



RF-BM-S02I








Bluetooth Low Energy Module

Version 1.0

Shenzhen RF-star Technology Co., Ltd.

May 15th, 2020

TI CC254X BLE Module List

Chipset	Core	Flash (Byte)	RAM (KB)	TX Power (dBm)	Model	Antenna	Dimension (mm)	Range (M)	Photo
CC2540	8051	256	8	+4	RF-BM-S01	PCB	13.7 × 17.4	100	
					RF-BM-S02	PCB	11.2 × 15.2	100	
					RF-BM-S02I	IPEX	11.2 × 15.2	150	
					RF-CC2540A1	PCB	15.2 × 24.1	100	
CC2541	8051	256	8	0	RF-BM-S01A	PCB	13.7 × 17.4	70	
					RF-BM-S02A	PCB	11.2 × 15.2	70	
					RF-BMPA-2541B1	PCB / IPEX	13.7 × 31.4	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

RF-BM-S02I is a Bluetooth Low Energy (BLE) module based on TI CC2540F256, an 8051 core BLE System-on-Chip (SoC). This PCB module integrates a 32 MHz crystal, a 32.768 kHz crystal, an LC balun, an RF matching filter, and a meander line IPEX connector. It is pre-programmed with the BLE 4.0 stack and an application communication protocol over its full speed USB interface. It can be used to design a USB dongle to easily establish BLE connection from a device to smart phones. Very low-power sleep modes are available. Short transition times between operating modes further enable low power consumption. RF-BM-S02I is pin-compatible with the RF-BM-S02 and RF-BM-S02A in SMT package, if the USB is not used on the RF-BM-S02 & RF-BM-S02I and the I²C/extra I/O is not used on the RF-BM-S02A. Compared to the RF-BM-S02I and RF-BM-S02, the RF-BM-S02A provides lower RF current consumption. The RF-BM-S02A does not have the USB interface of the RF-BM-S02 and RF-BM-S02I, and provides lower maximum output power in TX mode. The RF-BM-S02A also adds a HW I²C interface.

1.2 Key Features

- RF
 - Bluetooth low energy 4.0 compatible protocol stack for single-mode
 - Excellent link budget (up to 97 dBm), Enabling long-range applications without external front end
 - Accurate Digital Received Signal-Strength Indicator (RSSI)
 - Suitable for systems targeting compliance with worldwide radio frequency regulations: ETSI EN 300 328 and EN 300 440 Class 2 (Europe), FCC CFR47 Part 15 (US), and ARIB STD-T66 (Japan)
- Microcontroller
 - High-performance and low-power 8051 microcontroller core
 - In-system-programmable flash of 256 KB
 - 8-KB SRAM
- Layout
 - Few external components
 - 15.1 mm x 12.1 mm SMT Package
 - Pin-compatible with RF-BM-S02 and RF-BM-S02A (when not using USB or I2C)
- Peripherals
 - 12 bit ADC with eight channels and configurable resolution
 - Integrated high-power op-amp and ultra-low power comparator
 - General-purpose timers (one 16-bits, two 8-bits)
 - 13 General-purpose I/O pins (19 × 4 mA, 2 × 20 mA)
 - 32 kHz sleep timer with capture
 - Two powerful USARTs with support for several serial protocols
 - Full speed USB interface
 - IR generation Circuitry
 - AES security coprocessor
 - Battery monitor and temperature sensor
 - Each CC2540 contains a unique 48-bit IEEE address
- Low Power
 - Active mode RX down to 19.6 mA
 - Active mode TX (-6 dBm): 24 mA

- Power mode 1 (3- μ s wake-up): 235 μ A
- Power mode 2 (sleep timer on): 0.9 μ A
- Power mode 3 (external interrupts): 0.4 μ A
- Wide supply voltage range (2.0 V ~ 3.6 V)
- Full RAM and register retention in all power modes

1.3 Applications

- 2.4-GHz Bluetooth low energy system
- Mobile phone accessories
- Sports and leisure equipment
- Consumer electronics
- Human interface devices
- Keyboard, mouse
- Remote control
- USB dongles
- Health care and medical
- Smart lighting

1.4 Functional Block Diagram

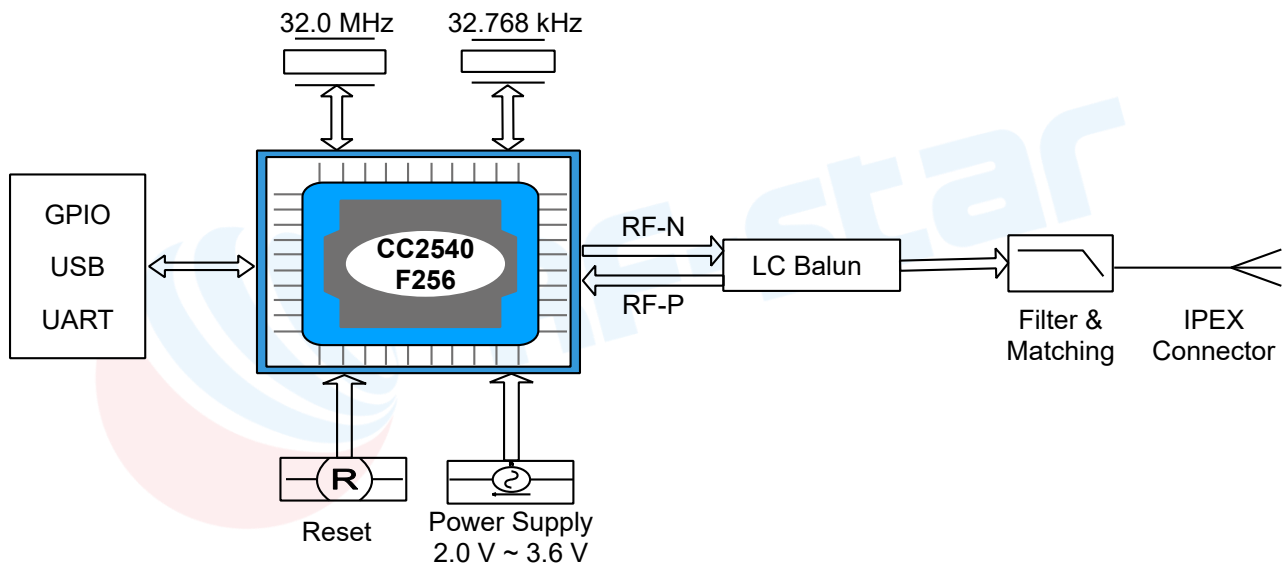


Figure 1. Functional Block Diagram of RF-BM-S02I

1.5 Part Number Conventions

The part numbers are of the form of RF-BM-S02I where the fields are defined as follows:

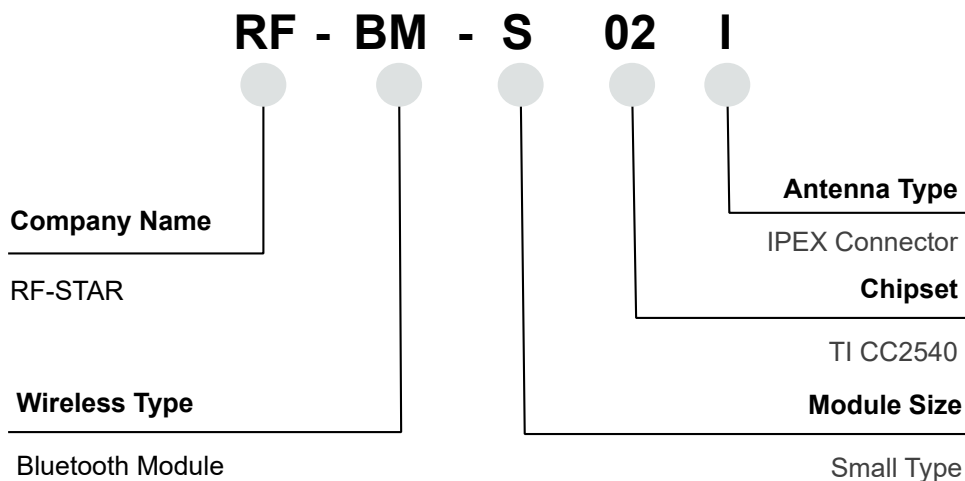


Figure 2. Part Number Conventions of RF-BM-S02I

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2 Module Configuration and Functions

2.1 Module Parameters

Table 1. Parameters of RF-BM-S02I

Chipset	CC2540F256
Supply Power Voltage	2.0 V ~ 3.6 V, recommended to 3.3 V
Frequency	2402 MHz ~ 2480 MHz
Transmit Power	Programmable: -23.0 dBm ~ +4.0 dBm
Receiving Sensitivity (low-gain mode)	-87 dBm
Receiving Sensitivity (high-gain mode)	-93 dBm
GPIO	13
Crystal	32 MHz, 32.768 kHz
RAM	8 KB
Flash	256 KB
Package	SMT Packaging
Frequency Error	±20 kHz
Dimension	15.2 mm x 11.2 mm x (2.1 ± 0.1) mm
Type of Antenna	IPEX Connector
Operating Temperature	-40 °C ~ +85 °C
Storage Temperature	-40 °C ~ +125 °C
RX Current	19.6 mA
TX Current (-6 dBm)	24.0 mA
Power mode 1 (3-μs wake-up)	235 μA
Power mode 2 (sleep timer on)	0.9 μA
Power mode 3 (external interrupts)	0.4 μA

2.2 Module Pin Diagram

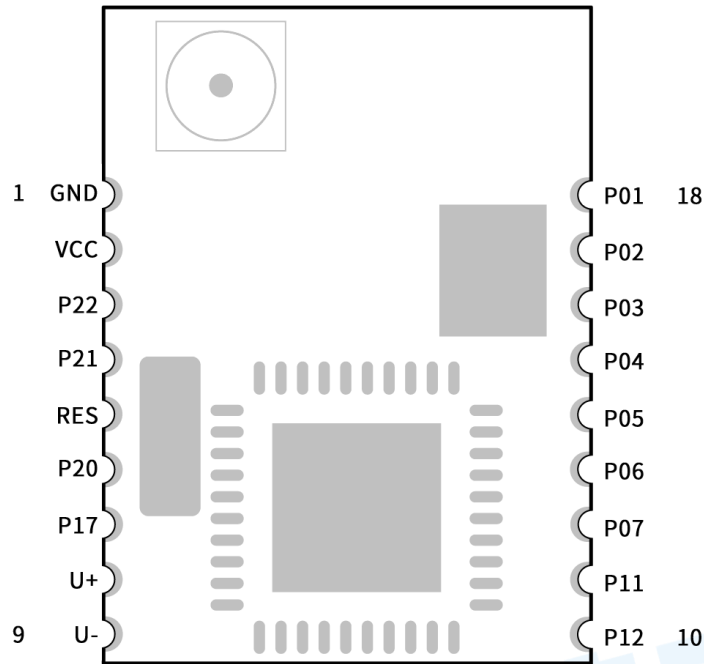


Figure 3. Pin Diagram of RF-BM-S02I

2.3 Pin Functions

Table 2. Pin Functions of RF-BM-S02I

Pin	Name	Chip Pin	Pin Type	Description
1	GND	-	GND	Ground
2	VCC	-	Power	Power supply 2.0 V ~ 3.6 V
3	P22	P2.2	I/O	
4	P21	P2.1	I/O	
5	RESET	RST	RESET	
6	P20	P2.0	I/O	
7	P17	P1.7	I/O	
8	USB_P	USB+	USB+	USB+
9	USB_N	USB-	USB-	USB-
10	P12	P1.2	I/O	
11	P11	P1.1	I/O	
12	P07	P0.7	I/O	
13	P06	P0.6	I/O	
14	P05	P0.5	I/O	

15	P04	P0.4	I/O	
16	P03	P0.3	I/O	
17	P02	P0.2	I/O	
18	P01	P0.1	I/O	



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-S02I

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

3.2 Handling Ratings

Table 4. Handling Ratings of RF-BM-S01

Items	Condition	Min.	Typ.	Max.	Unit
Storage Temperature	Tstg	-40	+25	+125	°C
Human Body Model	HBM		±2000		V
Moisture Sensitivity Level			2		
Charged Device Model			±750		V

3.3 Receiver RF Parameters

Table 5. Table of Receiver RF Parameters

When measured on the RF-BM-S02I reference design with T A = 25 °C, V BAT = 3.3 V, Fc = 2440 MHz with DC/DC enabled unless otherwise noted.

1 MBPS, GFSK, 250 kHz deviation, Bluetooth low energy mode, and 0.1% BER¹.

Parameters	Test Condition	Min.	Typ.	Max.	Unit
Receiver Sensitivity ²	High-gain mode		-93		dBm
Receiver Sensitivity ²	Standard mode		-87		dBm
Saturation ³			6		dBm
Co-channel Rejection ³			-5		dB
Adjacent-channel Rejection ³	±1 MHz		-5		dB
Adjacent-channel Rejection ³	±2 MHz		30		dB
Blocking ³			-30		dBm

Frequency Error Tolerance⁴	Including both initial tolerance and drift	-250		250	kHz
Symbol Rate Error Tolerance⁵		-80		80	ppm
Spurious Emission. Only Largest Spurious Emission Stated within Each Band.	Conducted measurement with a 50-Ω single-ended load. Complies with EN 300 328, EN 300 440 class 2, FCC CFR47, Part 15 and ARIB STD-T-66		-75		dBm
Current Consumption	RX mode, standard mode, no peripherals active, low MCU activity, MCU at 250 kHz		19.6		mA
	RX mode, high-gain mode, no peripherals active, low MCU activity, MCU at 250 kHz		22.1		mA

Note:

- 0.1% BER maps to 30.8% PER.
- The receiver sensitivity setting is programmable using a TI BLE stack vendor-specific API command. The default value is standard mode.
- Results based on standard gain mode.
- Difference between center frequency of the received RF signal and local oscillator frequency.
- Difference between incoming symbol rate and the internally generated symbol rate.

3.4 Transceiver RF Parameters

Table 6. Table of Transceiver RF Parameters

When measured on the RF-BM-S021 reference design with T A = 25 °C, V BAT = 3.3 V, Fc = 2440 MHz with DC/DC enabled unless otherwise noted.

Parameters	Test Condition	Min.	Typ.	Max.	Unit
Output Power	Delivered to a single-ended 50-Ω load through a balun using maximum recommended output power setting		4		dBm
	Delivered to a single-ended 50-Ω load through a balun using minimum recommended output power setting		-23		dBm
Programmable Output Power Range	Delivered to a single-ended 50 Ω load through a balun		27		dB
Spurious Emissions	Conducted measurement with a 50-Ω single-ended load. Complies with EN 300 328, EN 300 440 class 2, FCC CFR47, Part 15 and ARIB STD-T-66		-41		dBm
Current Consumption	TX mode, -23 dBm output power, no peripherals		21.1		mA

		active, low MCU activity, MCU at 250 kHz			
		TX mode, -6 dBm output power, no peripherals active, low MCU activity, MCU at 250 kHz		23.8	mA
		TX mode, 0 dBm output power, no peripherals active, low MCU activity, MCU at 250 kHz		27	mA
		TX mode, +4. dBm output power, no peripherals active, low MCU activity, MCU at 250 kHz		31.6	mA
Optimum Impedance	Load	Differential impedance as seen from the RF port (RF_P and RF_N) toward the antenna		70 + j30	Ω



4 Application, Implementation, and Layout

4.1 Module Photos



Figure 4. Photos of RF-BM-S02I

4.2 Recommended PCB Footprint

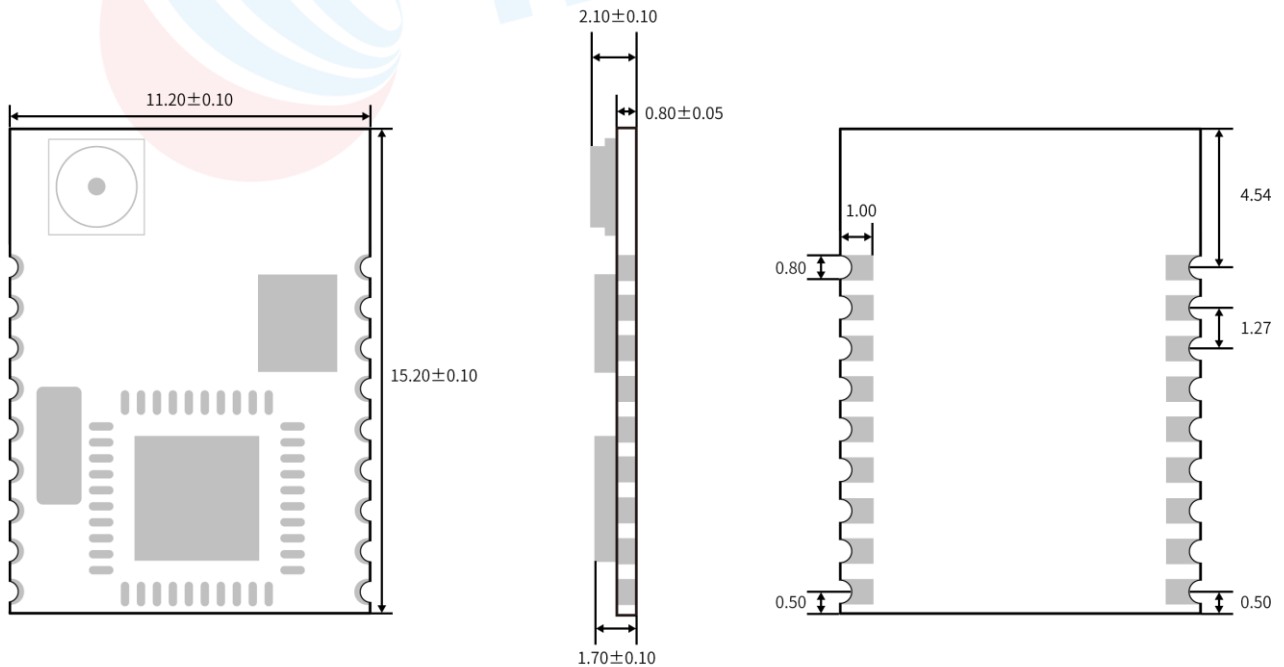


Figure 5. Recommended PCB Footprint of RF-BM-S02I (mm)

4.3 Antenna

RF-BM-S02I module is integrated the IPEX version 1 antenna seat, the specification of antenna seat is as follow:

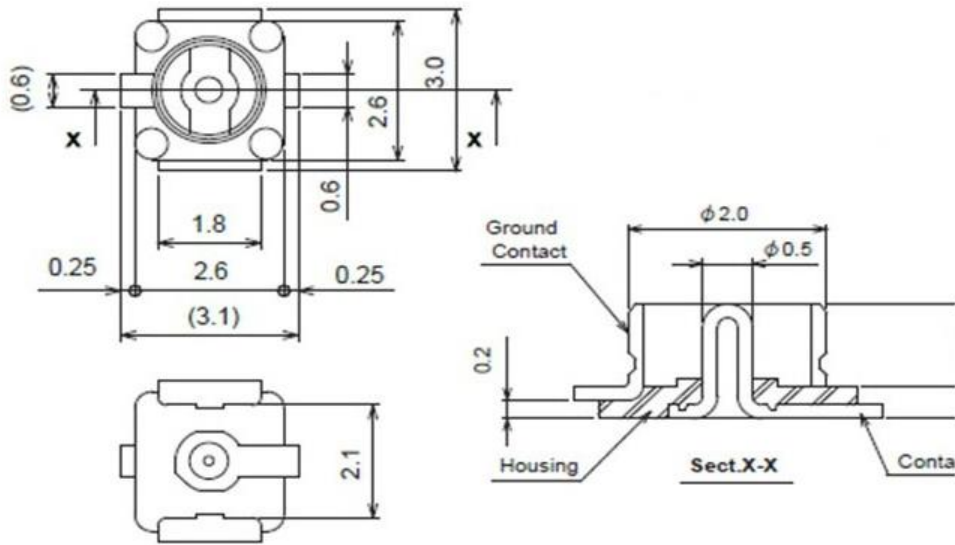


Figure 6. Specification of Antenna Seat

The specification of IPEX wire end is as follow:

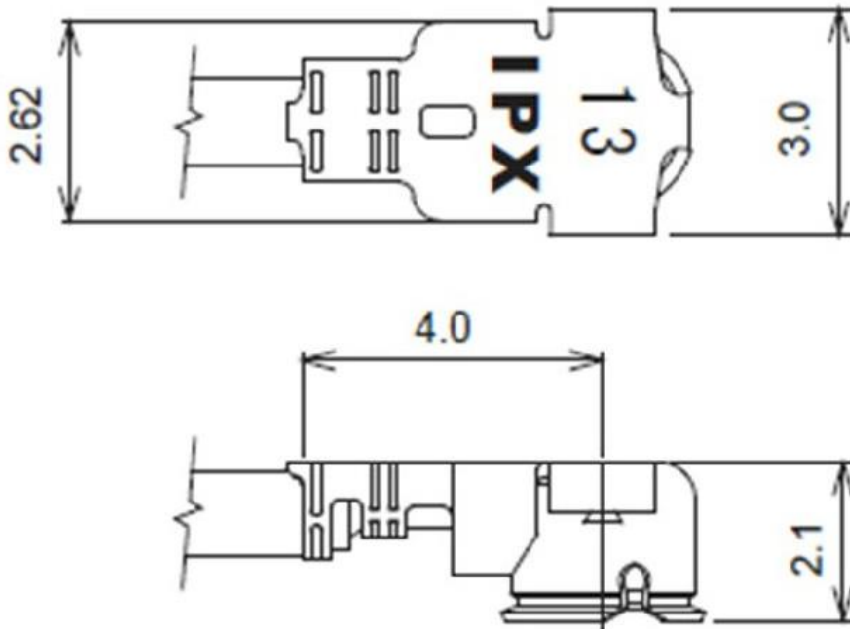


Figure 7. Specification of IPEX Wire

4.4 Schematic Diagram

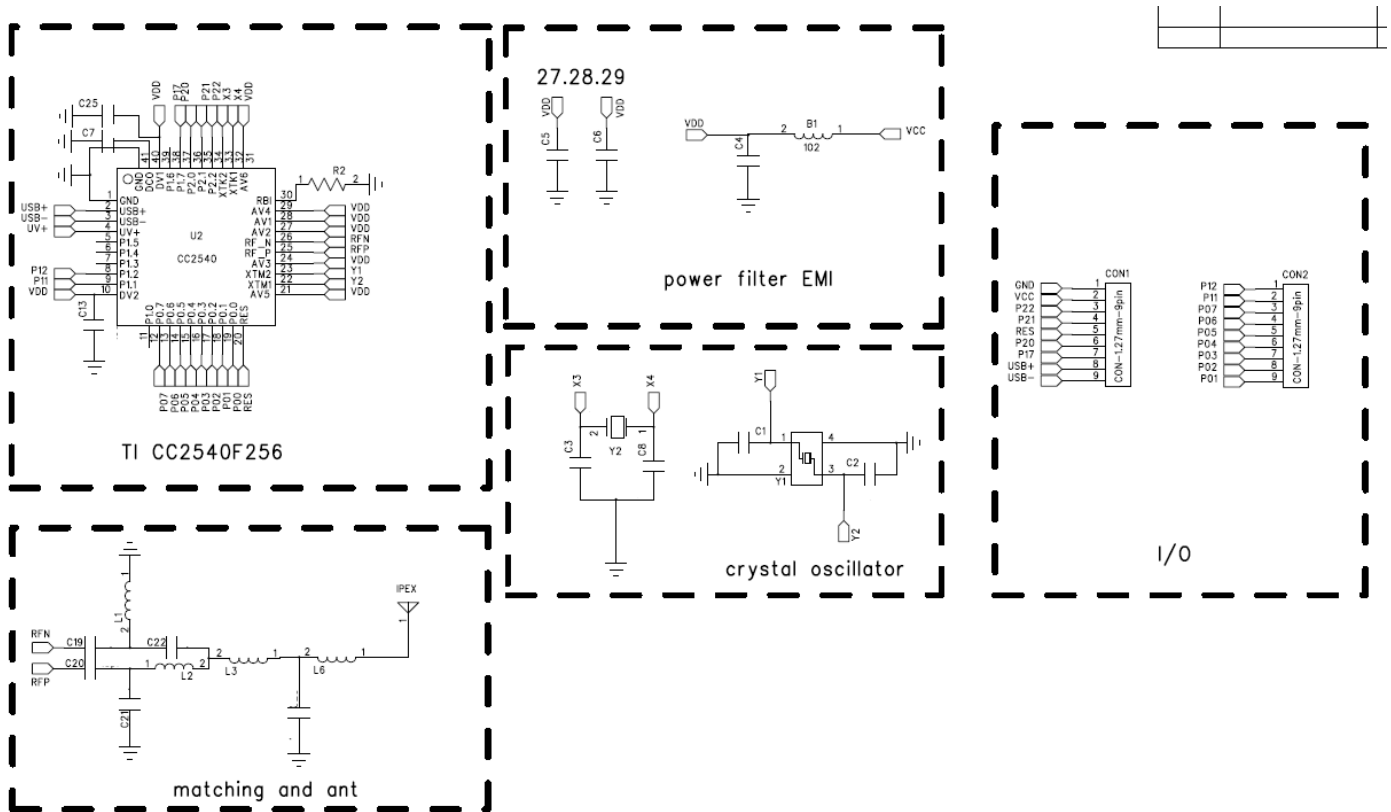


Figure 8. Schematic Diagram of RF-BM-S021

4.5 Basic Operation of Hardware Design

1. It is recommended to offer the 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 to route 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 some degrees;
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.
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.

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 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 seaside are poor.
3. The signal attenuation will be very obvious, if there is a metal near the antenna or the module is placed inside of the metal shell.
4. The incorrect power register set or the high data rate in 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.

4.6.2 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 the stable power supply and no frequently fluctuated 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.

4.6.3 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 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 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.

4.8 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 °C.

Table 7. 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 °C	150 °C
Max. Preheating Temperature (T_{max})	150 °C	200 °C
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 °C/s	Max. 3 °C/s
Liquid Temperature (T_L)	183 °C	217 °C
Time above Liquidus (t_L)	60 s ~ 90 s	30 s ~ 90 s
Peak Temperature (T_p)	220 °C ~ 235 °C	230 °C ~ 250 °C
Average Descend Rate (T_p to T_{max})	Max. 6 °C/s	Max. 6 °C/s
Time from 25 °C to Peak Temperature (t_2)	Max. 6 minutes	Max. 8 minutes
Time of Soldering Zone (t_p)	20±10 s	20±10 s

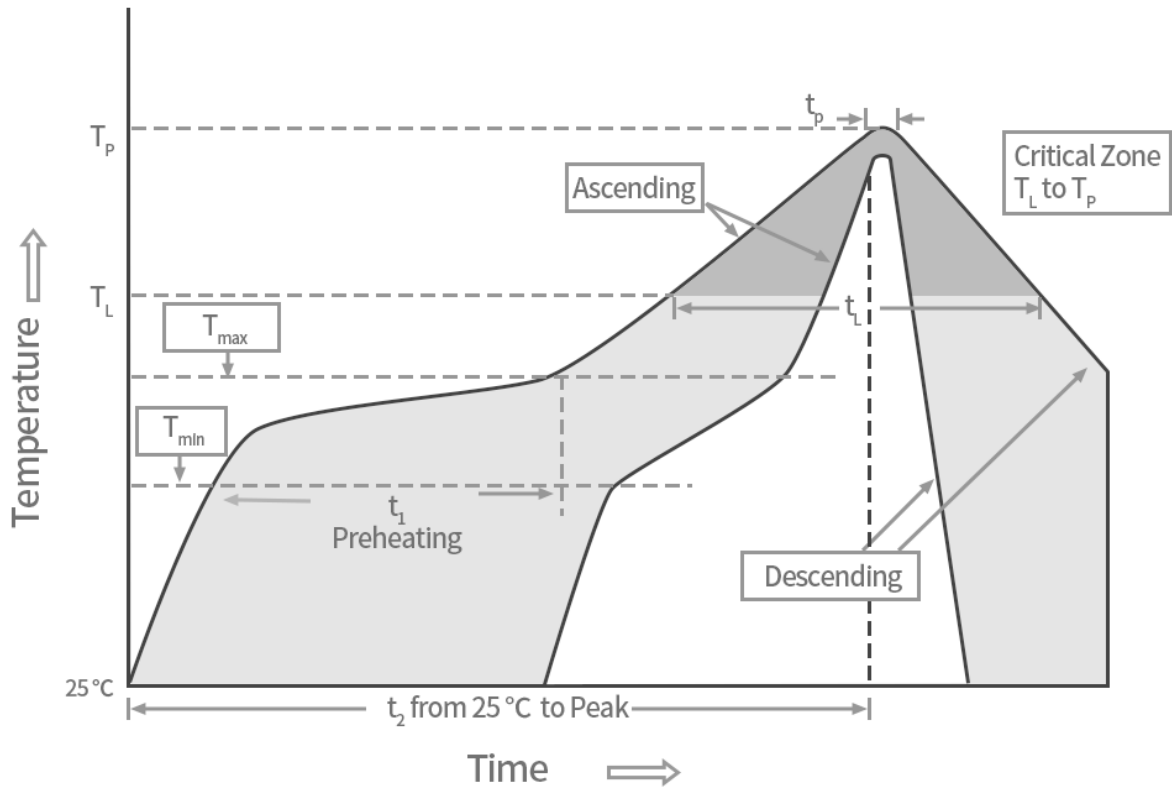


Figure 9. Recommended Reflow for Lead Free Solder

4.9 Optional Packaging



Figure 10. Optional Packaging Mode

Note: Default tray packaging.

5 Certification

5.1 Reach

Certificate No.: C150918025001

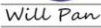
Verification of Conformity	
Applicant Name:	SHENZHEN RFSTAR TECHNOLOGY CO.,LTD
Address:	ZF BLOCK8,DIET A,INTERNET INDUSTRY BASE,BAOYUAN ROAD ,JIAOAN DIST.,SHENZHEN,CHINA
hereby declares that the product	
Product Tested:	BLE BLUETOOTH MODULE,ZIGBEE MODULE,WIFI MODULE
Model Number:	RF-8M-S01;RF-8M-S02;RF-8M-S03A;RF-8M-S03B;RF-8M-S03C;RF-8M-S03D;RF-8M-S03E;RF-8M-S03F;RF-8M-S03G;RF-8M-S03H;RF-8M-S03I;RF-8M-S03J;RF-8M-S03K;RF-8M-S03L;RF-8M-S03M;RF-8M-S03N;RF-8M-S03O;RF-8M-S03P;RF-8M-S03Q;RF-8M-S03R;RF-8M-S03S;RF-8M-S03T;RF-8M-S03U;RF-8M-S03V;RF-8M-S03W;RF-8M-S03X;RF-8M-S03Y;RF-8M-S03Z;RF-8M-S04;RF-8M-S05;RF-8M-S06;RF-8M-S07;RF-8M-S08;RF-8M-S09;RF-8M-S10;RF-8M-S11;RF-8M-S12;RF-8M-S13;RF-8M-S14;RF-8M-S15;RF-8M-S16;RF-8M-S17;RF-8M-S18;RF-8M-S19;RF-8M-S20;RF-8M-S21;RF-8M-S22;RF-8M-S23;RF-8M-S24;RF-8M-S25;RF-8M-S26;RF-8M-S27;RF-8M-S28;RF-8M-S29;RF-8M-S30;RF-8M-S31;RF-8M-S32;RF-8M-S33;RF-8M-S34;RF-8M-S35;RF-8M-S36;RF-8M-S37;RF-8M-S38;RF-8M-S39;RF-8M-S40;RF-8M-S41;RF-8M-S42;RF-8M-S43;RF-8M-S44;RF-8M-S45;RF-8M-S46;RF-8M-S47;RF-8M-S48;RF-8M-S49;RF-8M-S50;RF-8M-S51;RF-8M-S52;RF-8M-S53;RF-8M-S54;RF-8M-S55;RF-8M-S56;RF-8M-S57;RF-8M-S58;RF-8M-S59;RF-8M-S60;RF-8M-S61;RF-8M-S62;RF-8M-S63;RF-8M-S64;RF-8M-S65;RF-8M-S66;RF-8M-S67;RF-8M-S68;RF-8M-S69;RF-8M-S70;RF-8M-S71;RF-8M-S72;RF-8M-S73;RF-8M-S74;RF-8M-S75;RF-8M-S76;RF-8M-S77;RF-8M-S78;RF-8M-S79;RF-8M-S80;RF-8M-S81;RF-8M-S82;RF-8M-S83;RF-8M-S84;RF-8M-S85;RF-8M-S86;RF-8M-S87;RF-8M-S88;RF-8M-S89;RF-8M-S90;RF-8M-S91;RF-8M-S92;RF-8M-S93;RF-8M-S94;RF-8M-S95;RF-8M-S96;RF-8M-S97;RF-8M-S98;RF-8M-S99;RF-8M-S100
Ratings and principal characteristics:	The mixed test result is PASS, Conform to the requirements of the regulations
Conforms to the following specifications	Article 33 of Regulation (EC) No 1907/2006 requires supplier of an article containing a substance meeting the criteria in Article 37 and identified in accordance with Article 59(1) in a concentration above 0.1% (w/w) shall provide the recipient of the article with sufficient information, available to the supplier, to allow safe use of the article including, as a minimum, the name of that substance.
Relevant Standards/ Specifications/ Directives	
Verification Issuing Office Name & Address	Eurores Consumer Products Testing Service Co.,Ltd 3F, Huafeng Building No.77, Hefan Avenue Houjie Town, Dongguan City, Guangdong Province, China
Date of tests	Sep 22, 2019
Report no.	C150918025001
Signature:	
Name:	Will Pan
Position:	CPST
Date:	2019-9-22

Figure 11. Reach Certificate

6 Revision History

Date	Version No.	Description	Author
2018.01.23	V1.0	The initial version is released.	Aroo Wang
2018.04.25	V1.0	Update module parameters.	Aroo Wang
2018.08.02	V1.0	Update company address.	Aroo Wang
2020.05.15	V1.0	Add TI CC254X BLE module list.	Sunny Li

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.szrfstar.com.



7 Contact Us

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