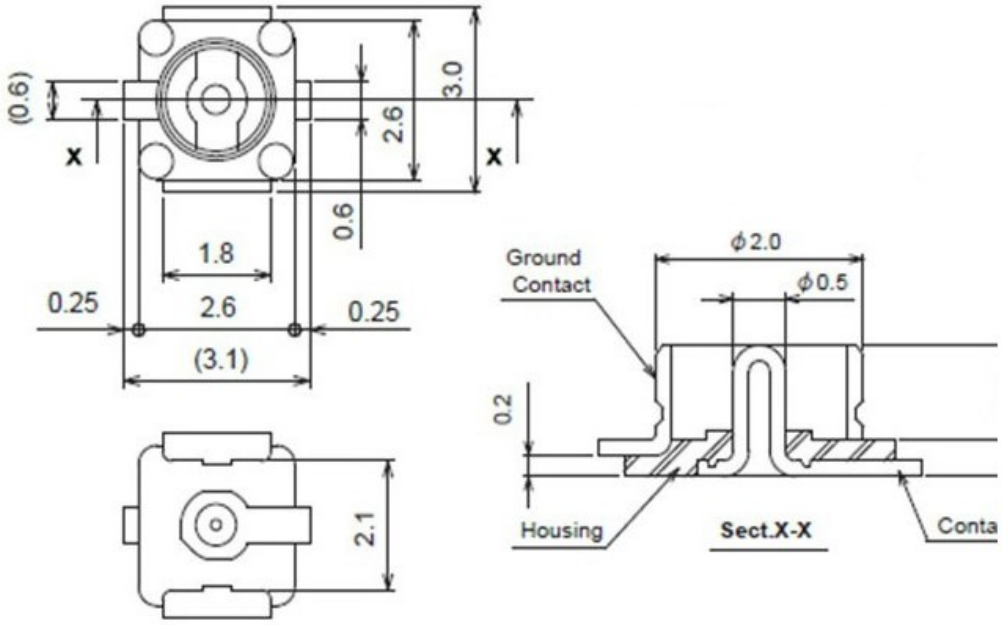

Figure 12. Specification of Antenna Seat

The specification of the IPEX wire end is as follows:

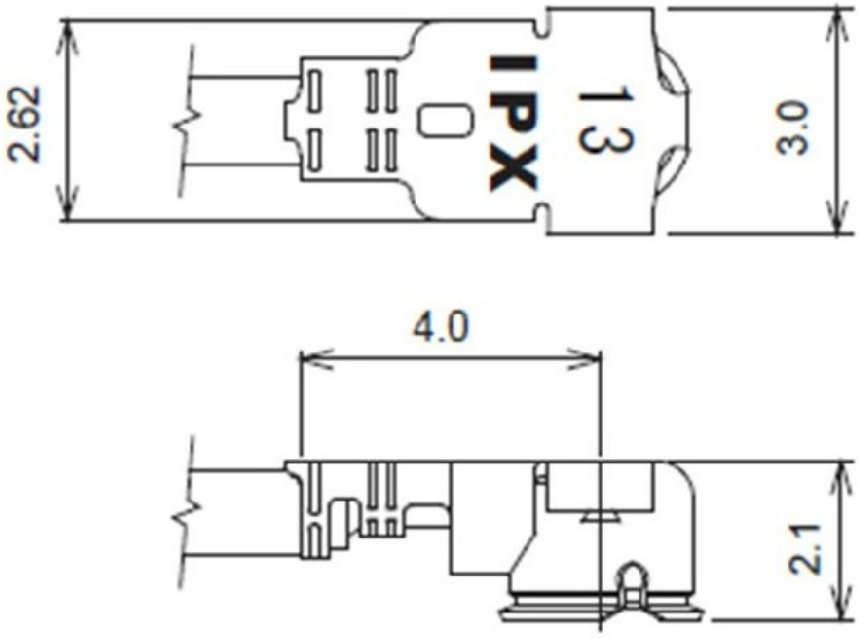

Figure 13. Specification of IPEX Wire

4.4 Schematic Diagram

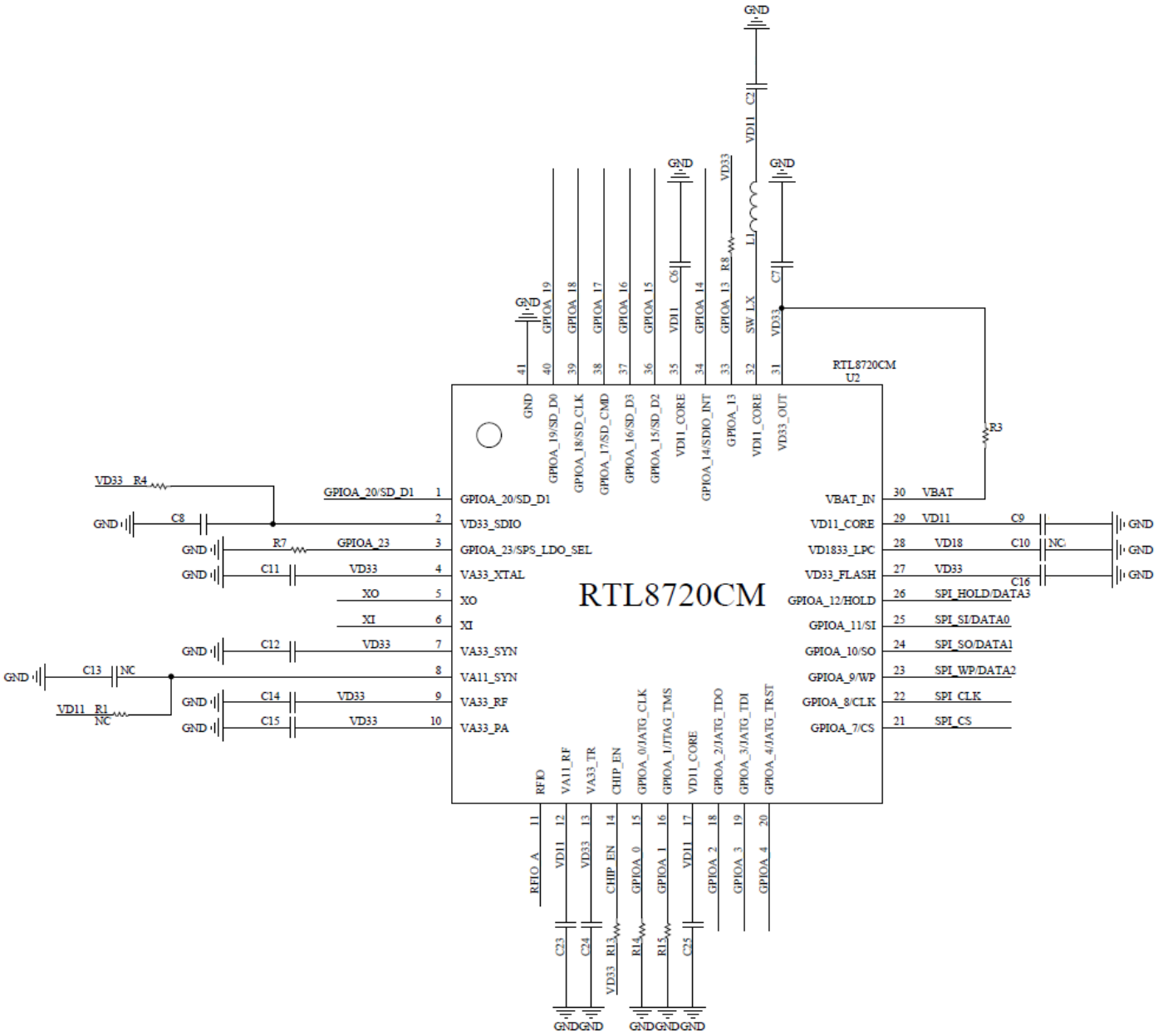

Figure 14. Schematic Diagram of RF-WM-20CMB1

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 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 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.

4.6.2 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 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.
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.

4.7 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:

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.

4.8 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 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 ℃	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

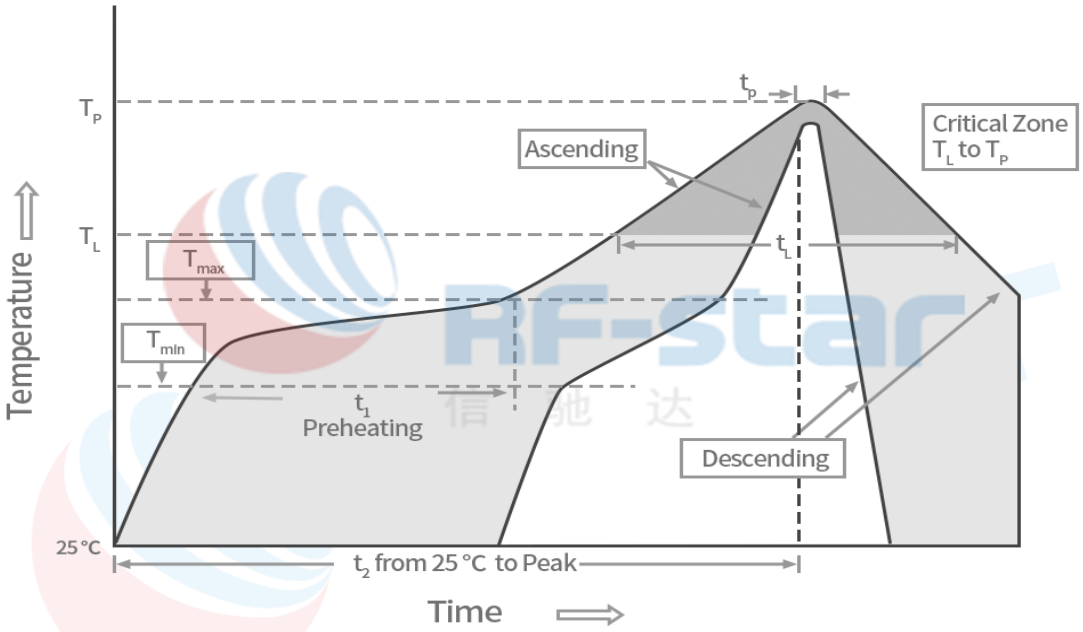

Figure 15. Recommended Reflow for Lead-Free Solder

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.

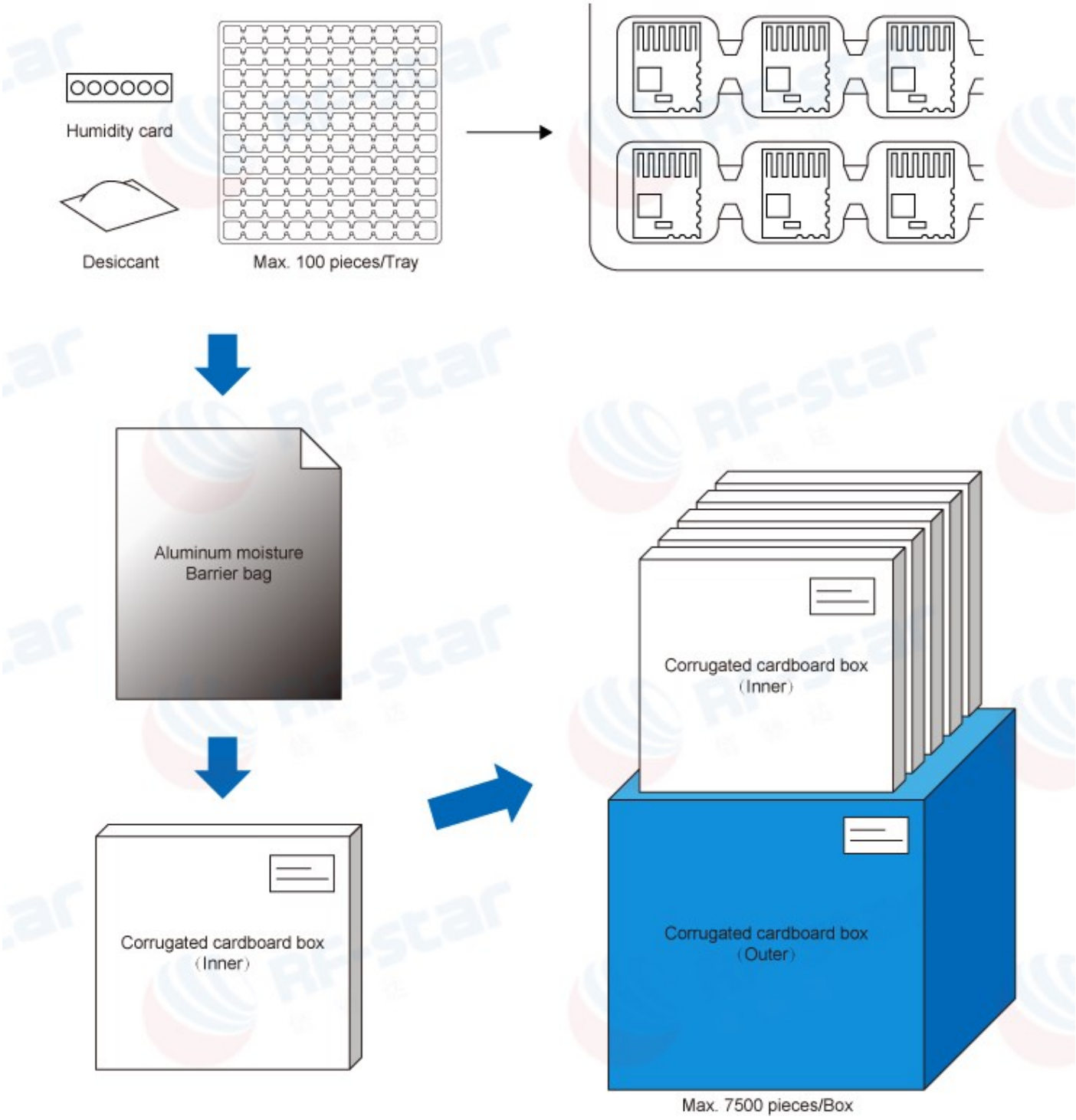

Figure 16. Default Package by Tray

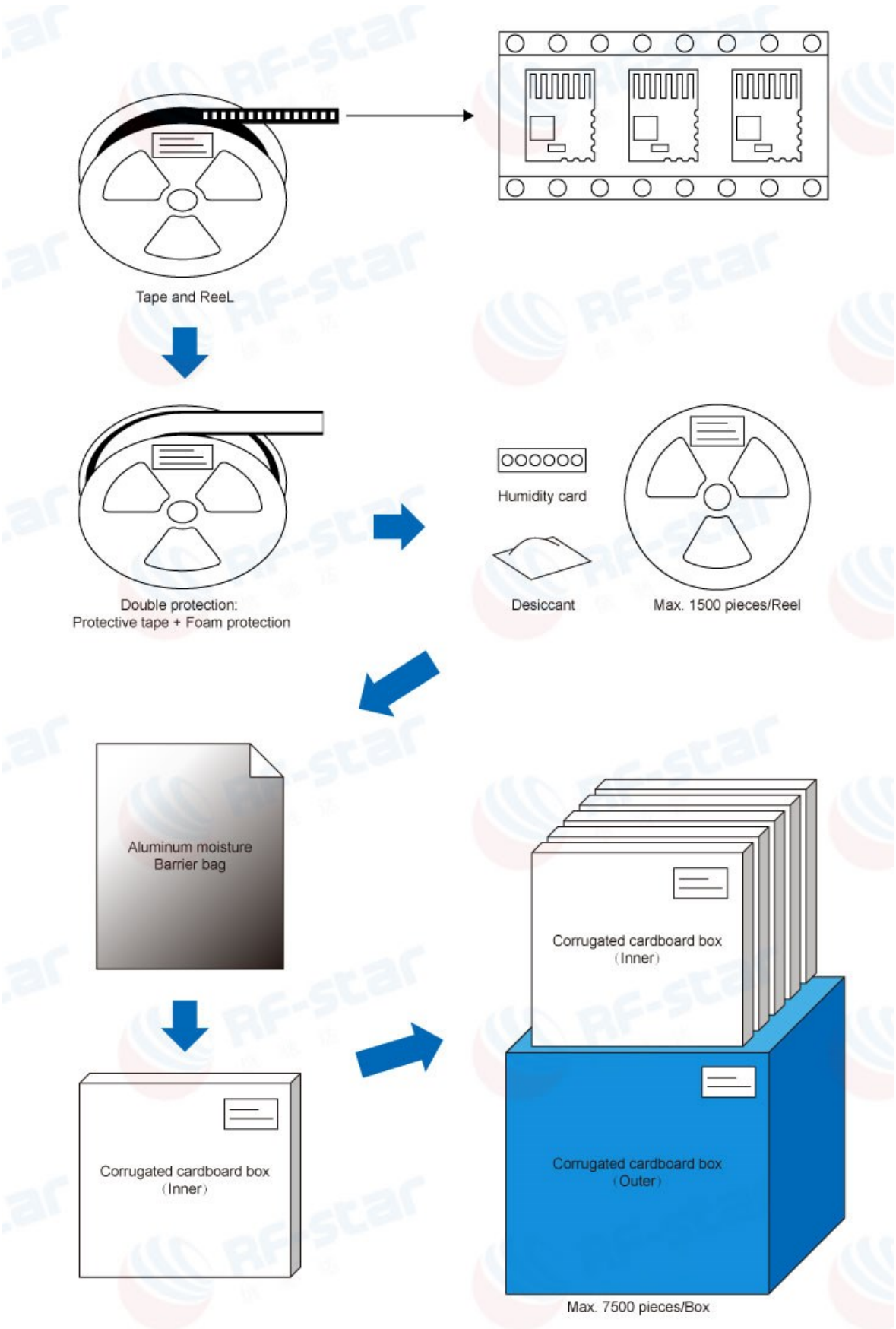

Figure 17. Package by Tape & Reel

6 Revision History

Date	Version No.	Description
2021.07.28	V1.0	The initial version is released.
2023.05.25	V1.0	Update MSL level. Update the Shenzhen office address.

Note:

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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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