RF-BM-2652P3 SimpleLink™ Multiprotocol BLE5.1 & ZigBee Wireless Module with Integrated Power Amplifier and Flash

Version 1.0

Shenzhen RF-star Technology Co., Ltd.

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TI CC26XX BLE Module List

Chipset	Core	Flash (KB)	RAM (KB)	TX Power (dBm)	Model	Antenna	Dimension (mm)	Range (M)	Photo
CC2640 R2FRSM	M3	128	28	2	RF-BM-4044B2	PCB	11.2 × 16.6	300	
					RF-BM-4044B3	IPEX	11.2 × 15.2	500	
					RF-BM-4044B4	CHIP	8 × 8	150	
CC2640 R2FRGZ	M3	128	28	5	RF-BM-4077B1	PCB	17 × 23.5	500	
CC2640 R2FRGZ – Q1					RF-BM-4077B2	PCB	17 × 23.5	500	
CC2642R	M4F	352	80	5	RF-BM-2642B1	PCB	17 × 23.5	500	
CC2652R	M4F	352	80	5	RF-BM-2652B1	PCB	17 × 23.5	BLE: 500 ZigBee: 300	
CC2652P	M4F	352	80	20	RF-BM-2652P1	Half-hole	16.4 × 25	BLE 1M: 350 BLE Long Range: 2200 ZigBee: 1100	
	M4F	352	80	20	RF-BM-2652P2	PCB / IPEX /	16.4 × 30	BLE 1M: 350	

						Half-hole		BLE Long Range: 2200 ZigBee: 1100	
CC1352R	M4F	352	80	5 / 14	RF-TI1352B1	IPEX	16.8 × 26.5	BLE: 500 ZigBee: 300 868 MHz: 1000	
CC1352P	M4F	352	80	20	RF-TI1352P1	Half-hole	16.4 × 25	BLE 1M: 350 BLE Long Range: 2200 ZigBee: 1100 868 MHz: 2500	

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-2652P3 is an RF module based on TI lower-power CC2652P SoC, which is a multiprotocol 2.4 GHz wireless module supporting Thread, Zigbee®, Bluetooth® 5.1 Low Energy, IEEE 802.15.4, IPv6-enabled smart objects (6LoWPAN), proprietary systems, including the TI 15.4-Stack (2.4 GHz), and concurrent multiprotocol through a Dynamic Multiprotocol Manager (DMM) driver. It integrates a 48 MHz crystal and a 32.768 kHz crystal, 352 KB of in-system Programmable Flash and an external flash of 1 MB, 256 KB ROM, 8 KB of Cache SRAM, 80 KB of ultra-low leakage SRAM. Its ARM® Cortex®-M4F core application processor can operate at an extremely low current at flexible power modes. And the module enables long-range and low-power applications using integrated +20 dBm high-power amplifier with best-in-class transmit current consumption at 85 mA. It features small size, robust connection distance, and rigid reliability.

1.2 Key Features

- RF Section
  - 2.4GHz RF transceiver compatible with Bluetooth 5.1 Low Energy and earlier LE specifications and IEEE 802.15.4 PHY and MAC
  - Excellent receiver sensitivity
    - ✧ -100 dBm for 802.15.4 (2.4 GHz)
    - ✧ -105 dBm for Bluetooth 125 kbps (LE coded PHY)
  - Output power up to +20 dBm with temperature compensation
  - Suitable for systems targeting compliance with worldwide radio frequency regulations
- Wireless Protocols
  - Thread, ZigBee®, Bluetooth® 5.1 Low Energy, IEEE 802.15.4, IPv6-nabld smart objects (6LoWPAN), Wi-SUN®, Proprietary systems, SimpleLink™ TI15.4-Stack (2.4 GHz), and Dynamic Multiprotocol Manager (DDM) driver
- Microcontroller
  - Powerful 48 MHz ARM® Cortex®-M4F processor
  - EEBMC CoreMark® score: 148
  - 352 KB of in-system programmable flash + 1 MB flash
  - 256 KB of ROM for protocols and library functions
  - 8 KB of cache SRAM (Alternatively available as general-purpose RAM)
  - 80 KB of ultra-low leakage SRAM. The SRAM is protected by parity to ensure high reliability of operation.
  - 2-pin cJTAG and JTAG debugging
  - Support OTA upgrade
- Ultra-low power sensor controller with 4 KB of SRAM
  - Sample, store, and process sensor data
  - Operation independent from system CPU
  - Fast wake-up for low-power operation
- Peripherals
  - Digital peripheral pins can be routed to 23 GPIOs
  - 4 × 32-bit or 8 × 16-bit general-purpose timers
  - 12-bit ADC, 200 ksamples/s, 8 channels
  - 2 × comparators with internal reference DAC (1 × continuous time, 1 × ultra-low power)
  - Programmable current source
  - 2 × UART
  - 2 × SSI (SPI, Microwave, TI)
  - I^2C

- I²S
- Real-time clock (RTC)
- AES 128 and 256 bit Crypto accelerator
- ECC and RSA public key hardware accelerator
- SHA2 accelerator (full suite up to SHA-512)
- True random number generator (TRNG)
- Capacitive sensing, up to 8 channels
- Integrated temperature and battery monitor

• External system
- On-chip buck DC/DC converter

• Low Power
- Wide supply voltage range: 1.8 V ~ 3.8 V
- Active-mode RX: 6.9 mA
- Active-mode TX at 0 dBm: 7.3 mA
- Active-mode TX at +5 dBm: 9.6 mA
- Active-mode TX at +10 dBm: 22 mA
- Active-mode TX at +20 dBm: 85 mA
- Active-mode MCU 48 MHz (CoreMark): 3.4 mA (71 µA/MHz)
- Sensor controller, low power-mode, 2 MHz, running infinite loop: 30.1 µA
- Sensor controller, active-mode, 24 MHz, running infinite loop: 808 µA
- Standby: 0.94 µA (RTC on, 80 KB RAM and CPU retention)
- Shutdown: 150 nA (wakeup on external events)

1.3 Applications

- 2400 to 2480 MH ISM and SRD systems with down to 4 kHz of receive bandwidth
- Home and building automation
- Building security system
- HVAC system
- Gateway
- IP network camera
- Fire safety system
- Smart grid
- Automatic meter reading
- Industrial transport
- Wireless sensor networks
- Factory automation and control
- Wireless healthcare applications
- Energy harvesting applications
- Asset tracking and management
- Electronic Shelf Label (ESL)
- Wired networking
- Small business router
- Portable electronics
- Set-top box
- Connected peripherals
- Keyboard and keypads
- Home theater & entertainment
- Electronic and robotic toys
- Wearables

1.4 Functional Block Diagram

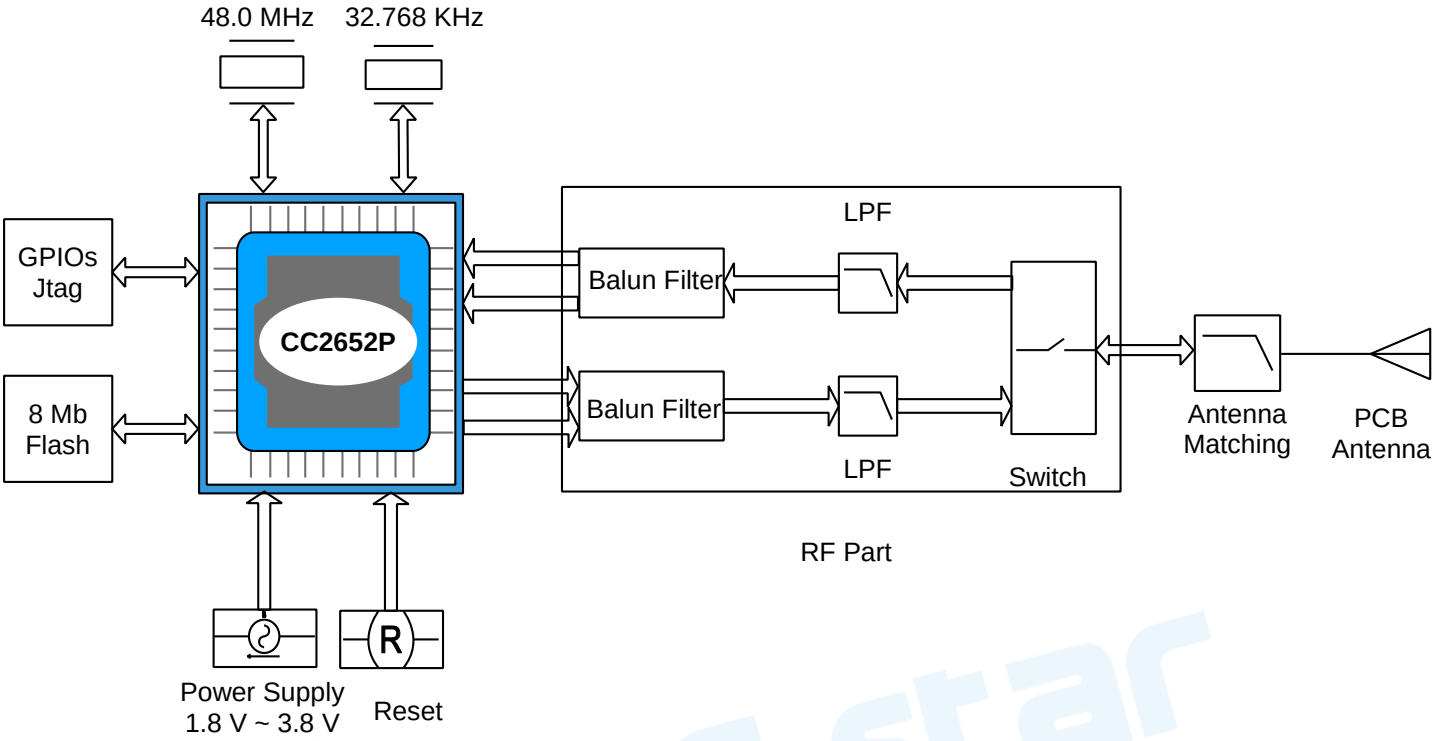

Figure 1. Functional Block Diagram of RF-BM-2652P3

1.5 Part Number Conventions

The part numbers are of the form of RF-BM-2652P3 where the fields are defined as follows:

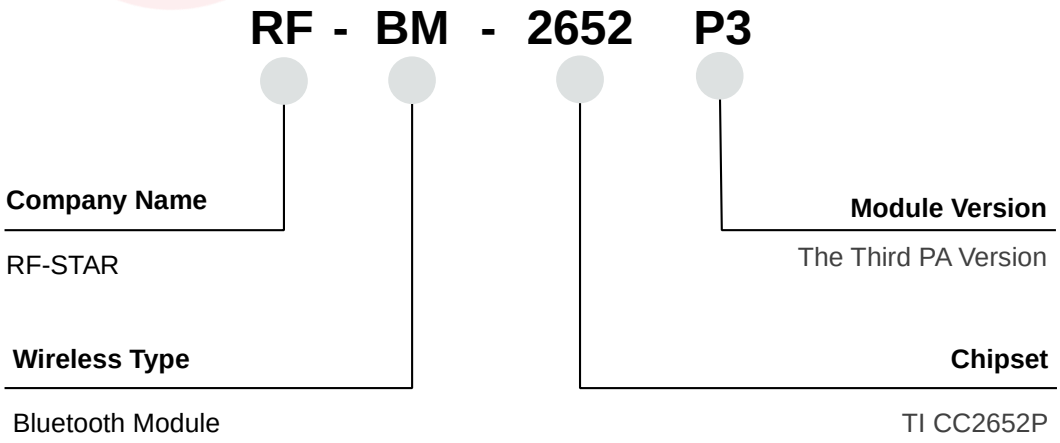

Figure 2. Part Number Conventions of RF-BM-2652P3

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2 Module Configuration and Functions

2.1 Module Parameters

Table 1. Parameters of RF-BM-2652P3

Chipset	CC2652P
Supply Power Voltage	1.8 V ~ 3.8 V, 3.3 V is recommended
Frequency	2402 MHz ~ 2480 MHz
Maximum Transmit Power	+20.0 dBm
Receiving Sensitivity	-100 dBm @ 802.15.4 (2.4 GHz) -105 dBm @ Bluetooth 125 kbps (LE Coded PHY)
GPIO	23
Power Consumption	RX current: 6.9 mA TX current: 7.3 mA @ 0 dBm 9.6 mA @ 5 dBm 22 mA @ 10 dBm 85 mA @ dBm MCU 48 MHz (CoreMark):3.4 mA (71 μA/MHz) Sensor Controller：30.1 μA @ Low Power-Mode, 2 MHz, running infinite loop 808 μA @ Active-Mode, 24 MHz, running infinite loop Standby: 0.94 μA Shutdown: 150 nA
Support Protocol	Bluetooth 5.1 Low Energy, ZigBee, Thread, IEEE 802.15.4, 6LoWPAN
Crystal	48 MHz, 32.768 kHz
Package	SMT packaging (Half hole)
Communication Interface	UART, SPI, I^2C, I^2S
Dimension	24.0 mm × 16.0 mm × (2.2 ± 0.1) mm
Type of Antenna	PCB antenna
Operating Temperature	-40 ℃ ~ +85 ℃
Storage Temperature	-40 ℃ ~ +125 ℃

2.2 Module Pin Diagram

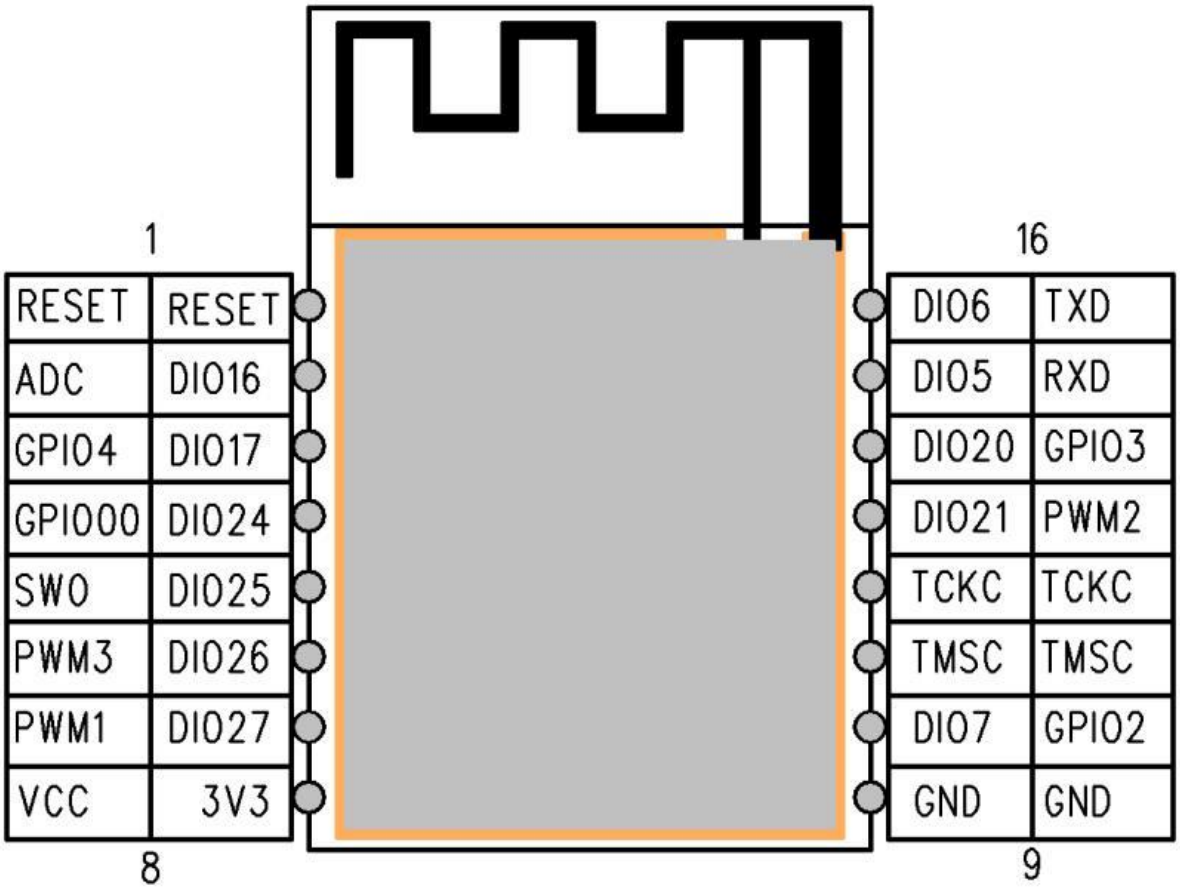

Figure 3. Pin Diagram of RF-BM-2652P3

2.3 Pin Functions

Table 2. Pin Diagram of RF-BM-2652P3

Pin	Name	Chip Pin	Function	Description
1	RESET	RESET_N		Reset, active low. No internal pullup resistor
2	ADC	DIO16	Digital	GPIO
3	GPIO04	DIO17	Digital	GPIO
4	GPIO00	DIO24	Digital or Analog	GPIO, analog capability
5	SWO	DIO25	Digital or Analog	GPIO, analog capability
6	PWM3	DIO26	Digital or Analog	GPIO, analog capability
7	PWM1	DIO27	Digital or Analog	GPIO, analog capability
8	VCC	3V3	-	Power supply: 1.8 V ~ 3.8 V, 3.3 V recommended.
9	GND	GND	GND	Ground
10	GPIO2	DIO7	Digital	GPIO, high-drive capability

11	TMSC	TMSC	Digital	JTAG TMSC, high-drive capability
12	TCKC	TCKC	Digital	JTAG TCKC
13	PWM2	DIO21	Digital	GPIO
14	GPIO3	DIO20	Digital	GPIO
15	RXD	DIO5	Digital	GPIO, high-drive capability
16	TXD	DIO6	Digital	GPIO, high-drive capability

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-2652P3

Items	Condition	Min.	Typ.	Max.	Unit
Operating Supply Voltage	/	1.8	3.3	3.8	V
Operating Temperature	/	-40	+25	+85	℃

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 RF-BM-2652P3

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			±500		V

4 Application, Implementation, and Layout

4.1 Module Photos

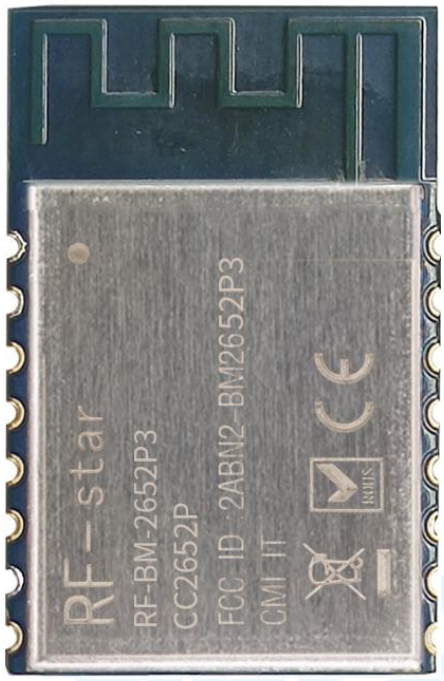

Figure 3. Photos of RF-BM-2652P3

4.2 Recommended PCB Footprint

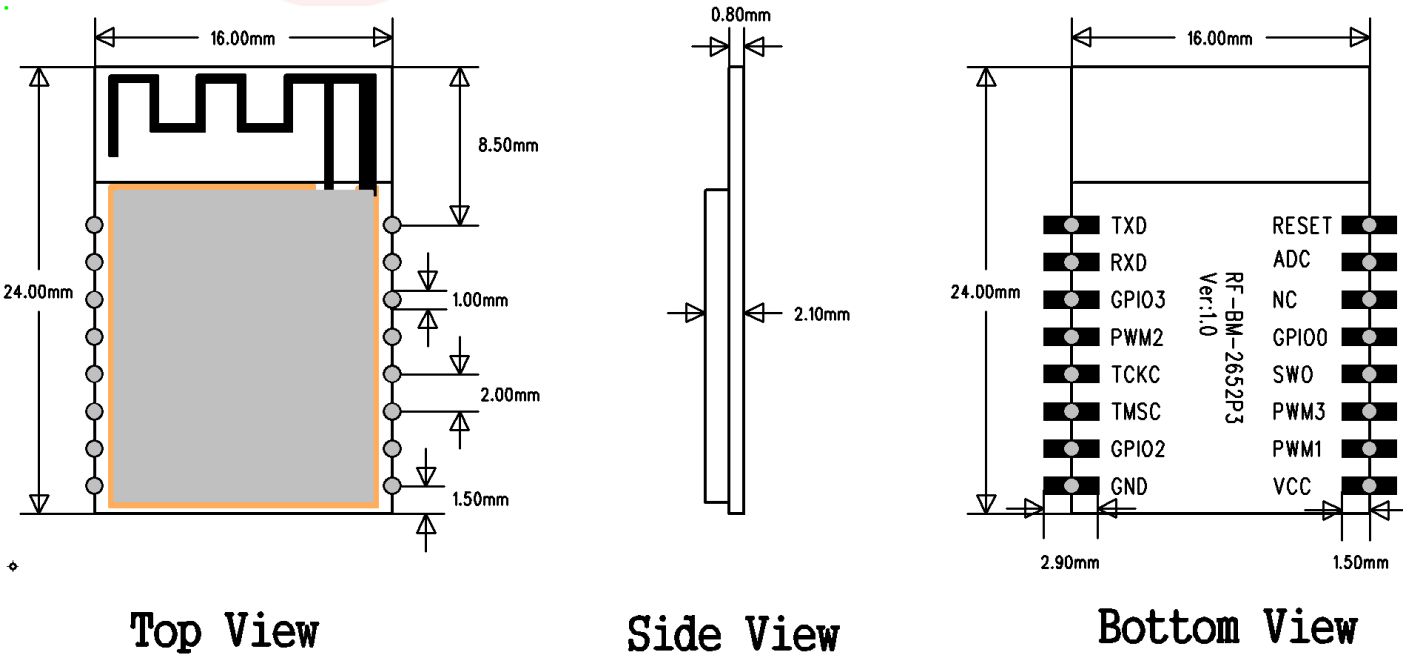

Figure 4. Recommended PCB Footprint of RF-BM-2652P3

4.3 Schematic Diagram

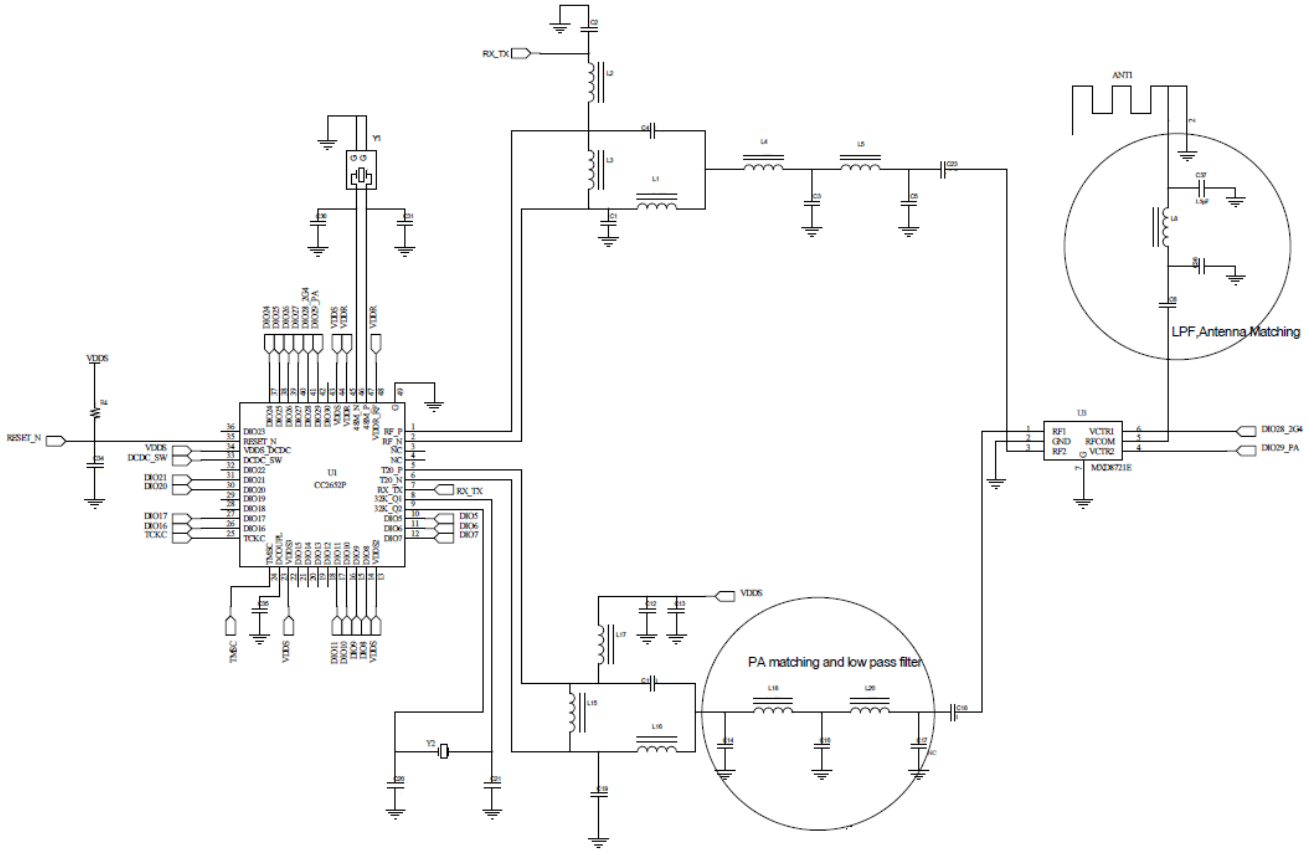

Figure 5. Schematic Diagram of RF-BM-2652P3

4.4 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.
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.

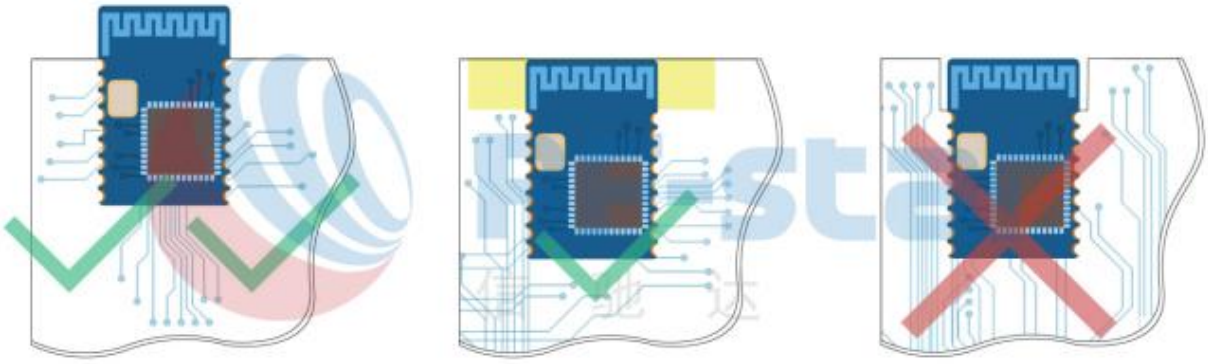

Figure 4. Recommendation of Antenna Layout

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 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.

4.5.2 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 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.

4.5.3 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.

4.6 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.

4.7 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

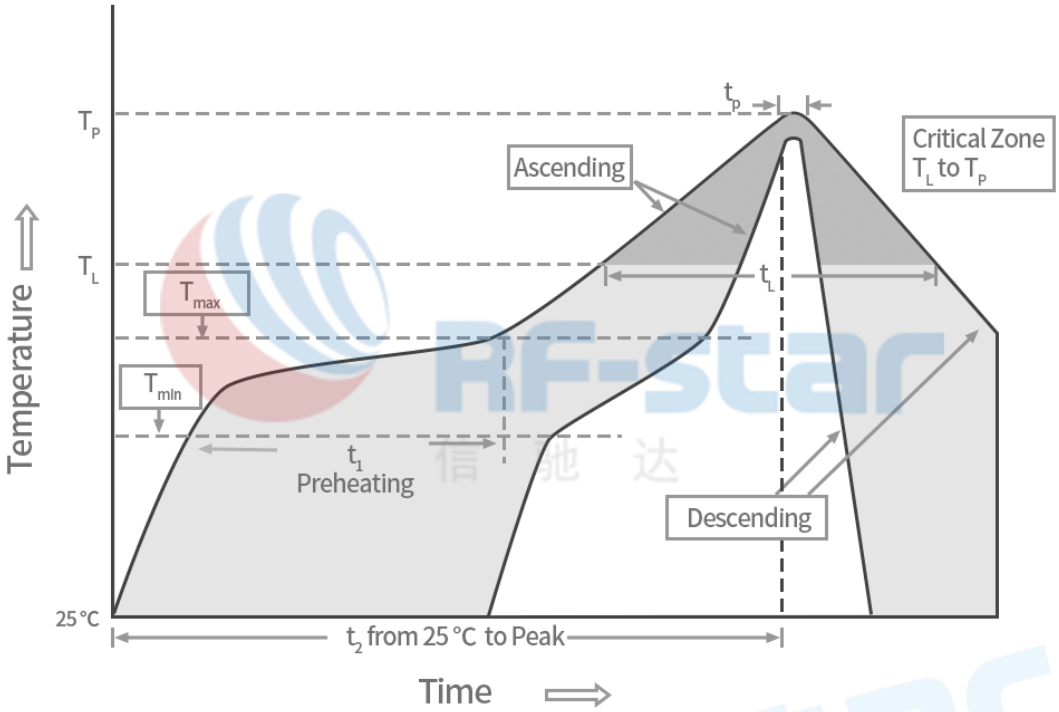

Figure 5. Recommended Reflow for Lead Free Solder

4.8 Optional Packaging

Figure 6. Optional Packaging Mode

Note: Default tray packaging.

5 Revision History

Date	Version No.	Description
2021.02.02	V1.0	The initial version is released.

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.

6 Contact Us

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