RF-BM-ND10 nRF52833

Bluetooth 5.3 Low Energy, Bluetooth mesh, NFC, Thread and ZigBee Wireless Module

Version 1.0

Shenzhen RF-star Technology Co., Ltd.

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1 Device Overview

1.1 Description

RF-BM-ND10 is a multiprotocol Radio Frequency module based on Nordic nRF52833 SoC. It integrates a 32 MHz crystal, 512 KB Flash, and 128 KB RAM. Its 64 MHz ARM® Cortex®-M4 with FPU core processor can operate at an extremely low current at flexible power modes. Its 2.4 GHz RF transceiver is compatible with Bluetooth 5.3 Low Energy, Bluetooth Mesh, Direction Finding AoA and AoD, Thread, ZigBee and NFC. Up to 8 dBm TX power makes the module a robust coverage range. The module has wide range of analog and digital interfaces such as NFC-A, ADC, Full-speed 12 Mbps USB 2.0, High-speed 32 MHz SPI, UART/SPI/TWI, PWM, I2S and PDM, which makes it be applicable in a number of applications over USB with low power consumption.

1.2 Key Features

- RF Features
  - Bluetooth 5.3 Low Energy
  - Bluetooth Mesh
  - Direction find AoA and AoD
  - IEEE 802.15.4-2006
    - ZigBee
    - Thread
  - NFC
  - Proprietary
  - Nordic SoftDevice ready with support for concurrent multiprotocol
- Data rates
  - Bluetooth®5.3: 2 Mbps, 1 Mbps, 500 kbps, and 125 kbps
  - IEEE 802.15. 4-2006: 250 kbps
  - Proprietary 2.4 GHz: 2 Mbps, 1 Mbps
- Receiving sensitivity
  - -103 dBm for BLE 125 kbps (LE coded PHY)
  - -96 dBm for 1 Mbps PHY
- TX Power: -20 dBm ~ +8 dBm, configurable in 4 dB steps
- Powerful 32-bit 64 MHz ARM® Cortex®-M4 processor with FPU
- Memory
  - 512 KB flash
  - 128 RAM
  - Support OTA upgrade
- Wide Operation Range
  - Power Supply: 1.7 V ~ 3.6 V
  - Operating temperature: -40 °C to +85 °C
  - Storage temperature: -40 °C to +125 °C
- Rich Peripherals
  - 42 GPIOs
  - USB 2.0 full speed (12 Mbps) controller
  - High-speed 32 MHz SPI
  - Type 2 near field communication (NFC-A) tag with wake-on field
  - Programmable peripheral interconnect (PPI)
  - EasyDMA automated data transfer between memory and peripherals
  - 12-bit, 200 ksps ADC - 8 configurable channels with programmable gain
  - 64 level comparator
  - 15 level low-power comparator with wake-up from System OFF mode
  - Temperature sensor
  - 4x four channel pulse width modulator (PWM) unit with EasyDMA
  - Audio peripherals - I2S, digital microphone interface (PDM)
  - 5x 32-bit timer with counter mode
  - Up to 4x SPI master/3x SPI slave with EasyDMA

- Up to 2x I2C compatible two-wire master/slave
- 2x UART (CTS/RTS) with EasyDMA
- Quadrature decoder (QDEC)
- 3x real-time counter (RTC)

• Dimension: 33 mm x 17.7 mm x 2.1 mm

1.3 Applications

• Mouse and Keyboard
• Health/fitness sensor
• Monitor devices
• Wireless payment enabled devices
• Smart home sensor and controllers
• Industrial IoT sensor and controllers
• Remote controls
• Gaming controller

1.4 Functional Block Diagram

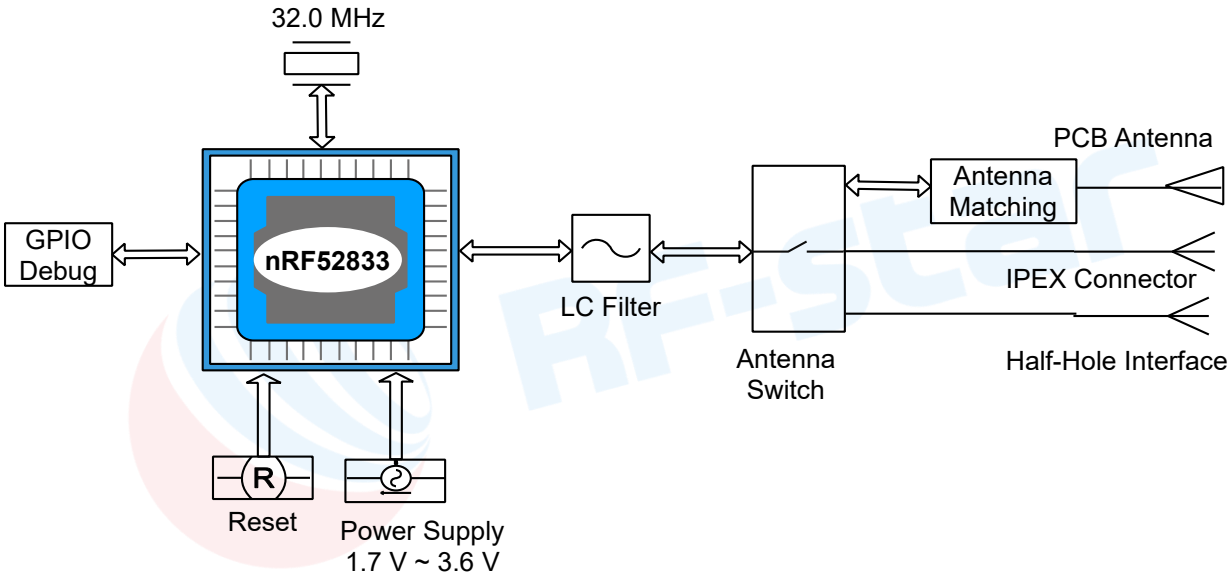

Figure 1. Functional Block Diagram of RF-BM-ND10

1.5 Part Number Conventions

The part numbers are of the form of RF-BM-ND10 where the fields are defined as follows:

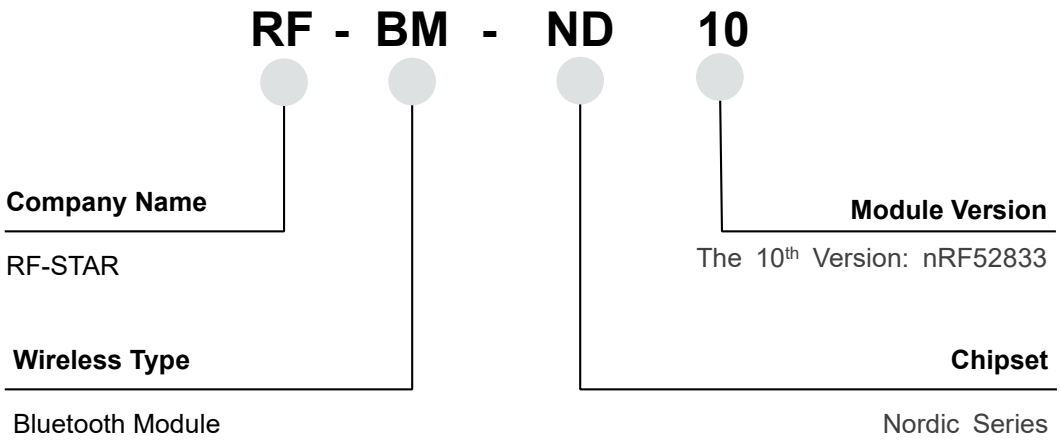

Figure 2. Part Number Conventions of RF-BM-ND10

Table of Contents

2 Module Configuration and Functions

2.1 Module Parameters

Table 1. Parameters of RF-BM-ND10

Chipset	nRF52833-QIAA
Supply Power Voltage	1.7 V ~ 3.6 V, recommended to 3.3 V
Frequency	2402 MHz ~ 2480 MHz
Transmit Power	-20 dBm ~ +8.0 dBm
Receiving Sensitivity	-103 dBm for BLE 125 kbps (LE coded PHY) -96 dBm for 1 Mbps PHY
GPIO	42
Support Protocol	Bluetooth 5.3 Low Energy, Bluetooth Mesh, AoA and AoD, Thread, ZigBee, NFC and Proprietary
Crystal	32 MHz
Package	SMT packaging (1.27-mm half-hole pitch stamp stick)
Dimension	33.0 mm × 17.0 mm × 2.1 mm
Type of Antenna	PCB antenna / IPEX connector / Half-hole ANT interface
Operating Temperature	-40 ℃ ~ +85 ℃
Storage Temperature	-40 ℃ ~ +125 ℃

2.2 Module Pin Diagram

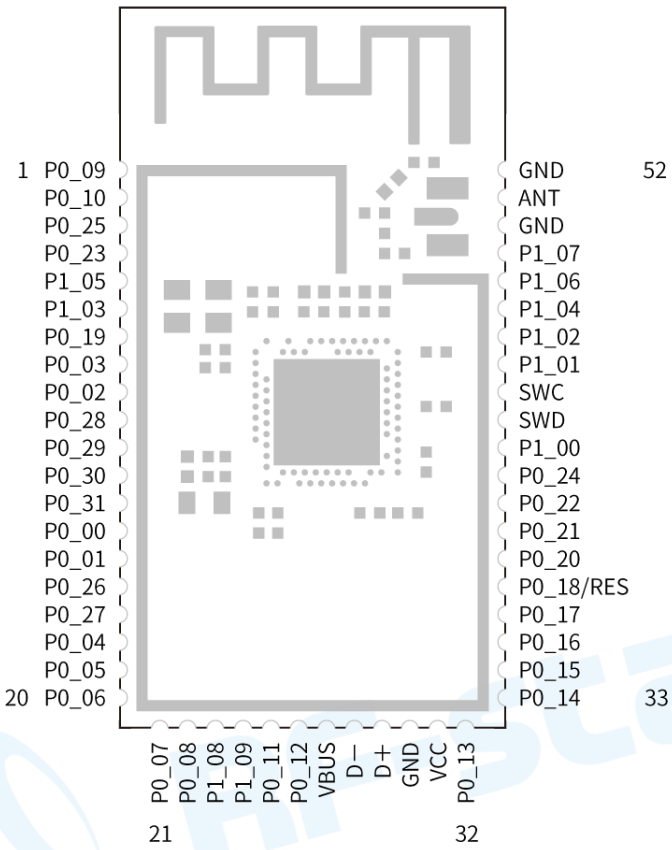

Figure 3. Pin Diagram of RF-BM-ND10

2.3 Pin Functions

Table 2. Pin Functions of RF-BM-ND10

Pin	Name	Chip Pin	Function	Description
1	P0_09	P0.09	Digital I/O	General purpose I/O
		NFC1	NFC input	NFC antenna connection
2	P0_10	P0.10	Digital I/O	General purpose I/O
		NFC2	NFC input	NFC antenna connection
3	P0_25	P0.25	Digital I/O	General purpose I/O
4	P0_23	P0.23	Digital I/O	General purpose I/O
5	P1_05	P1.05	Digital I/O	General purpose I/O
6	P1_03	P1.03	Digital I/O	General purpose I/O
7	P0_19	P0.19	Digital I/O	General purpose I/O
8	P0_03	P0.03	Digital I/O	General purpose I/O
		AIN1	Analog input	Analog input

9	P0_02	P0.02	Digital I/O	General purpose I/O
		AIN0	Analog input	Analog input
10	P0_28	P0.28	Digital I/O	General purpose I/O
		AIN4	Analog input	Analog input
11	P0_29	P0.29	Digital I/O	General purpose I/O
		AIN5	Analog input	Analog input
12	P0_30	P0.30	Digital I/O	General purpose I/O
		AIN6	Analog input	Analog input
13	P0_31	P0.31	Digital I/O	General purpose I/O
		AIN7	Analog input	Analog input
14	P0_00	P0.00	Digital I/O	General purpose I/O
		XL1	Analog input	Connection for 32.768 kHz crystal
15	P0_01	P0.01	Digital I/O	General purpose I/O
		XL2	Analog input	Connection for 32.768 kHz crystal
16	P0_26	P0.26	Digital I/O	General purpose I/O
17	P0_27	P0.27	Digital I/O	General purpose I/O
18	P0_04	P0.04	Digital I/O	General purpose I/O
		AIN2	Analog input	Analog input
19	P0_05	P0.05	Digital I/O	General purpose I/O
		AIN3	Analog input	Analog input
20	P0_06	P0.06	Digital I/O	General purpose I/O
21	P0_07	P0.07	Digital I/O	General purpose I/O
		TRACECLK	Trace clock	Trace buffer clock
22	P0_08	P0.08	Digital I/O	General purpose I/O
23	P1_08	P1.08	Digital I/O	General purpose I/O
24	P1_09	P1.09	Digital I/O	General purpose I/O
		TRACEDATA3	Trace data	Trace buffer TRACEDATA[3]
25	P0_11	P0.11	Digital I/O	General purpose I/O
		TRACEDATA2	Trace data	Trace buffer TRACEDATA[2]
26	P0_12	P0.12	Digital I/O	General purpose I/O
		TRACEDATA1	Trace data	Trace buffer TRACEDATA[1]
27	VBUS	VBUS	USB Power	5 V input for USB 3.3 V regulator

28	D-	D-	USB	USB D-
29	D+	D+	USB	USB D+
30	GND	GND	GND	
31	VCC	VCC	VCC	Power supply: 1.7 V ~ 3.6 V, recommend to 3.3 V
32	P0_13	P0.13	Digital I/O	General purpose I/O
33	P0_14	P0.14	Digital I/O	General purpose I/O
34	P0_15	P0.15	Digital I/O	General purpose I/O
35	P0_16	P0.16	Digital I/O	General purpose I/O
36	P0_17	P0.17	Digital I/O	General purpose I/O
37	P0_18	P0.18	Digital I/O	General purpose I/O
		nRESET		Configurable as pin RESET
38	P0_20	P0.20	Digital I/O	General purpose I/O
39	P0_21	P0.21	Digital I/O	General purpose I/O
40	P0_22	P0.22	Digital I/O	General purpose I/O
41	P0_24	P0.24	Digital I/O	General purpose I/O
42	P1_00	P1.00	Digital I/O	General purpose I/O
		TRACEDATA0	Trace data	Trace buffer TRACEDATA[0]
43	SWDIO	SWDIO	Debug	Serial wire debug I/O for debug and programming
44	SWDCLK	SWDCLK	Debug	Serial wire debug clock input for debug and programming
45	P1_01	P1.01	Digital I/O	General purpose I/O
46	P1_02	P1.02	Digital I/O	General purpose I/O
47	P1_04	P1.04	Digital I/O	General purpose I/O
48	P1_06	P1.06	Digital I/O	General purpose I/O
49	P1_07	P1.07	Digital I/O	General purpose I/O
50	GND	GND	GND	
51	ANT	ANT	ANT	Half-hole ANT pin
52	GND	GND	GND	

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-ND10

Items	Condition	Min.	Typ.	Max.	Unit
Operating Supply Voltage	Battery Mode	1.7	3.3	3.6	V
Operating Temperature	/	-40	+25	+85	℃
Environmental Hot Pendulum	/	-20		+20	℃/min

3.2 Handling Ratings

Table 4. Handling Ratings of RF-BM-ND10

Items	Condition	Min.	Typ.	Max.	Unit
Storage Temperature	Tstg	-40	+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

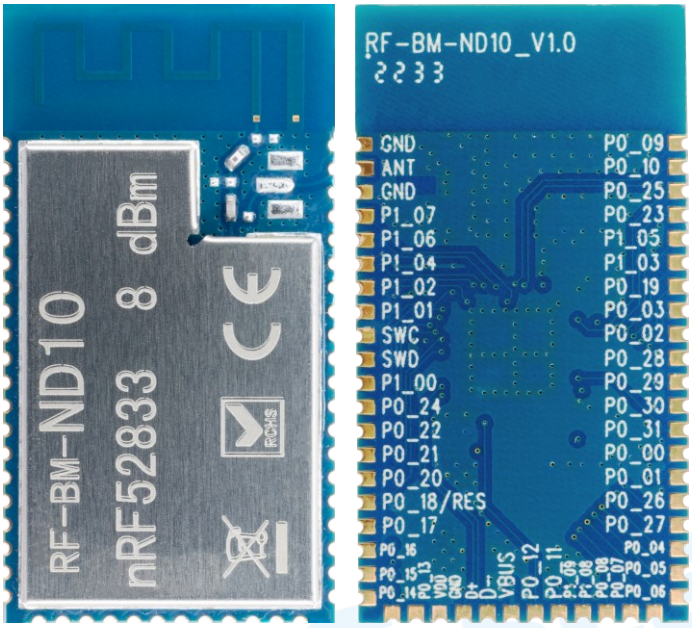

Figure 4. Photos of RF-BM-ND10

4.2 Recommended PCB Footprint

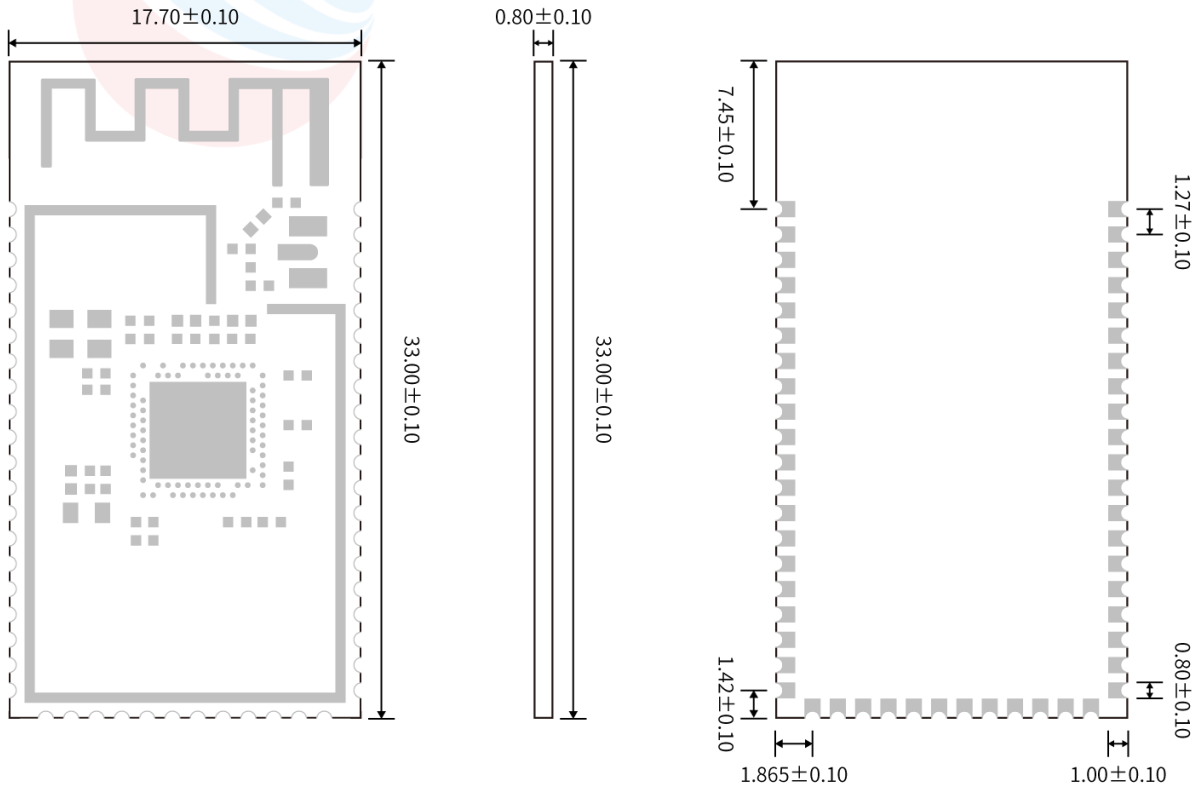

Figure 5. Recommended PCB Footprint of RF-BM-ND10 (mm)

4.3 Schematic Diagram

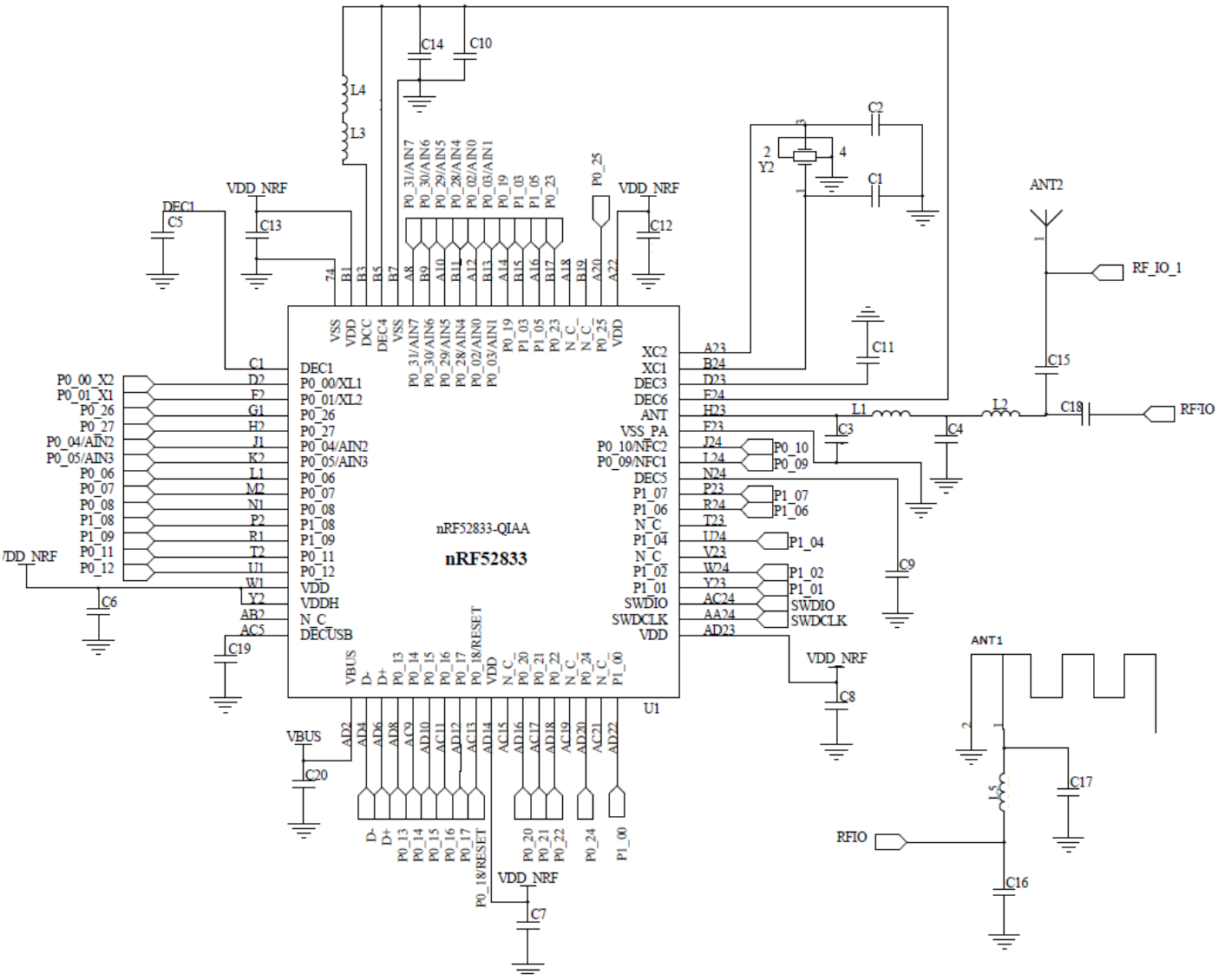

Figure 6. Schematic Diagram of RF-BM-ND10

4.4 Reference Design

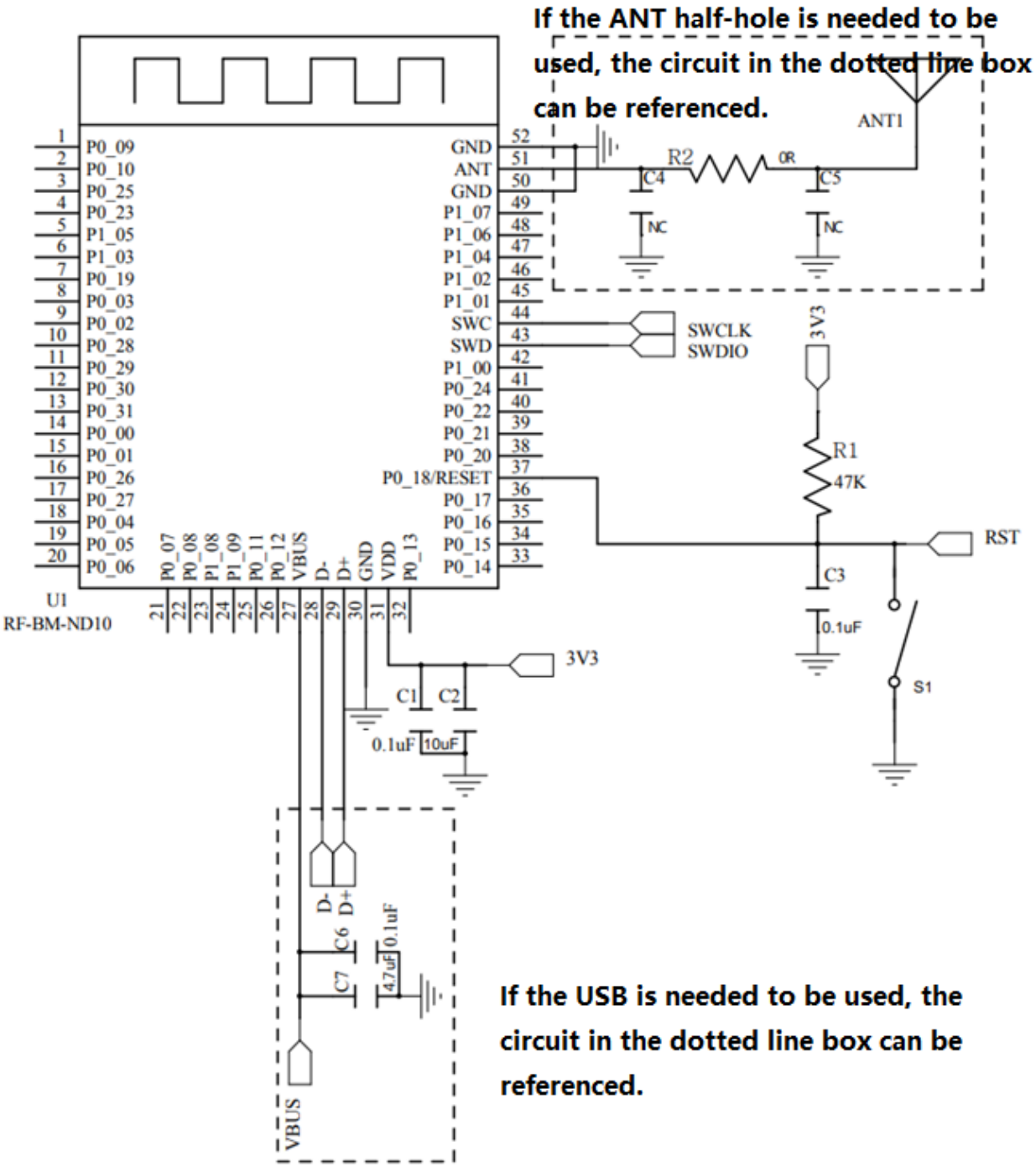

Figure 7. Reference Design of RF-BM-ND10

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.

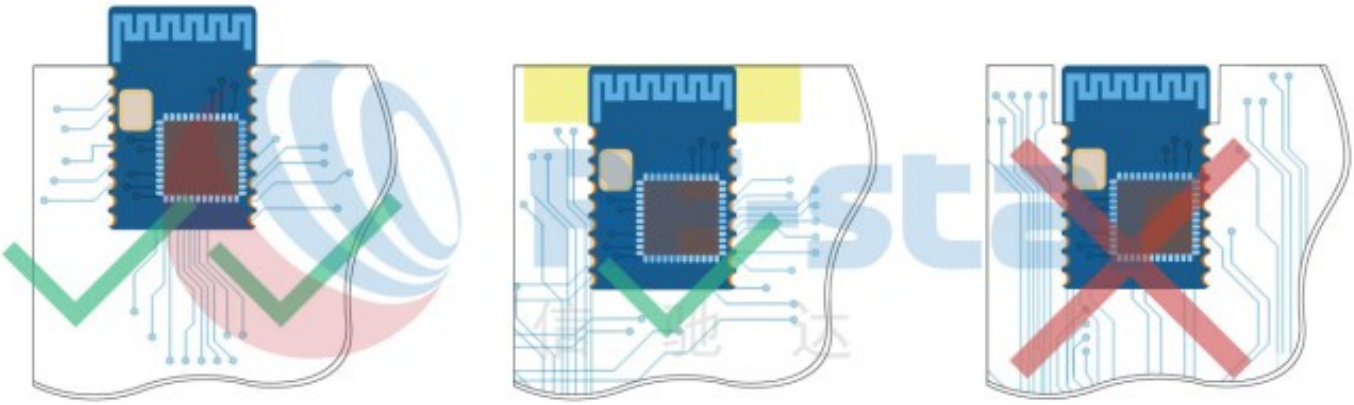

Figure 8. Recommendation of Antenna Layout

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

4.5.2 Antenna Output Mode Modification

1. RF-BM-ND10 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 ANT pin or IPEX connector, pls unsolder the Capacitor in red circle and rotate it 90 degrees clockwise so that to put it into the yellow circle location. The location of the Capacitor is shown in the figure below.

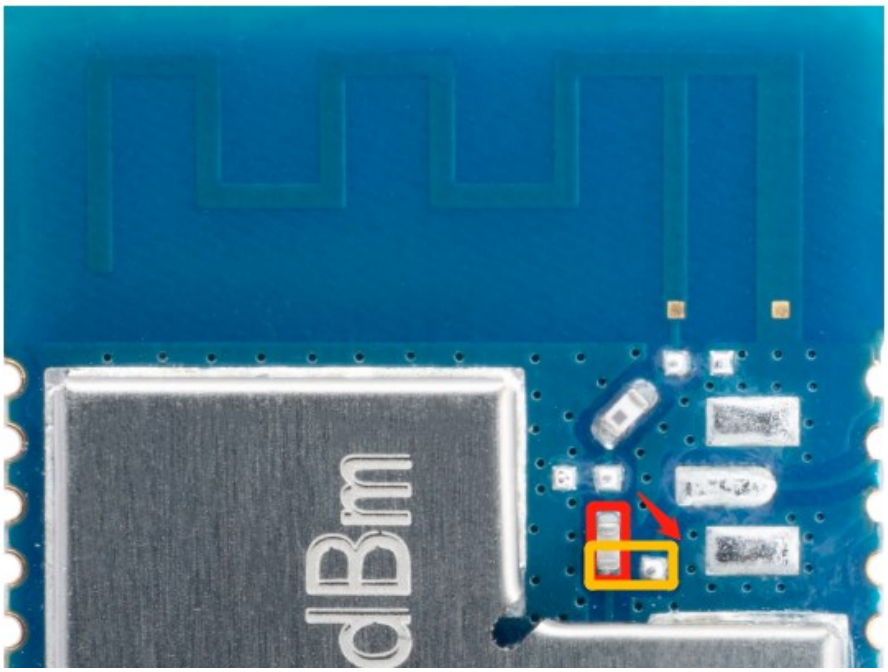

Figure 9. Antenna Output Mode Change of RF-BM-ND10

4.5.3 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.

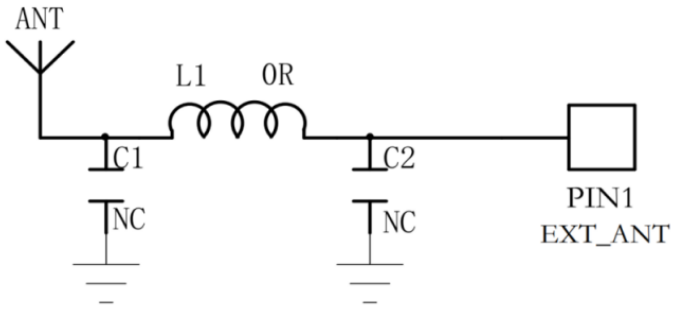

Figure 10. Reference Design of the External Antenna

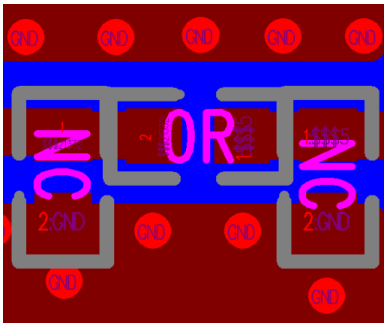

Figure 11. Reference Design of the External Antenna Traces

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.

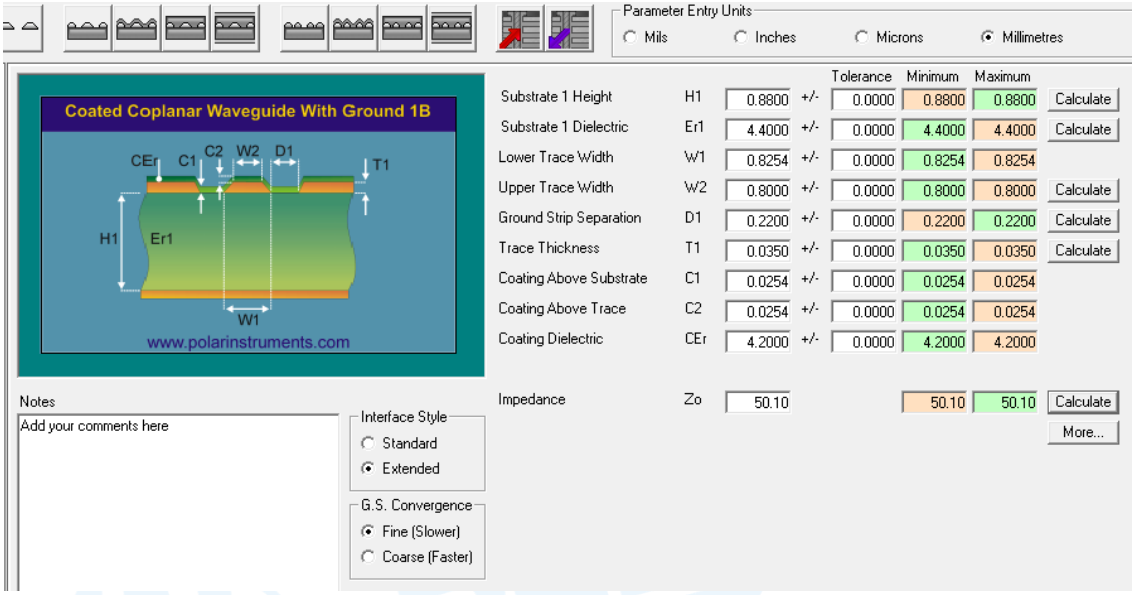

Figure 12. SI9000 Impedance Calculation Diagram

4.5.4 IPEX Connector Specification

RF-BM-ND10 module can be integrated with the IPEX version 1 antenna seat, the specification of the antenna seat is as follows:

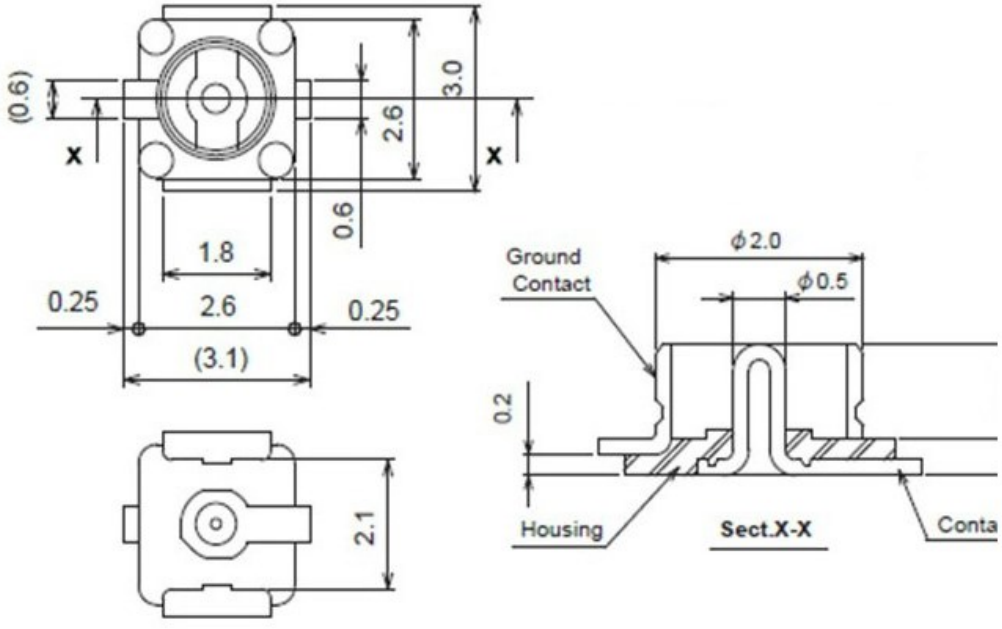

Figure 13. Specification of Antenna Seat

The specification of the IPEX wire end is as follows:

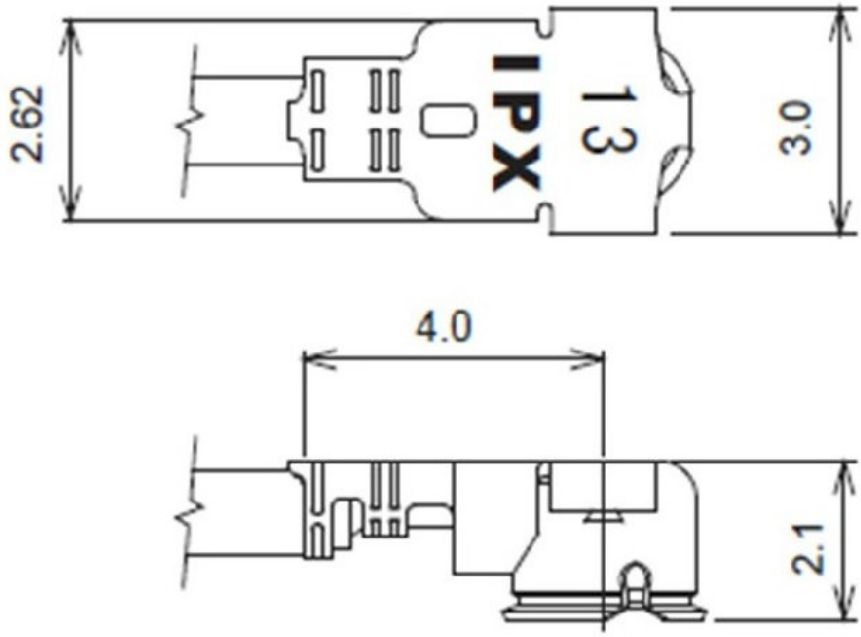

Figure 14. Specification of IPEX Wire

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 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 ℃.

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

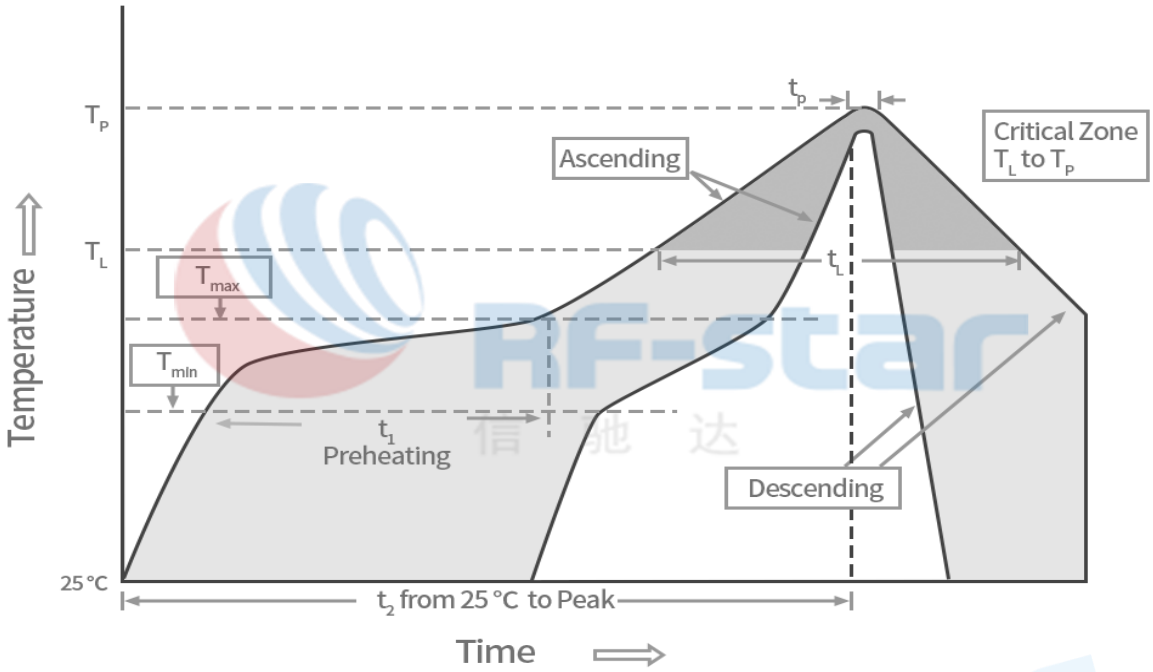

Figure 15. Recommended Reflow for Lead-Free Solder

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.

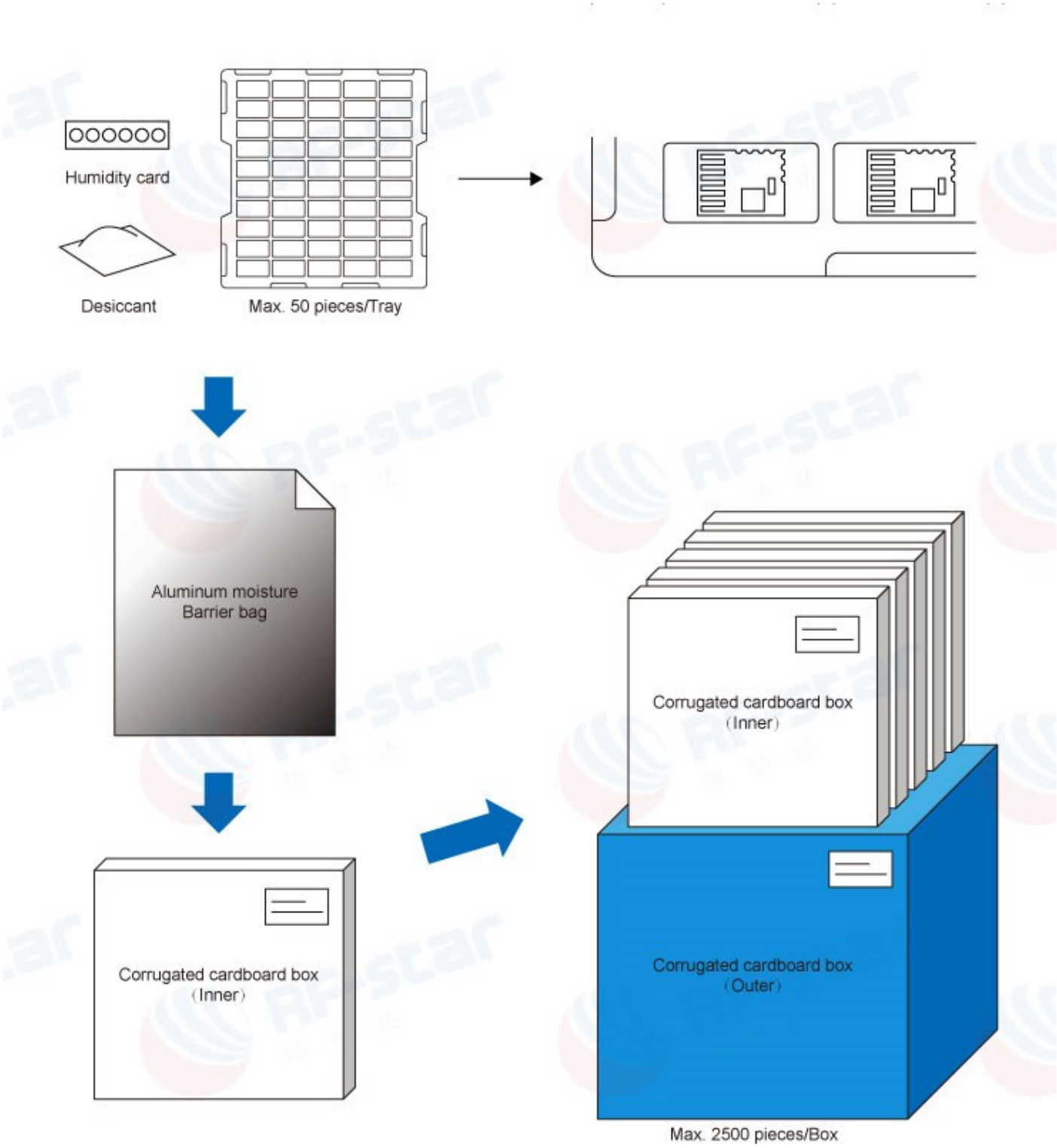

Figure 16. Default Package by Tray

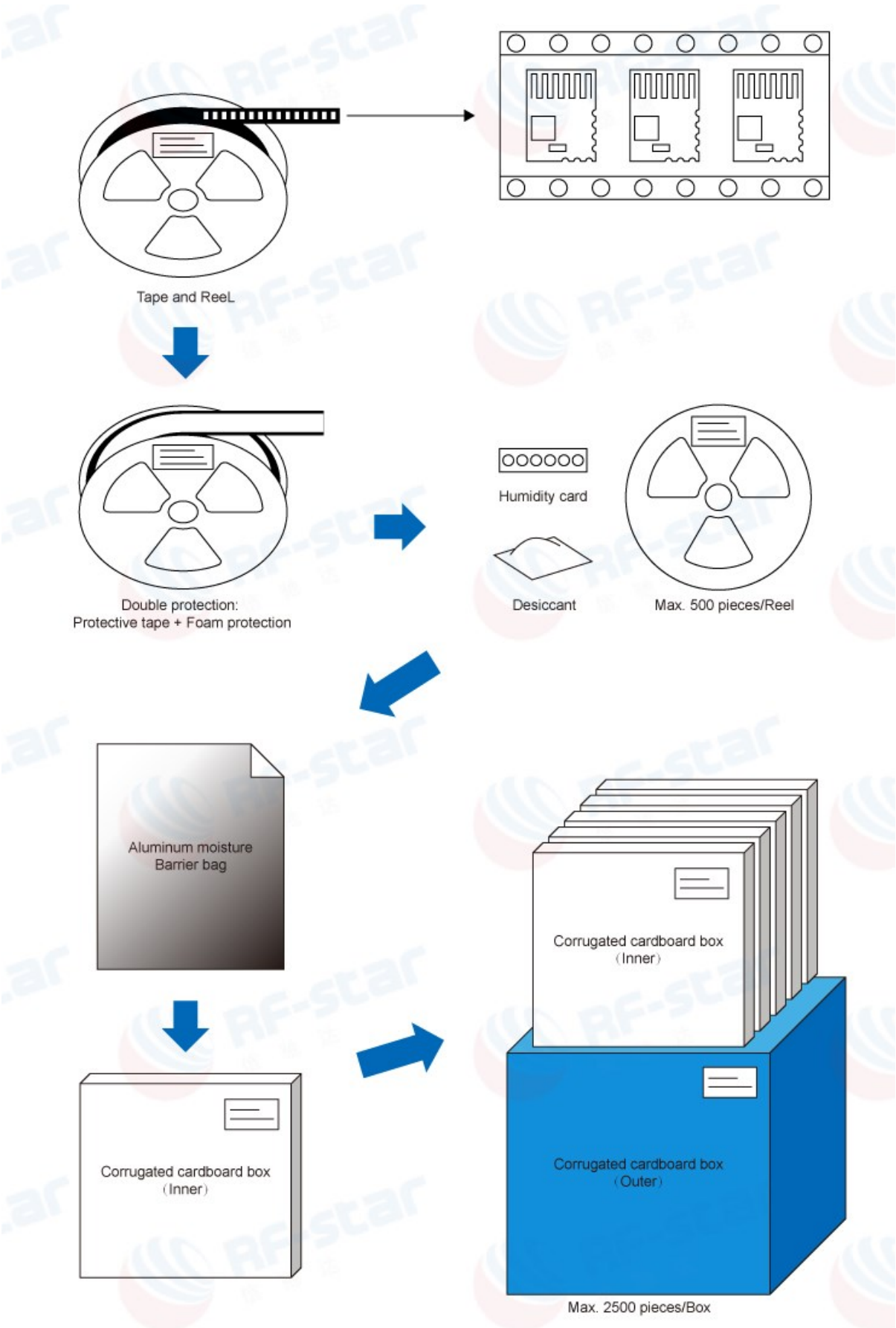

Figure 17. Package by Tape & Reel

6 Revision History

Date	Version No.	Description
2022.11.10	V1.0	The initial version is released.
2022.12.06	V1.0	Update the antenna output way.
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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