RF-ZM-2530P1 and RF-ZM-2530P1I CC2530 with PA CC2592 Low-Power 2.4 GHz IEEE 802.15.4 and ZigBee Module

Version 1.0

Shenzhen RF-star Technology Co., Ltd.

Mar. 22nd, 2023

1 Device Overview

1.1 Description

RF-ZM-2530P1/P1I is a low power IEEE 802.15.4, ZigBee and RF4CE module based on TI CC2530F256 and a power amplifier CC2592. This module can be widely applied to short distance wireless network communication field with the characteristics of low power consumption, small volume, strong anti-interference ability and so on. The module uses RF-specific high dielectric constant, low loss sheet, and four-layer board wiring. Capacitance inductance components are from high-precision and high Q series. The module also uses onboard power supply filter circuit and RF optimization matching circuit, which makes the module better stability and farther transmission distance. To meet the industrial application requirements, the module can be equipped with a shield on it, which increases the anti-jamming capability.

1.2 Key Features

- RF Features
  - 2.4 GHz IEEE 8.02.15.4 compliant RF transceiver
  - ZigBee
  - RF4CE
- TX power: up to +21 dBm
- Receiving sensitivity: -100 dBm
- Microcontroller: High-performance and low-power 8051 microcontroller core with code prefetch
- Memory
  - Flash: 256 KB
  - RAM: 8 KB with retention in all power modes
- Rich Peripherals
  - Five-channel DMA
  - Integrated high-performance op-amp and ultralow-power comparator
  - IEEE 802.15.4 MAC timer, general-purpose timers (one 16-bit, two 8-bit)
  - IR generation circuitry
  - 32-kHz sleep timer with capture
  - CSMA/CA hardware support
  - Accurate digital RSSI/LQI support
  - Battery monitor and temperature sensor
  - 12-bit ADC with 8 channels and configurable resolution
  - AES security coprocessor
  - Two powerful USARTs with support for several serial protocols
  - 19 general-purpose I/O pins (17 × 4 mA, 2 × 20 mA)
  - Watchdog timer
- Dimension
  - RF-ZM-2530P1: 25.5 mm x 16.3 mm x 2.1 mm
  - RF-ZM-2530P1I: 25.5 mm x 16.3 mm x 2.2 mm

1.3 Applications

- 2.4 GHz IEEE 802.15.4 systems
- RF4CE remote control systems
- ZigBee systems
- Home automation
- Building automation
- Industrial control and monitoring

- Low-power wireless sensor networks
- Consumer electronics
- Health care

1.4 Functional Block Diagram

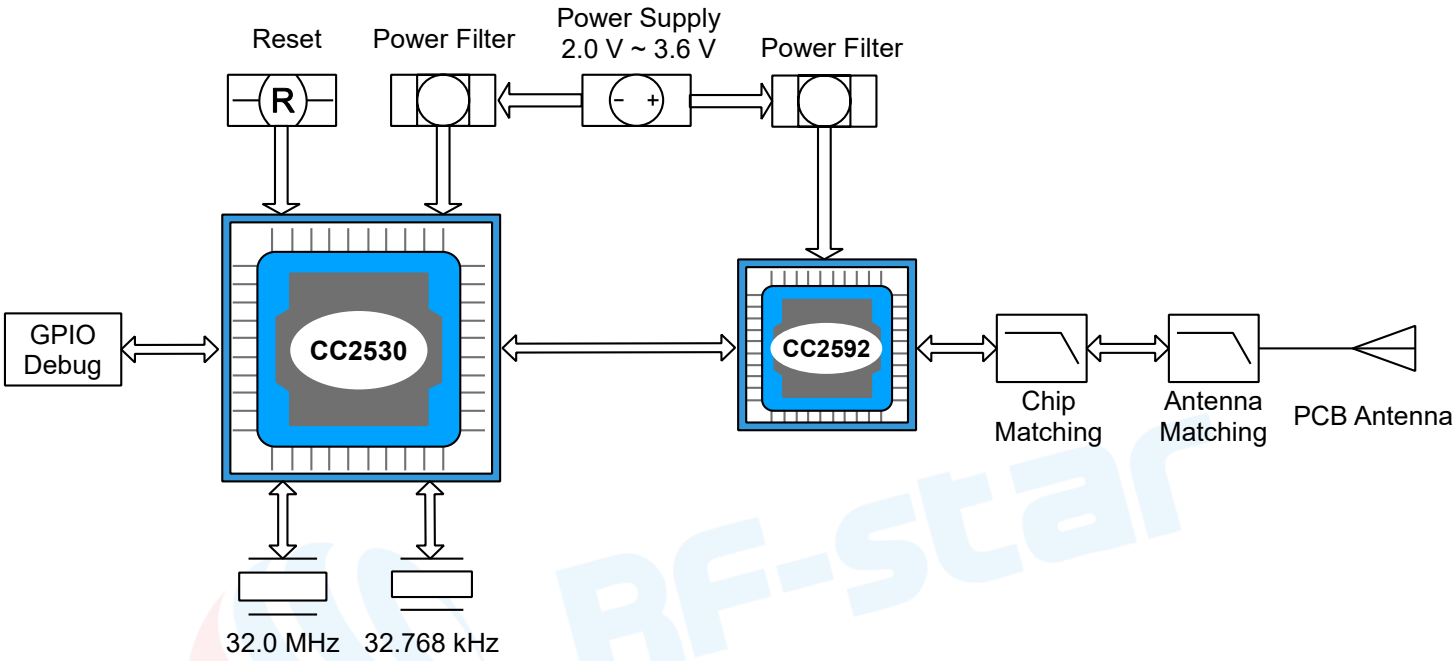


Figure 1. Functional Block Diagram of RF-ZM-2530P1

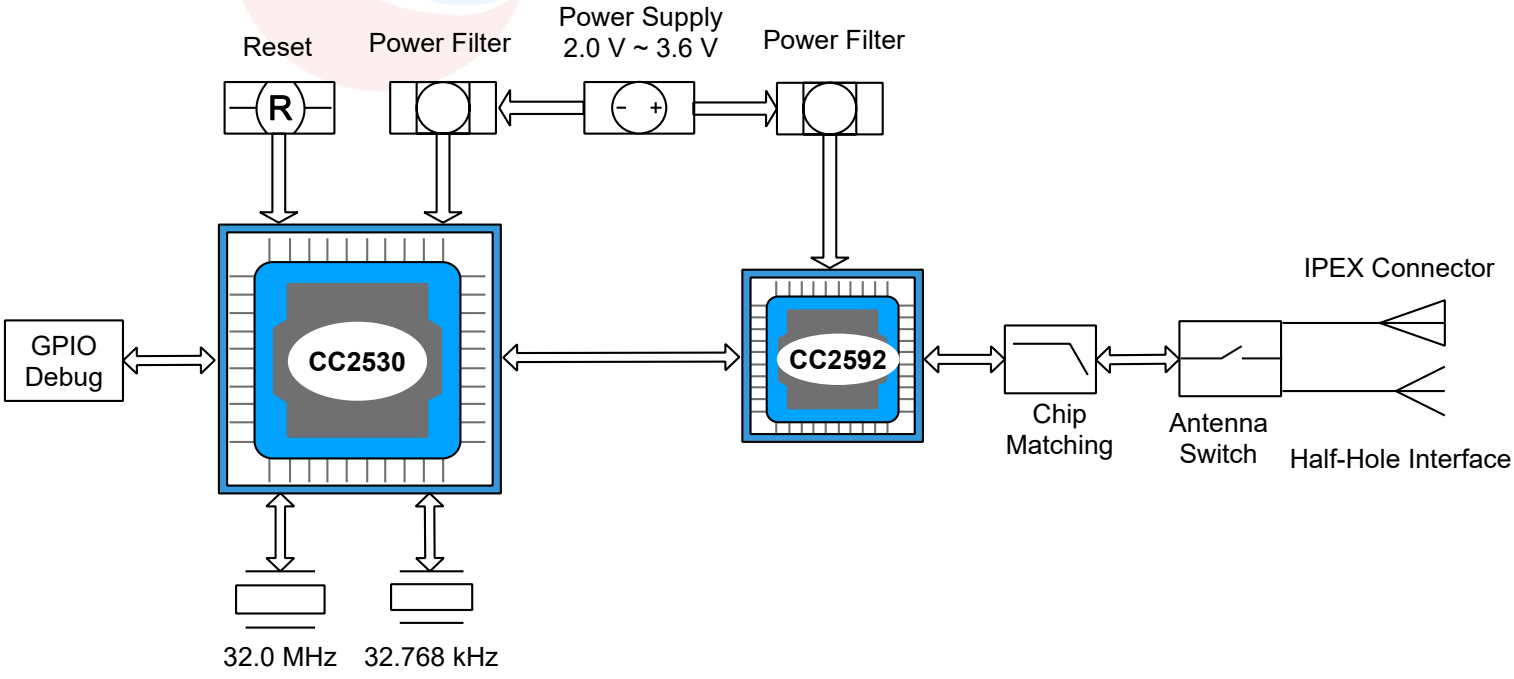


Figure 2. Functional Block Diagram of RF-ZM-2530P1I

1.6 Part Number Conventions

The part numbers are of the form of RF-ZM-2530P1/P1I where the fields are defined as follows:

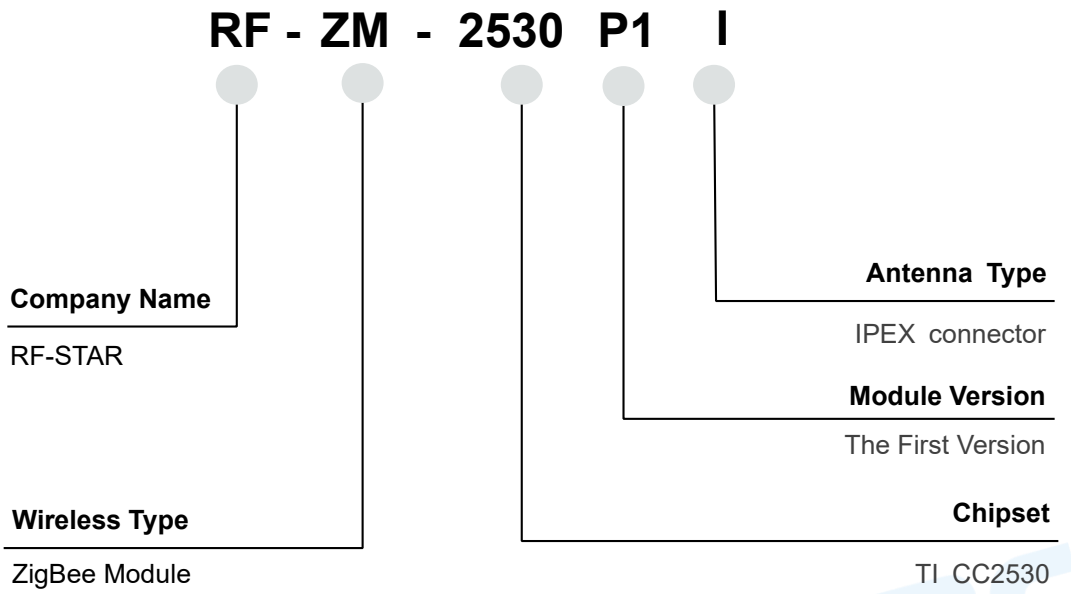


Figure 3. Part Number Conventions of RF-ZM-2530P1/P1I

Table of Contents

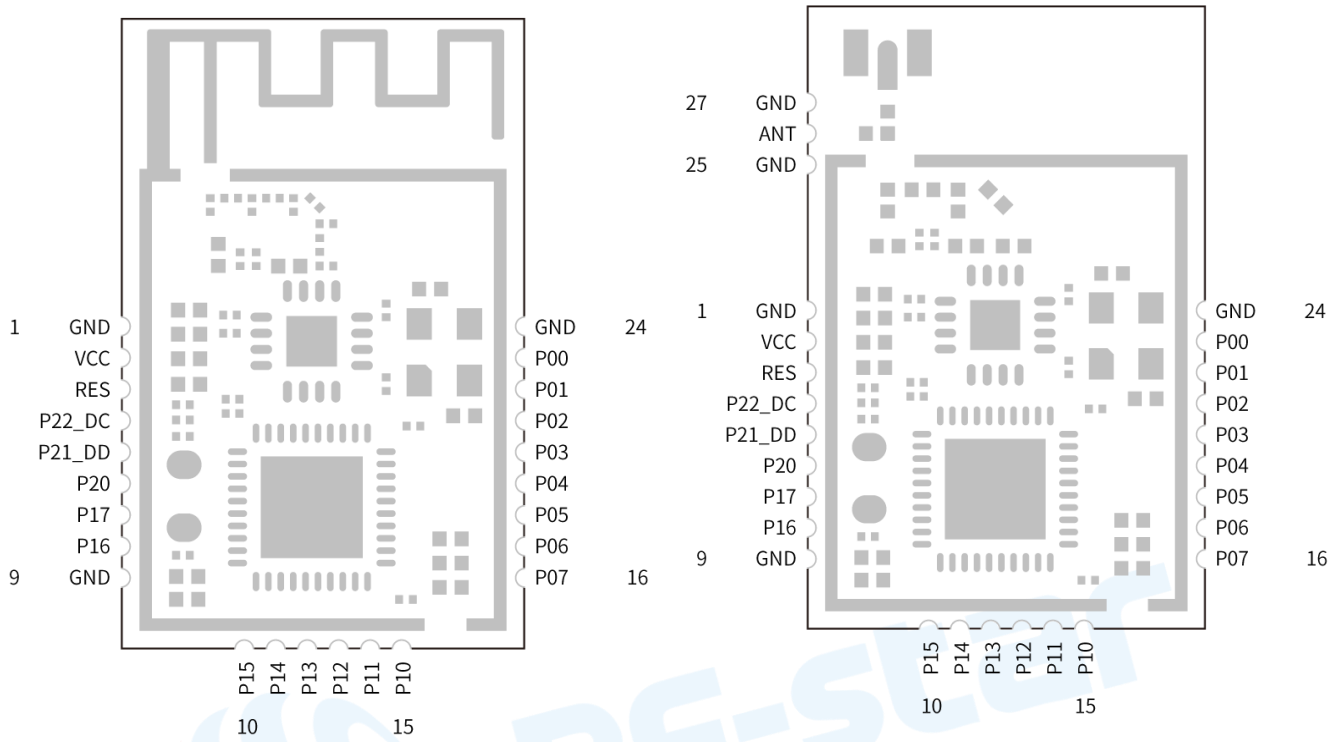
2 Module Configuration and Functions

2.1 Module Parameters

Table 1. Parameters of RF-ZM-2530P1/P1I

Chipset	CC2530F256 CC2592
Supply Power Voltage	2.0 V ~ 3.6 V, recommended to 3.3 V
Frequency	2394 MHz ~ 2507 MHz
Maximum Transmit Power	+21 dBm
Receiving Sensitivity	-100 dBm
GPIO	16
RAM	8 KB
Flash	256 KB
Crystal	32 MHz, 32.768 kHz
Dimension	RF-ZM-2530P1: 25.5 mm x 16.3 mm x 2.1 mm RF-ZM-2530P1I: 25.5 mm x 16.3 mm x 2.2 mm
Type of Antenna	RF-ZM-2530P1: PCB antenna RF-ZM-2530P1I: IPEX connector/Half-hole ANT pin
Package	SMT packaging (1.27-mm half-hole pitch stamp stick)
Operating Temperature	-40 ℃ ~ +85 ℃
Storage Temperature	-40 ℃ ~ +125 ℃

2.2 Module Pin Diagram



RF-ZM-2530P1 RF-ZM-2530P1I

Figure 4. Pin Diagram of RF-ZM-2530P1/P1I

2.3 Pin Functions

Table 2. Pin Functions of RF-ZM-2530P1

Pin	Name	Chip Pin	Pin Type	Description
1	GND	GND	Ground	
2	VCC	VCC	VCC	Power supply: 2.0 V ~ 3.6 V. Recommend to 3.3 V
3	RES	RESET_N	Reset	Reset, active low
4	P22_DC	P2_2	Digital I/O	Port 2.2/Connect to the DC of CC Debugger
5	P21_DD	P2_1	Digital I/O	Port 2.1/Connect to the DD of CC Debugger
6	P20	P2_0	Digital I/O	Port 2.0
7	P17	P1_7	Digital I/O	Port 1.7
8	P16	P1_6	Digital I/O	Port 1.6
9	GND	GND	Ground	
10	P15	P1_5	Digital I/O	Port 1.5
11	P14	P1_4	Digital I/O	Port 1.4

12	P13	P1_3	Digital I/O	Port 1.3
13	P12	P1_2	Digital I/O	Port 1.2
14	P11	P1_1	Digital I/O	Port 1.1
15	P10	P1_0	Digital I/O	Port 1.0
16	P07	P0_7	Digital I/O	Port 0.7
17	P06	P0_6	Digital I/O	Port 0.6
18	P05	P0_5	Digital I/O	Port 0.5
19	P04	P0_4	Digital I/O	Port 0.4
20	P03	P0_4	Digital I/O	Port 0.3
21	P02	P0_2	Digital I/O	Port 0.2
22	P01	P0_1	Digital I/O	Port 0.1
23	P00	P0_0	Digital I/O	Port 0.0
24	GND	GND	Ground	

Table 3. Pin Functions of RF-ZM-2530P1I

Pin	Name	Chip Pin	Pin Type	Description
1	GND	GND	Ground	
2	VCC	VCC	VCC	Power supply: 2.0 V ~ 3.6 V, Recommend to 3.3 V
3	RES	RESET_N	Reset	Reset, active low
4	P22_DC	P2_2	Digital I/O	Port 2.2 / Connect to the DC of CC Debugger
5	P21_DD	P2_1	Digital I/O	Port 2.1 / Connect to the DD of CC Debugger
6	P20	P2_0	Digital I/O	Port 2.0
7	P17	P1_7	Digital I/O	Port 1.7
8	P16	P1_6	Digital I/O	Port 1.6
9	GND	GND	Ground	
10	P15	P1_5	Digital I/O	Port 1.5
11	P14	P1_4	Digital I/O	Port 1.4
12	P13	P1_3	Digital I/O	Port 1.3
13	P12	P1_2	Digital I/O	Port 1.2
14	P11	P1_1	Digital I/O	Port 1.1
15	P10	P1_0	Digital I/O	Port 1.0
16	P07	P0_7	Digital I/O	Port 0.7

17	P06	P0_6	Digital I/O	Port 0.6
18	P05	P0_5	Digital I/O	Port 0.5
19	P04	P0_4	Digital I/O	Port 0.4
20	P03	P0_4	Digital I/O	Port 0.3
21	P02	P0_2	Digital I/O	Port 0.2
22	P01	P0_1	Digital I/O	Port 0.1
23	P00	P0_0	Digital I/O	Port 0.0
24	GND	GND	Ground	
25	GND	GND	Ground	
26	ANT			External ANT pin
27	GND	GND	Ground	

3 Specifications

3.1 Recommended Operating Conditions

Functional operation does not guarantee performance beyond the limits of the conditional parameter values in the table below. Long-term work beyond this limit will affect the reliability of the module more or less.

Table 4. Recommended Operating Conditions of RF-ZM-2530P1/P1I

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

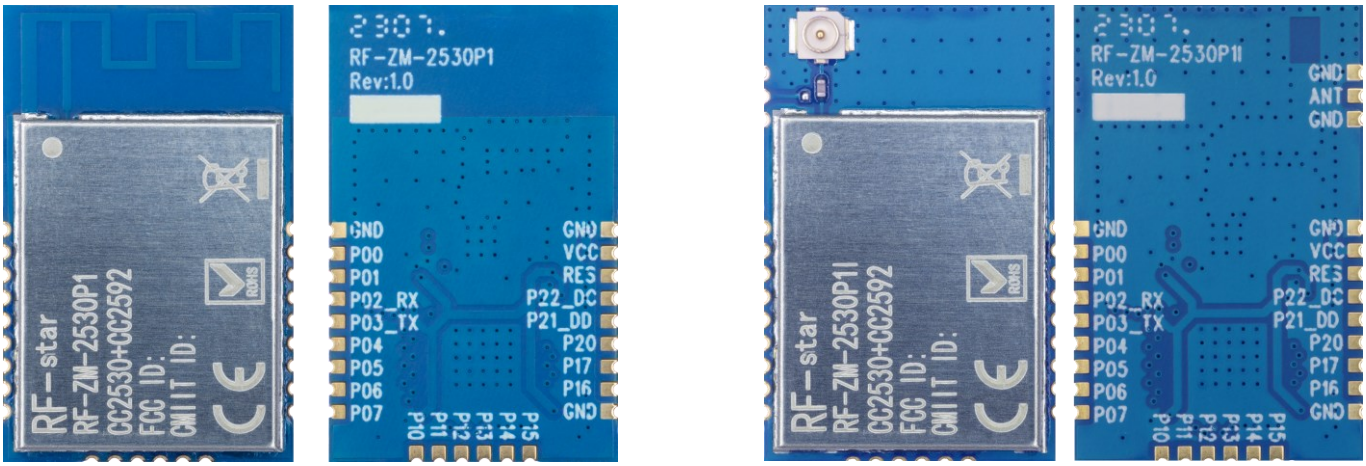
3.2 Handling Ratings

Table 5. Handling Ratings of RF-ZM-2530P1/P1I

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

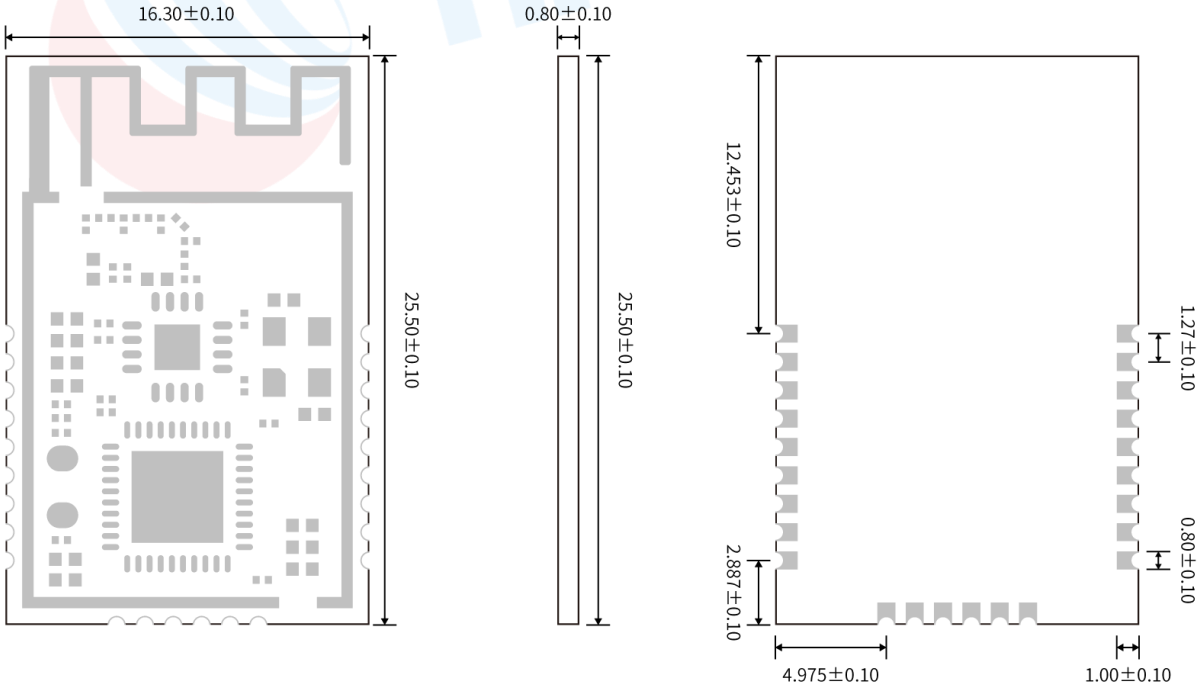
4.1 Module Photos



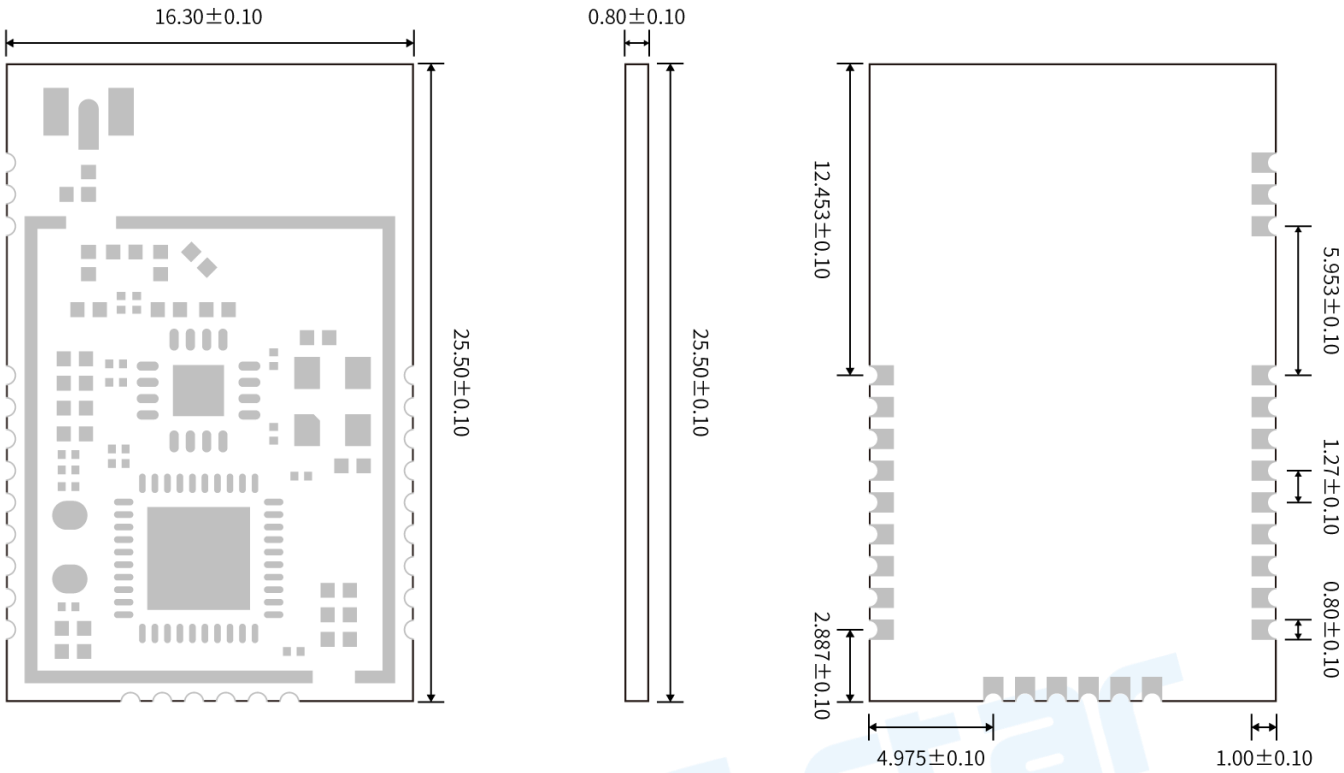
RF-ZM-2530P1 RF-ZM-2530P1I

Figure 5. Photos of RF-ZM-2530P1/P1I

4.2 Recommended PCB Footprint



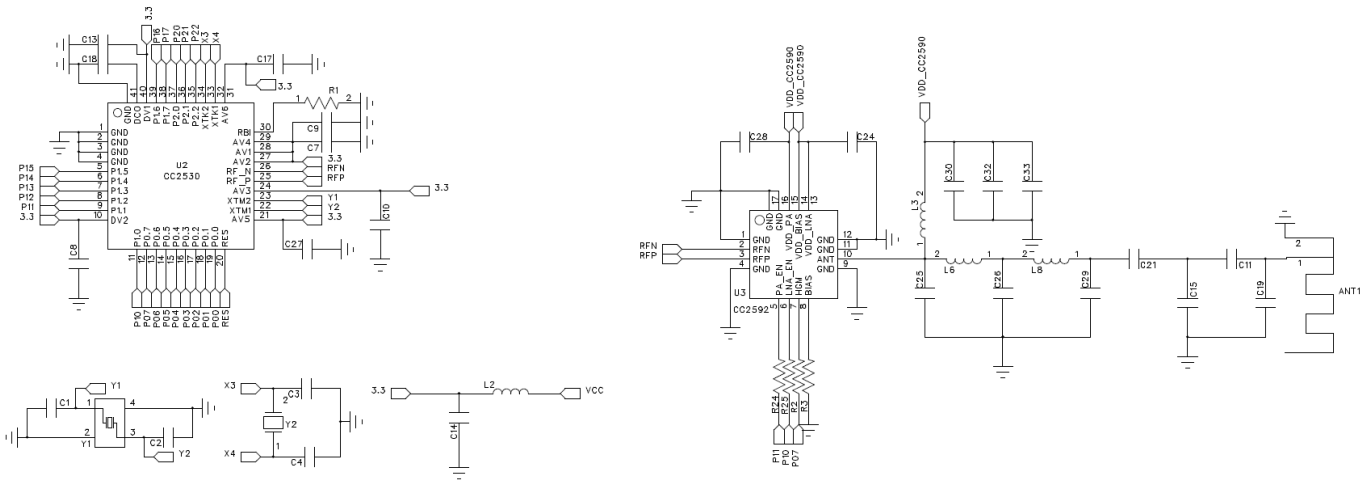
RF-ZM-2530P1



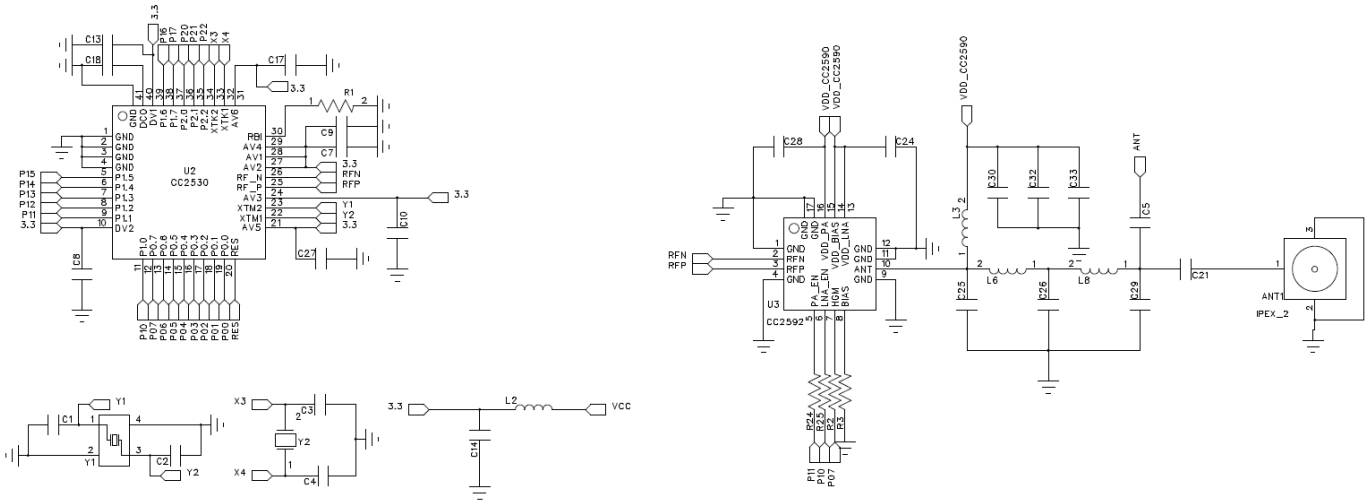
RF-ZM-2530P1I

Figure 6. Recommended PCB Footprint of RF-ZM-2530P1/P1I (mm)

4.3 Schematic Diagram



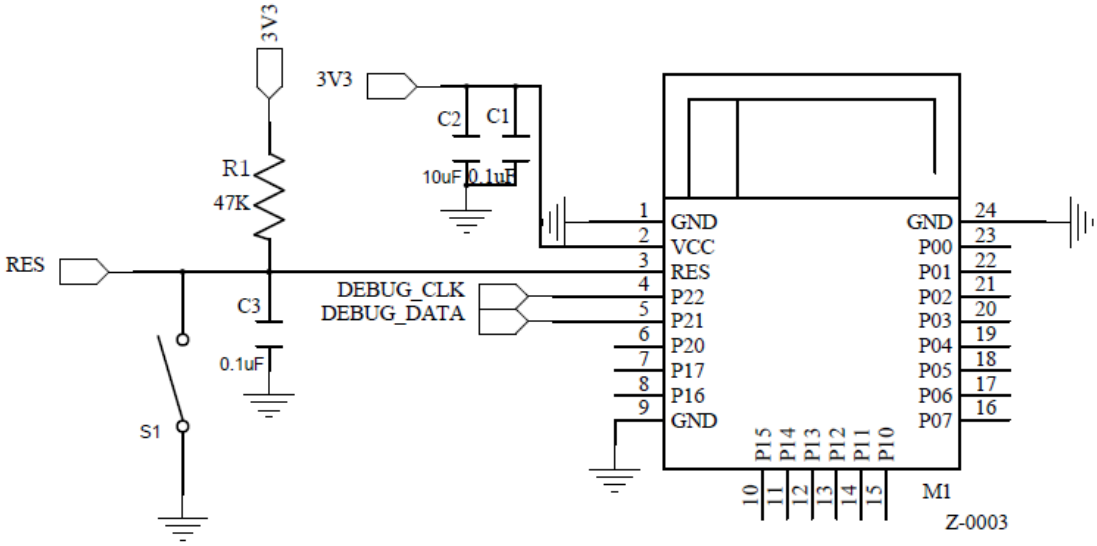
RF-ZM-2530P1



RF-ZM-2530P1I

Figure 7. Schematic Diagram of RF-ZM-2530P1/P1I

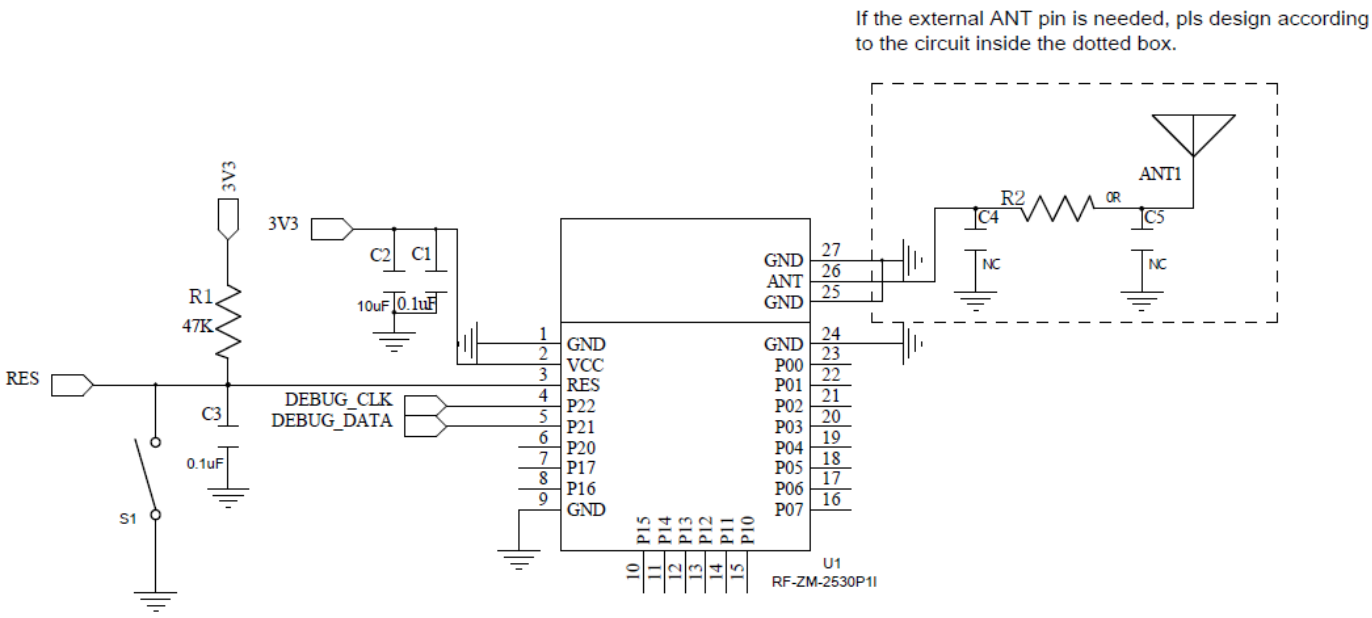
5.4 Reference Design of RF-BM-2530P1/P1I



Remark: P07, P10 and P11 are used for CC2592 enable control, the related pins are shown as below:

CC2530	CC2592
P07	HGM
P10	LNA_LE
P11	PA_LE

Figure 8. Reference Design of RF-ZM-2530P1



Remark: P07, P10 and P11 are used for CC2592 enable control, the related pins are shown as below:

CC2530	CC2592
P07	HGM
P10	LNA_LE
P11	PA_LE

Figure 9. Reference Design of RF-ZM-2530P1I

5.5 Antenna

5.5.1 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.

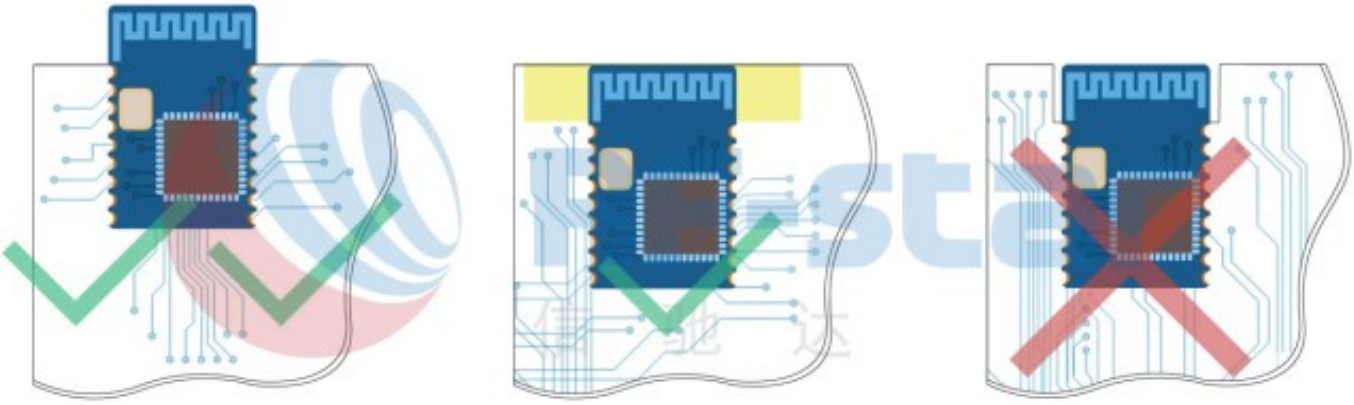


Figure 10. Recommendation of Antenna Layout

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

5.5.2 Antenna Output Mode Modification of RF-ZM-2530P1I

1. RF-ZM-2530P1I has two antenna output modes. The one is an IPEX connector and an half-hole ANT pin (ANT pin, see pin function table for details).

The default delivery is the ***IPEX connector***, and the capacitor connected to the IPEX is welded. If you want to use the external antenna by the ANT pin, the capacitor position should be removed to the left solder joint to have the access to the ANT pin. The location of the capacitor is shown in the figure below.

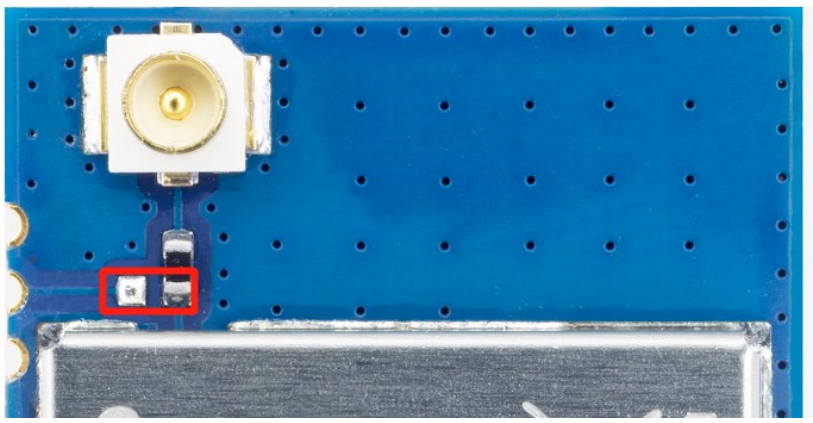


Figure 11. Antenna Output Mode Change of RF-ZM-2530P1I

5.5.3 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.

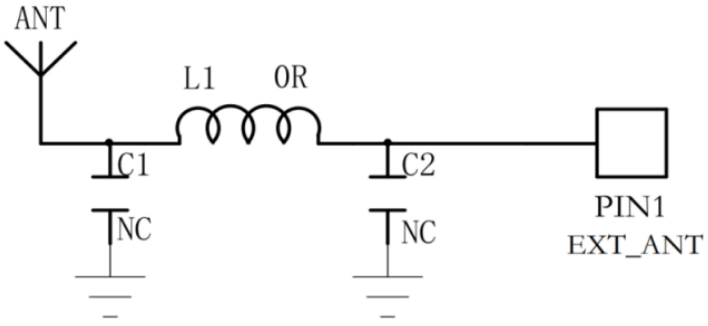


Figure 12. Reference Design of the External Antenna

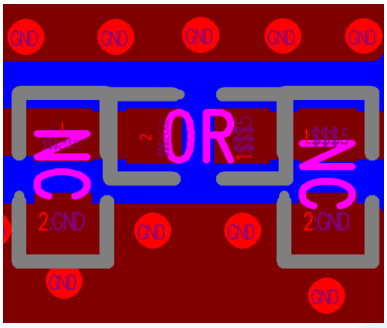


Figure 13. Reference Design of the External Antenna Traces

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.

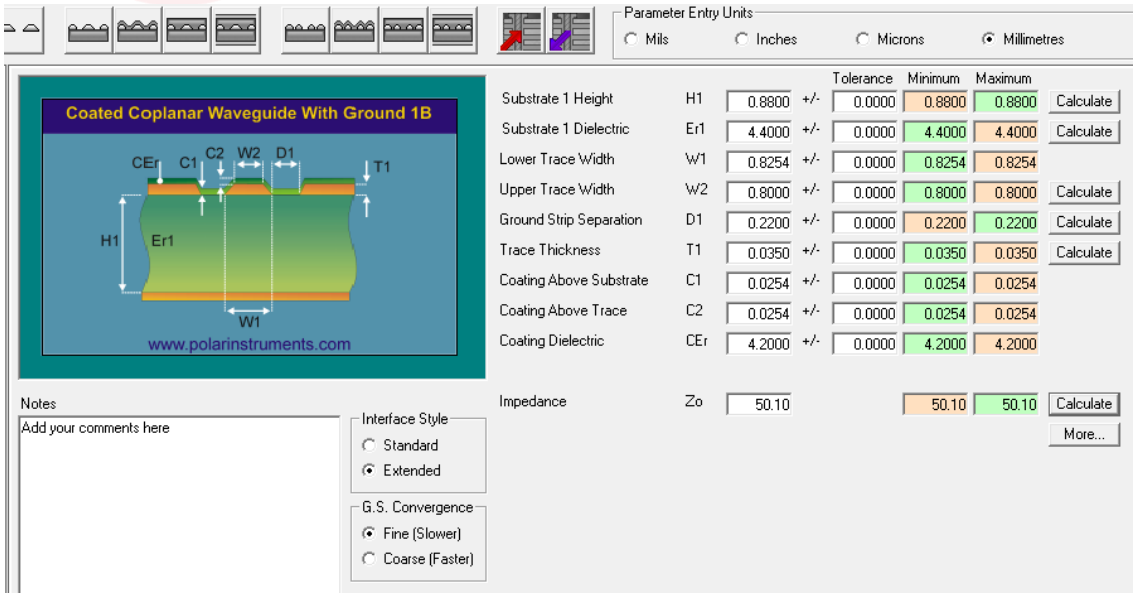


Figure 14. SI9000 Impedance Calculation Diagram

5.5.4 IPEX Connector Specification

RF-ZM-2530P1 module is integrated the IPEX version 1 antenna seat, the specification of the antenna seat is as follows:

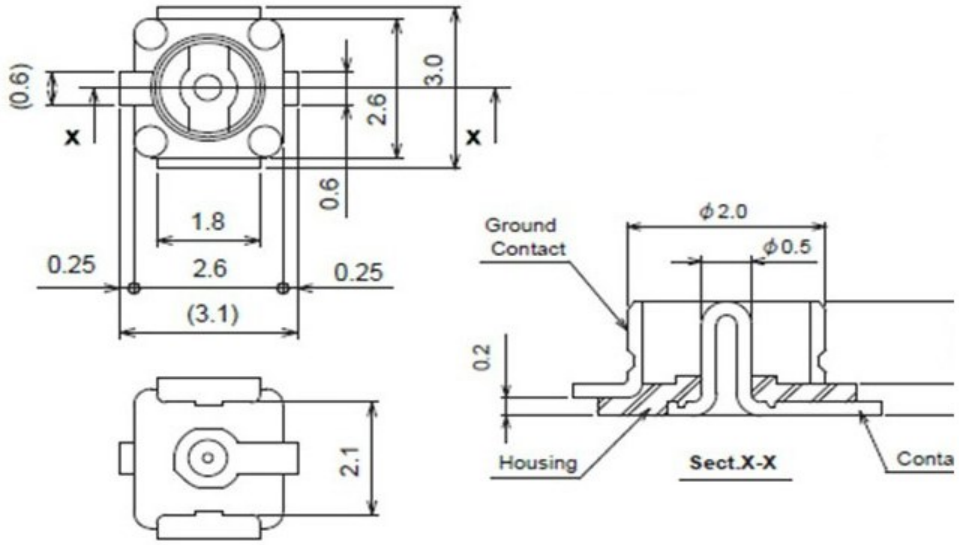


Figure 15. Specification of Antenna Seat

The specification of the IPEX wire end is as follows:

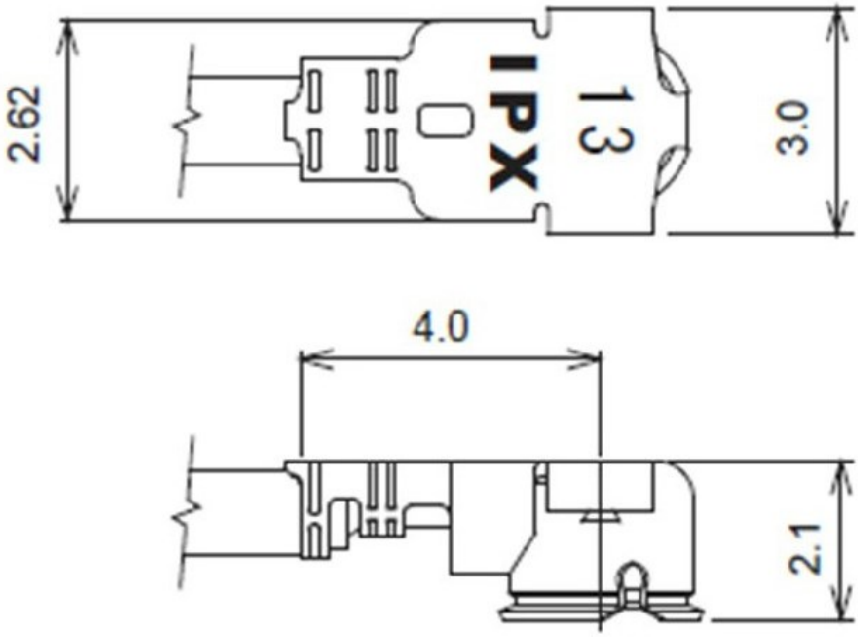


Figure 16. Specification of IPEX Wire

5.6 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.

5.7 Trouble Shooting

5.7.1 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.

5.7.2 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.

5.7.3 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.

5.8 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.

5.9 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 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

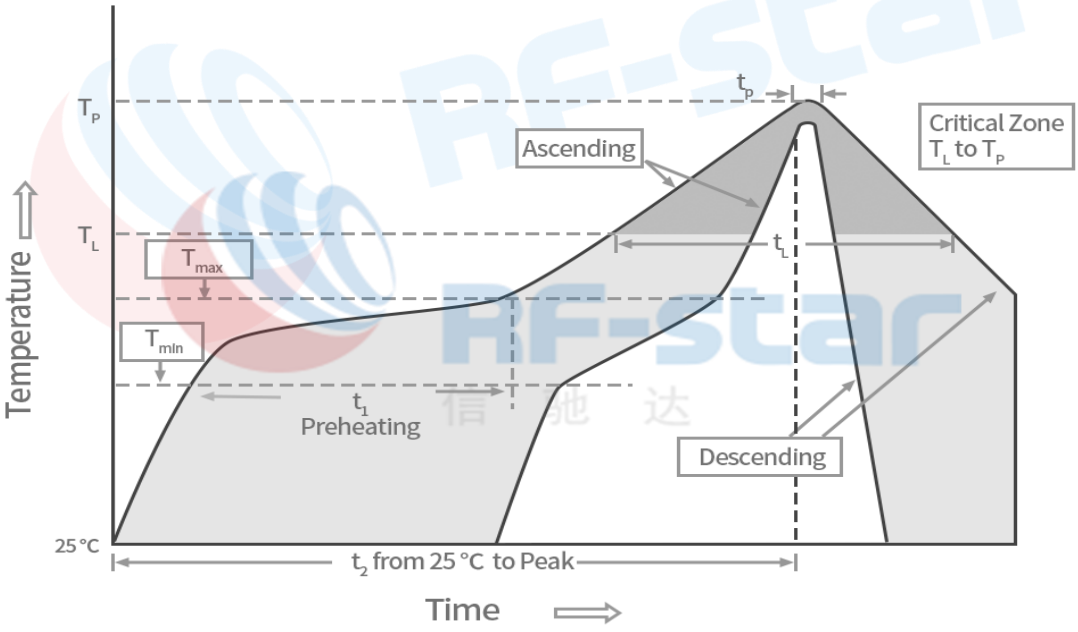


Figure 17. Recommended Reflow for Lead-Free Solder

6 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.

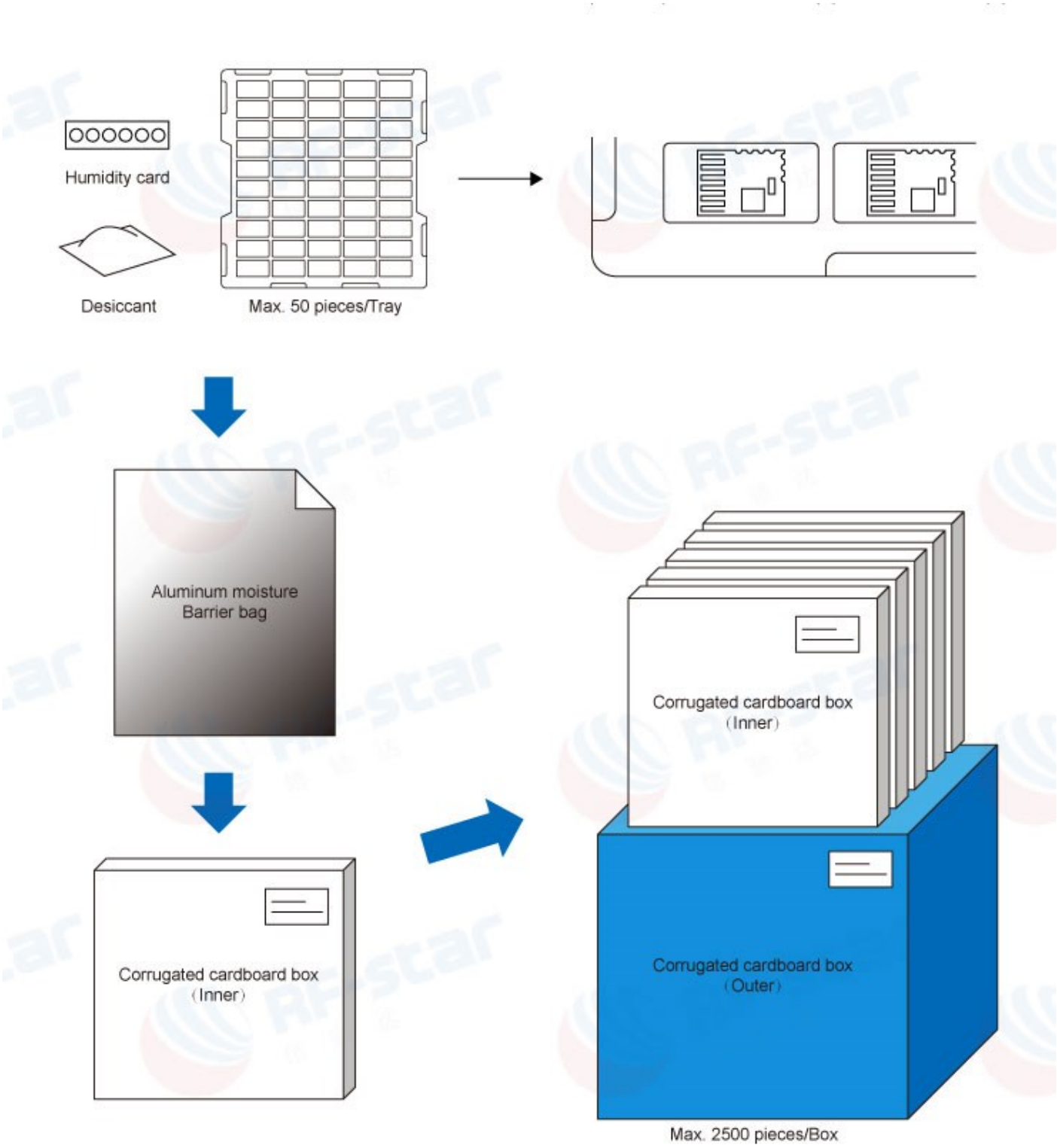


Figure 18. Default Package by Tray

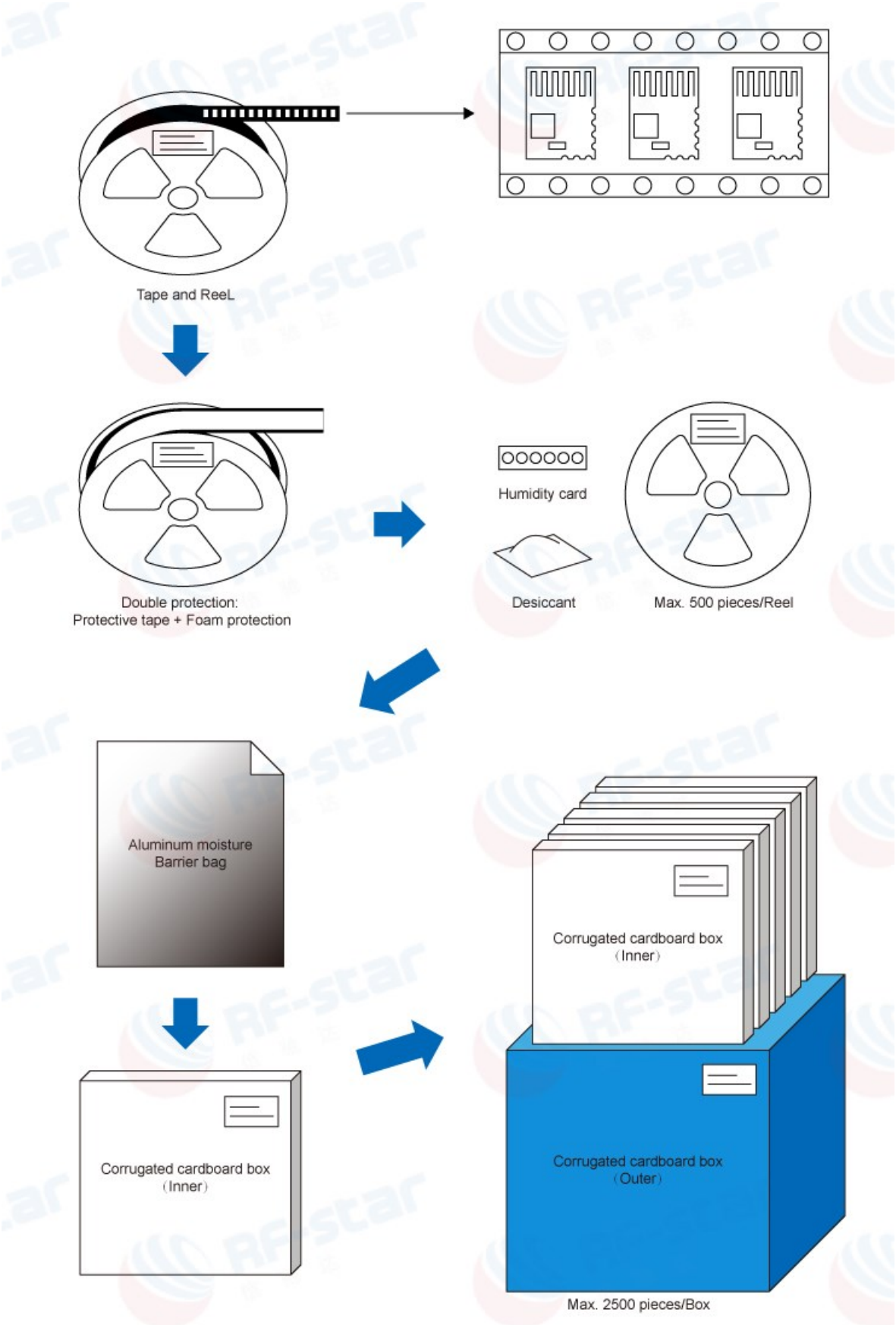


Figure 19. Package by Tape & Reel

7 Revision History

Date	Version No.	Description
2023.03.22	V1.0	The initial version is released.
2023.05.25	V1.0	Update MSL level. Update the Shenzhen office address.

Note:

1. The document will be optimized and updated from time to time. Before using this document, please make sure it is the latest version.
2. To obtain the latest document, please download it from the official website: www.rfstariot.com and www.szrfstar.com.

8 Contact Us

SHENZHEN RF-STAR TECHNOLOGY CO., LTD.

Shenzhen HQ:

Add.: Room 502, Podium Building No. 12, Shenzhen Bay Science and Technology Ecological Park, Nanshan District, Shenzhen, Guangdong, China, 518063

Tel.: 86-755-8632 9829

Chengdu Branch:

Add.: N2-1604, Global Center, North No. 1700, Tianfu Avenue, Hi-Tech District, Chengdu, Sichuan, China, 610095

Tel.: 86-28-8692 5399

Email: sunny@szrfstar.com, sales@szrfstar.com

Web.: www.rfstariot.com, www.szrfstar.com