RSBRS02ABR

Bluetooth 4.2 Low Energy Module

Version 1.0

Shenzhen RF-star Technology Co., Ltd.

Jan. 10th, 2020

RF-star BLE Module List

Chipset	Core	Flash (Byte)	RAM (KB)	TX Power (dBm)	Model	Antenna	Dimension (mm)	Range (M)	Photo
RS02A1-B	M0+	256	8	5	RSBRS02AB	PCB	11.2×15.2	150	
					RSBRS02ABR	PCB	11.2×15.2	150	
					RSBRS02ABRI	IPEX	11.2×15.2	250	
RS02A1-A	M0+	256	8	7	RSBRS02AA	PCB	11.2×15.2	180	
					RSBRS02AI	IPEX	11.2×15.2	300	

Note:

1. The communication distance is the longest distance obtained by testing the module's maximum transmission power in an open and interference-free environment in sunny weather.
2. Click the picture to buy modules.

1 Device Overview

1.1 Description

RSBRS02ABRis a compact size, cost effective single-mode Bluetooth low energy module based onRF-star256 KB flash SoC RS02A1-B chip with super low power consumption (BLE TX: 13.0 mA @ 0 dBm, BLE RX: 12.0 mA), good noise reduction, better sensitivity, robust transmission distance, and high reliability. The module integrates a 16 MHz crystal, an RF matching filter, apower filter, and a meander line inverted-F PCB antenna.It supports BLE stack v5.0 and is preprogrammed with an easy-to-integrate serial interface communication protocol.

1.2 Key Features

- Frequency: 2402 MHz ~ 2480.0 MHz
- BLE
  - Compiles with Bluetooth v5.0 (1/2 Mbps, extended ADV payload)
  - TX: Up to +5 dBm transceiver output power
  - RX: -94 dBm sensitivity @ 1 Mbps
  - Single-pin antenna interface
  - Link layer and AES/CCM integrated
- CPU
  - 32-bit ARM Cortex-M0+ @ 48 MHz
  - Single cycle multiplier
  - 65 µA/MHz running from SRAM
  - Serial wire debug
- Memory
  - ROM 80 KB
  - SRAM 36 KB, 4 KB Cache
  - Flash 256 KB
  - 32B eFuse
- Power
  - Supply voltage: 2.3 V ~ 3.6 V
  - Hibernation mode (GPIO retention): 2µA @ 3 V, wakeup by GPIO or RTC
  - Sleep mode (BLE linked, 40 KB SRAM data retention): 5µA, wakeup by GPIO, RTC or BLE
  - BLE TX: 13.0 mA @ 0 dBm
  - BLE RX: 12.0 mA
- Clock and Timer
  - 16 MHz crystal and RC oscillator
  - 5 x 16 bit timer
  - Real timer clock (RTC)
  - Watchdog
- Peripherals
  - 11 general purpose I/Os. Function IO any-route support
  - 2 x UARTs with CTS/RTS
  - SPI with master/slave configurable
  - I^2C with master/slave configurable
  - 7816 T-0 master interface
  - Keyboard interface
  - 4-channel 9-bit general purpose ADC
  - Infra-red generator
  - 4 x PWM
  - Quadrature decoder (QDEX) interface
  - 12 MHz clock output
  - RSSI (1 dB resolution)
- DMA
  - 2-channel

1.3 Applications

- Smart toys
- Gaming controller

- E-lock
- Smart lighting
- Electronic shelf label
- Location based service
- Medical devices
- Fitness equipment
- Environmental sensor nodes
- Passive key-less entry (PKE)
- Phone accessories
- Health-care equipment
- Energy harvesting
- Thermometer
- Human input devices
- Wearable

1.4 Functional Block Diagram

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Figure 1. Functional Block Diagram of RSBRS02ABR

1.5 Part Number Conventions

The part numbers are of the form of RSBRS02ABR where the fields are defined as follows:

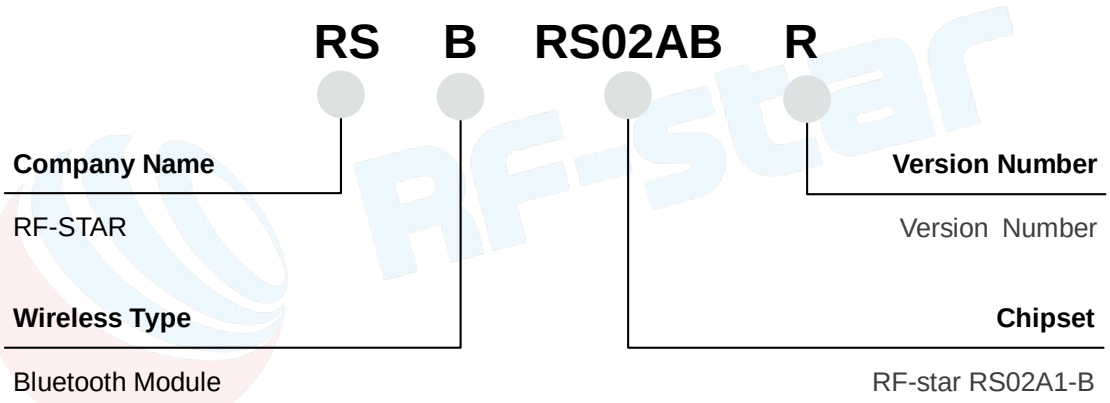

Figure 2. Part Number Conventions of RSBRS02ABR

FCC Statement

FCC Statement

FCC standards: FCC CFR Title 47 Part 15 Subpart C Section 15.247

Integral antenna with antenna gain 0dBi

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.

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

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.

We will retain control over the final installation of the modular such that compliance of the end product is assured. In such cases, an operating condition on the limit modular approval for the module must be only approved for use when installed in devices produced by a specific manufacturer. If any hardware modify or RF control software modify will be made by host manufacturer,C2PC or new certificate should be apply to get approval,if those change and modification made by host manufacturer not expressly approved by the party responsible for compliance ,then it is illegal.

FCC Radiation Exposure Statement

This modular complies with FCC RF 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.

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 Transmitter Module FCC ID: 2ABN2-RSBRS02ABR Or Contains FCC ID: 2ABN2-RSBRS02ABR”

When the module is installed inside another device, the user manual of the host must contain below warning statements;

1. 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.

(2) This device must accept any interference received, including interference that may cause undesired operation.

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.

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

The devices must be installed and used in strict accordance with the manufacturer's instructions as described in the user documentation that comes with the product.

Any company of the host device which install this modular with limit modular approval should perform the test of radiated & conducted emission and spurious emission, etc. according to FCC part 15C : 15.247 and 15.209 & 15.207 ,15B Class B requirement, Only if the test result comply with FCC part 15C : 15.247 and 15.209 & 15.207 ,15B Class B requirement，then the host can be sold legally.

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2 Module Configuration and Functions

2.1 Module Parameter

Table 1. Parameters of RSBRS02ABR

Chipset	RS02A1-B
Supply Power Voltage	2.3 V ~ 3.6 V, recommended to 3.3 V
Modulation	GFSK
Frequency	2402 MHz ~ 2480.0 MHz
Chanel Number	40 (channel spacing of 2 MHz)
Transmit Power	-20.0 dBm ~ +5.0 dBm
Receiving Sensitivity	-94 dBm
GPIO	11
Crystal	16 MHz
ROM	80 KB
SRAM	36 KB, 4 KB Cache
Flash	256 KB
Package	SMT Packaging
Frequency Error	±20 kHz
Dimension	15.1 mm x 11.2 mm x (1.5 ± 0.1) mm
Type of Antenna	PCB Antenna
Operating Temperature	-40 ℃ ~ +85℃
Storage Temperature	-40 ℃ ~ +125 ℃
Hibernation Current	5 μA (Test software RS02A1-B-test.hex)
Current of Broadcast Event	90 μA (Broadcast interval: 200 ms @ 0 dBm)
Current of Connection Event	0.35 mA (Connection interval: 20 ms @ 0 dBm)

2.2 Module Pin Diagram

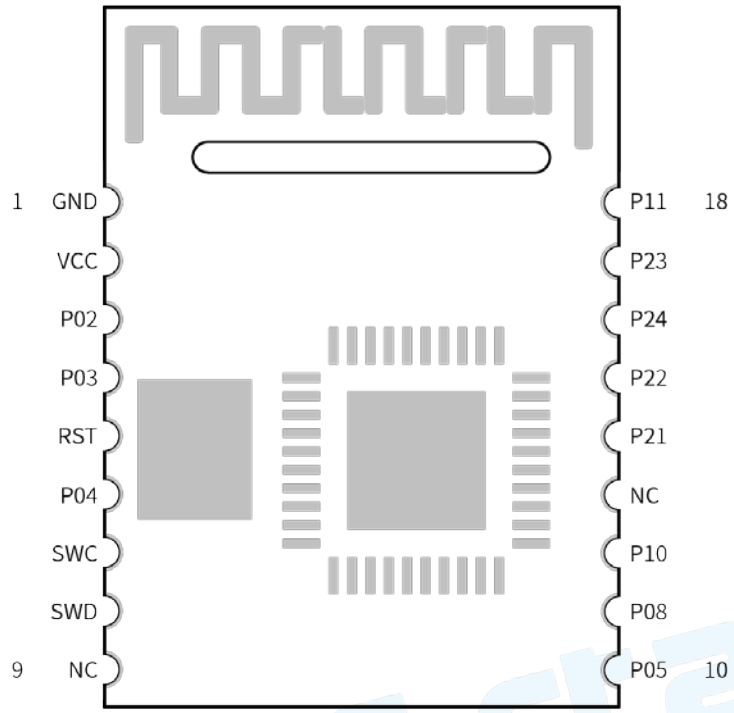

Figure 3. Pin Diagram of RSBRS02ABR

2.3 Pin Functions

Table 2. Pin Functions of RSBRS02ABR

Pin	Name	Chip Pin	Pin Type	Remarks
1	GND	GND	Ground	Ground
2	VCC	VCC	VCC	Power supply: 2.3 V ~ 3.6 V, Recommended to 3.3 V
3	P02	P02	I/O	
4	P03	P03	I/O	
5	RESET	RESET	RESET	Active low
6	P04	P04	I/O	
7	SWC	SWC	SWCLK	Connect J-Link simulator SWCLK
8	SWD	SWD	SWDIO	Connect J-Link simulator SWDIO
9	NC	NC	NC	
10	P05	P05	I/O	
11	P08	P08	I/O	
12	P10	P10	I/O	
13	NC	NC	NC	

14	P21	P21	I/O	
15	P22	P22	I/O	
16	P24	P24	I/O	
17	P23	P23	I/O	
18	P11	P11	I/O	

3 Specifications

3.1 Absolute Maximum Ratings

Table 3. Absolute Maximum Ratings

Identification	Condition	Min.	Typ.	Max.	Unit
Source & IO	Battery mode	2.3	3.3	3.6	V
Operating Temperature	/	-40	25	+85	℃
Environmental Hot Pendulum	/	-20		20	℃ / Min

Notes: To ensure the RF performance, the ripple wave on the source must be less than ±300 mV.

3.2 Handling Ratings

Table 4. Handling Ratings of RSBRS02ABR

Items	Condition	Min.	Typ.	Max.	Unit
Storage Temperature	Tstg	-40	+25	+125	℃
Human Body Model	HBM		±2000		V
Moisture Sensitivity Level			2		
Charged Device Model			±250		V

3.3 RF Characteristics

3.3.1 Receiver RF Specifications

Table 5. Receiver RF Specifications

Parameters		Symbol	Min.	Typ.	Max.	Unit
Sensitivity		Pmin		-94		dBm
Sensitivity (dirty on)		Pmin		-93		dBm
Maximum Input Power		Pmax		0		dBm
In-band Blocking	Co-channel interference	CI0		7		dB
	Interferer at f_{offs} = +1 MHz	CI1		-1		dB
	Interferer at f_{offs} = -1 MHz	CI1		-6		dB
	Interferer at f_{offs} = +2 MHz	CI2		-38		dB
	Interferer at f_{offs} = -2 MHz	CI2		-35		dB
	Interferer at f_{offs} = +3 MHz	CI3		-42		dB
	Interferer at f_{offs} = -3 MHz	CI3		-33		dB
	Interferer at image channel (Fimage)	CI4		-29		dB

	Interferer at image channel (Fimage + 1 MHz)	CI5		-32		dB
	Interferer at image channel (Fimage - 1 MHz)	CI5		-32		dB
Out-of-band Blocking	f= 30 MHz ~ 2000 MHz			>-25		dB
	f= 2000 MHz ~ 2399 MHz			>-30		dB
	f= 2484 MHz ~ 3000 MHz			>-30		dB
	f= 3000 MHz ~ 12750 MHz			>-25		dB
Intermodulation Performance for Wanted Signal at -64 dBm and 1 Mbps BLE, 3rd, 4th and 5thOffset Channel				>-35		dBm
Upper Limit of Monotonous Range		Pissi(max)		-20		dBm

3.3.2 Transceiver RF Specifications

Table 6. Transceiver RF Specifications

Parameters		Symbol	Min.	Typ.	Max.	Unit
Output Power		Ptx	-20		+5	dBm
TX RF Output Steps				3		dB
Average Frequency deviation for 10101010 patterns		ΔF2AVG		238		kHz
Average Frequency deviation for 11110000 patterns		ΔF1AVG		260		kHz
Eye opening = ΔF2AVG/ΔF1AVG		EO	0.88	0.91	0.94	
Frequency Accuracy			-10		10	kHz
Maximum Frequency Drift			-6		5	kHz
Initial Frequency Drift			-5		5	kHz
Drift Rate		FDR	-5.5		14.5	kHz/50μs
Spurious Emissions	F < 1 GHz			-68		dBm
	F > 1 GHz including harmonics			-48		dBm
In-band Emissions	< f ± 2 MHz (f = 2400 MHz ~ 2483.5 MHz, Ptx = 0 dBm)			-45		dBm
	> f ± 3MHz (f = 2400 MHz ~ 2483.5 MHz, Ptx = 0 dBm)			-49		dBm

3.3.3RF Test

When measured on the RSBRS02ABR reference design with T A = 25 ℃, V BAT = 3.3 V with DC/DC, channel of 39th (2442 MHz) enabled unless otherwise noted.

Table 7. Table of RF Test

Test Item	Parameter	Test Value	Unit
Transmitter	Power	<5	dBm
	Frequency Deviation	2.168	kHz
Receiver	Sensitivity (8% PER)	-93.5	dBm

3.4 Power Consumption Summary

Table 8. DC Characteristics Table

Ta=25℃, V_{IN}=3.0V, unless otherwise specified.

Parameter		Ratings			Unit
		Min.	Typ.	Max.	
V_{IH} (Logic-1 input voltage)	VDDR = 3.3 V	2.0			V
	VDDR = 2.5 V	1.7			V
	VDDR = 1.8 V	1.2			V
I_{IH} (Logic-1 input current)				+10	μA
V_{IL} (Logic-0 input voltage)	VDDR = 3.3 V			0.8	V
	VDDR = 2.5 V			0.7	V
	VDDR = 1.8 V			0.6	V
I_{IL} (Logic-0 input current)		-10			μA
V_{OH} (Logic-1 output voltage, IOL = -20/-15/-10/-5 mA)		VDDR -0.4			V
V_{OL} (Logic-0 output voltage, IOH = -20/-15/-10/-5 mA)				0.4	V
Rx Mode, 1 Mbps mode			12		mA
TX mode, 0 dBm output power			13		mA
CPU active (running from flash)			65		μA/MHz
Hibernation mode (SRAM no retention, IO retention and IO wakeup or RTC wakeup)			2		μA
Sleep mode (SRAM 32kB retention, BLE linked, flash sleep included)			5		μA

4 Application, Implementation, and Layout

4.1 Module Photos

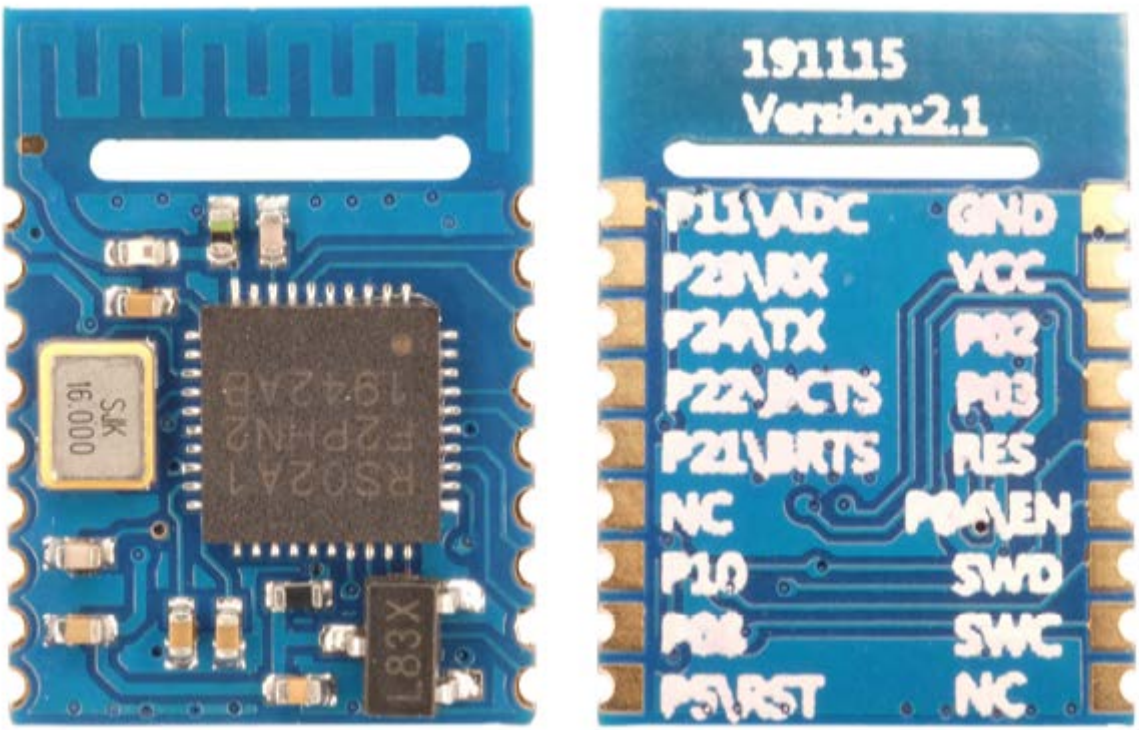

Figure 4. Photos of RSBRS02ABR

4.2 Recommended PCB Footprint

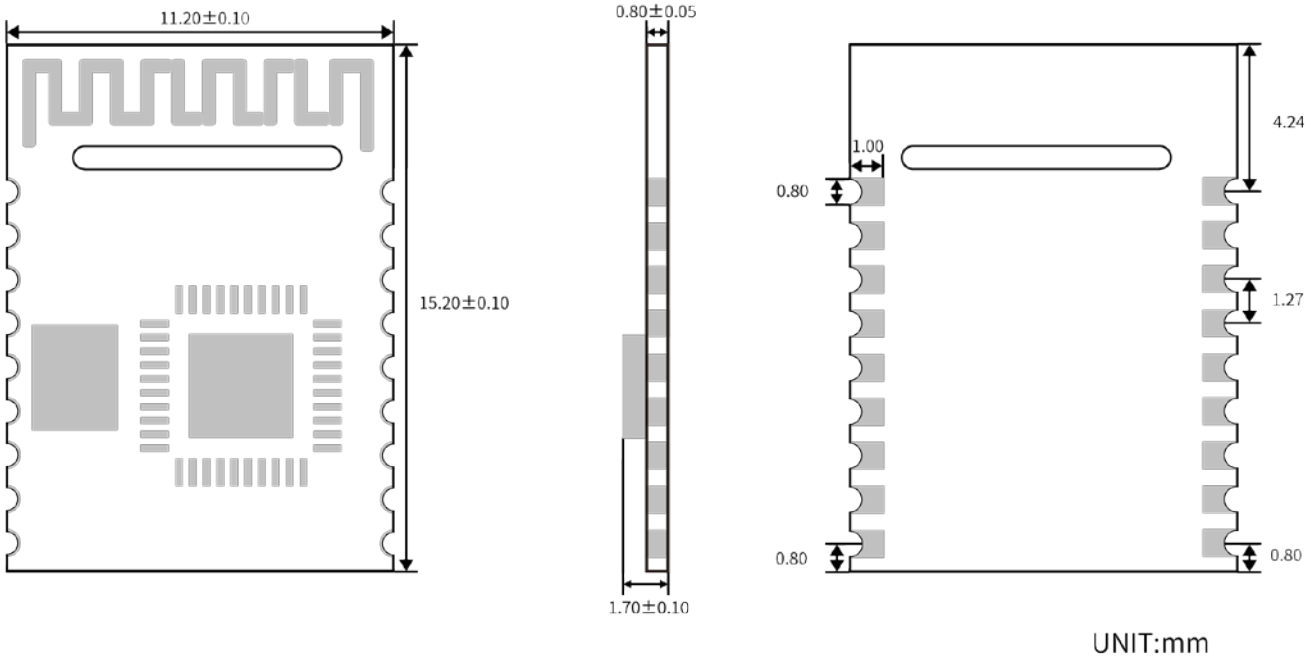

Figure 5. Recommended PCB Footprint of RSBRS02ABR (mm)

4.3 Schematic Diagram

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Figure 6. Schematic Diagram of RSBRS02ABR

4.4 Basic Operation of Hardware Design

1. It is recommended to offerthe module with a DC stabilized power supply, a tiny power supply ripple coefficient and the 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 the stable power supply and no frequently fluctuated 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 module should avoid high-frequency digital routing, high-frequency analog routing and power routing.If it has toroute the wire on the bottom of 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 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 somedegrees;
6. Assuming that there are devices with large electromagnetic interference around the module,which will greatly affect themodule 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 same2.4 GHzphysical layer, for example: USB3.0.
9. 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.
10. The antenna must not be installed inside the metal case, which will cause the transmission distance to be greatly weakened.
11. The recommendation of antenna layout.

    The inverted-F antenna position on PCB is free space electromagnetic radiation. The location and layout of

antenna is a key factor 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 the best to hollow out the antenna position in the following figure so as to ensure that S11 of the module is minimally affected.

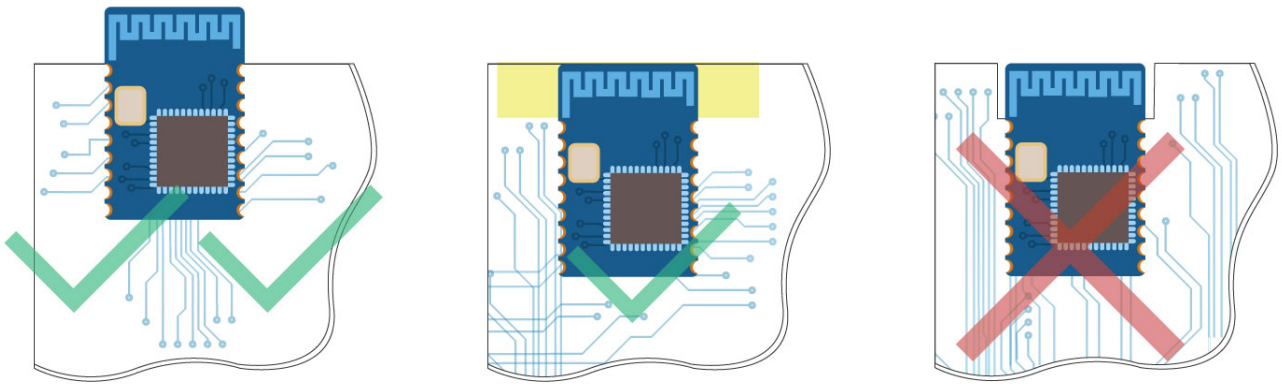

Figure 7. Recommendation of Antenna Layout

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

4.5 Trouble Shooting

4.5.1 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 communication packet loss rate.The performances of ground absorption andreflectionof 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 seaside are poor.
3. The signal attenuation will be very obvious, if there is a metal near the antenna or themodule is placed inside of the metal shell.
4. The incorrect power register set or the high data ratein an 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 module or the poor quality of antenna will affect the communication distance.

4.5.2 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 the stable power supplyand no frequently fluctuatedvoltage.
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.

4.5.3 High Bit Error Rate

1. There areco-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 reliability.
3. If the extension wire or feeder wire is of poor quality or too long, the bit error rate will be high.

4.6Electrostatics Discharge Warnings

The module will be damaged for the discharge of static. RF-star suggest 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 module, even causing the failure.

4.7 Soldering and Reflow Condition

1. Heating method: Conventional Convection or IR/convection.
2. Temperature measurement: Thermocouple d = 0.1 mm to 0.2 mm CA (K) or CC (T) at soldering portion or equivalent methods.
3. Solder paste composition: Sn/3.0 Ag/0.5 Cu
4. Allowable reflow soldering times: 2 times based on the following reflow soldering profile.
5. Temperature profile: Reflow soldering shall be done according to the following temperature profile.

6. Peak temperature: 245 ℃.

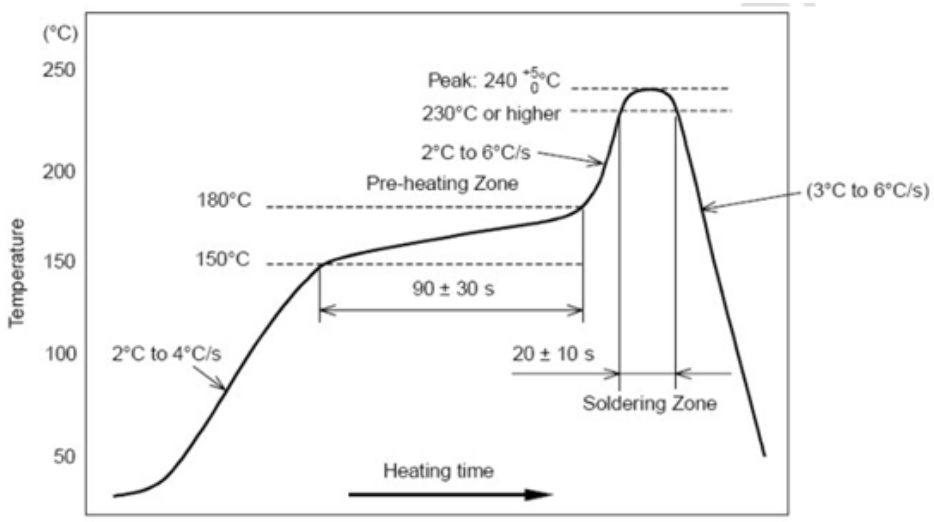

Figure 8. Recommended Reflow for Lead Free Solder

4.8 Optional Packaging

Figure 9. Optional Packaging Mode

Note: Default tray packaging.

5 Revision History

Date	Version No.	Description	Author
2020.01.03	V1.0	The initial version is released.	Aroo Wang
2020.01.10	V1.0	Add RF-star BLE module list.	Sunny Li

6 Contact Us

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