RF-BM-BG22B1 EFR32BG22

Bluetooth 5.2 Low Energy Module

Version 1.0

Shenzhen RF-star Technology Co., Ltd.

1 Device Overview

1.1 Module Series

There are three modules of RF-BM-BG22Bx series. All of them are based on Silicon Labs EFR32BG22 series. Because the EFR32BG22 chips are compatible in package, pins and peripherals, those three modules are pin-to-pin compatible with each other as well.

Table 1. Module Specification of RF-BM-BG22Bx

Model	Chip Model	Max. CPU Speed	TX Power	FLASH	RAM	Protocol
BG22B1	EFR32BG22C112F352GM32-C	38.4 MHz	0 dBm	352 kB	32 kB	BT5.2
BG22B2	EFR32BG22C222F352GM32-C	76.8 MHz	+6 dBm	352 kB	32 kB	BT5.2 Proprietary
BG22B3	EFR32BG22C224F512GM32-C	76.8 MHz	+6 dBm	512 kB	32 kB	BT5.2 Direction finding Proprietary

Note: RF-BM-BG22B1 and RF-BM-BG22B2 do not support AoA/AoD and LE Long Range (125 kbps and 500 kbps) PHYs.

1.2 Description

RF-BM-BG22B1 is an RF module based on EFR32BG22C112F352GM32-C, one of Gecko family of SoCs from Silicon Labs, with a 32-bit ARM® Cortex®-M33 core with 38.4 MHz maximum operating frequency. It integrates a 38.4 MHz crystal, a matching, an antenna matching, a low-pass filter and antenna options of a meander line inverted-F PCB antenna and a half-hole interface. It supports Bluetooth 5.2 low energy and can be preprogrammed with a serial interface communication protocol for simple programming. It also has a range of analog and digital interfaces such as PRS, ADC, UART, SPI, I²C, PWM, ISO 7816, IrDA, I²S, EUART and PDM. It features low power consumption, compact size, robust connection distance, and rigid reliability. The module reaches up to 0 dBm TX power. 1.27-mm pitch stamp stick package for easy assembling and cost-effective PCB design. RF-BM-BG22B1 is pin-to-pin compatible with BG22B2 and BG22B3.

1.3 Key Features

- Protocol
  - Bluetooth 5.2 low energy
- Supported Modulation Format
  - 2 (G)FSK with fully configurable shaping
- High-Performance 32-bit 38.4 MHz ARM® Cortex®-M33 with DSP instruction and floating-point unit for efficient signal processing
- Memory
  - Flash: 352 kB
  - RAM: 32 kB
- TX power: -28 dBm ~ 0 dBm
- Wide Peripherals
  - 12-bit 1 Mbps SAR Analog to Digital Converter (ADC)
  - Up to 18 GPIOs with output state retention and asynchronous interrupts

- 8 Channel DMA Controller
- 12 Channel Peripheral Reflex System (PRS)
- 4×16-bit Timer / Counter with 3 Compare / Capture / PWM channels
- 1×32-bit Timer / Counter with 3 Compare / Capture / PWM channels
- 32-bit Real Time Counter
- 24-bit Low Energy Timer for waveform generation
- 1×Watchdog Timer
- 2×Universal Synchronous / Asynchronous Receiver / Transmitter (UART / SPI / SmartCard (ISO 7816) / IrDA / I²S)
- 1×Enhanced Universal Asynchronous Receiver / Transmitter (EUART)
- 2×I²C interface with SMBus support
- Digital microphone interface (PDM)
- Precision Low-Frequency RC Oscillator enabling single-crystal operation
- RFSENSE with selective OOK mode
- Die temperature sensor with +/-2 degree C accuracy across temperature range

• Wide Operation Range
- 2.2 V to 3.8 V single power supply
- Operating temperature: -40 °C to +85 °C

• Security Features
- Secure Boot with Root of Trust and Secure Loader (RTSL)
- Hardware Cryptographic Acceleration for AES128/256, SHA-1, SHA-2 (up to 256-bit), ECC (up to 256-bit), ECDSA, and ECDH
- True Random Number Generator (TRNG) compliant with NIST SP800-90 and AIS-31
- ARM® TrustZone®
- Secure Debug with lock / unlock

1.4 Applications

- Asset tags and beacons
- Consumer electronics remote controls
- Portable medical
- Sports, fitness and wellness devices
- Connected home
- Building automation and security

1.5 Functional Block Diagram

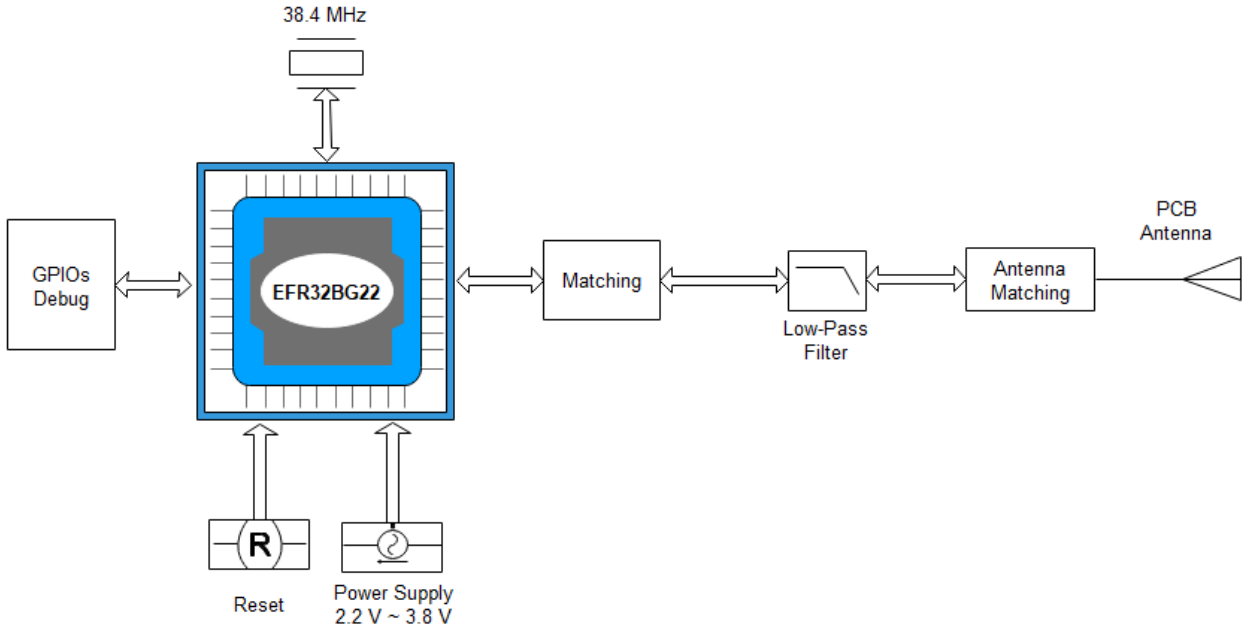

Figure 1. Functional Block Diagram of RF-BM-BG22B1

1.6 Part Number Conventions

The part numbers are of the form of RF-BM-BG22B1 where the fields are defined as follows:

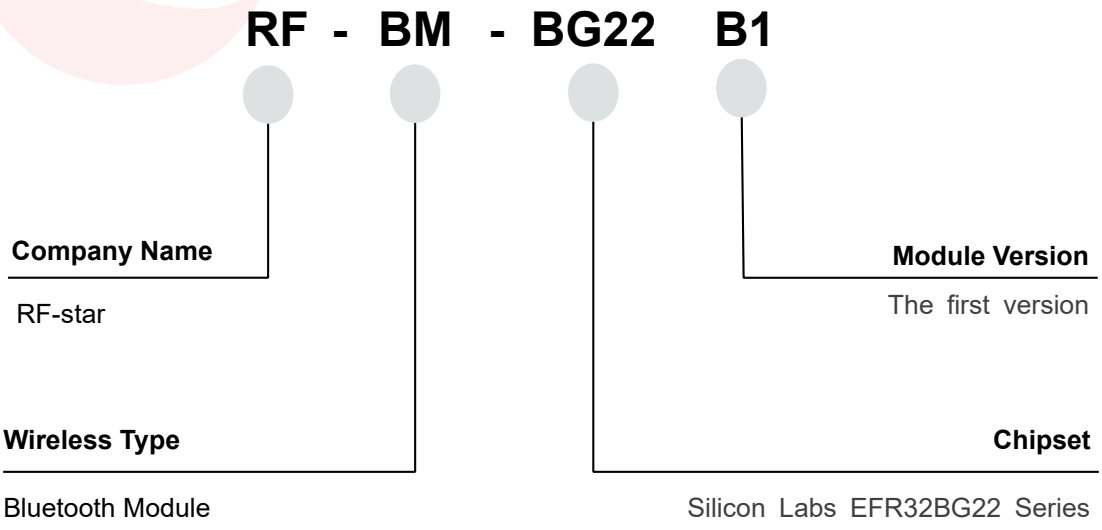

Figure 2. Part Number Conventions of RF-BM-BG22B1

Table of Contents

1 Device Overview 1
1.1 Module Series 1
1.2 Description 1
1.3 Key Features 1
1.4 Applications 2
1.5 Functional Block Diagram 3
1.6 Part Number Conventions 3
Table of Contents 4
2 Module Configuration and Functions 5
2.1 Module Parameters 5
2.2 Module Pin Diagram 6
2.3 Pin Functions 6
3 Specifications 7
3.1 Recommended Operating Conditions 7
3.2 Handling Ratings 7
4 Application, Implementation, and Layout 8
4.1 Module Photos 8
4.2 Recommended PCB Footprint 8
4.3 Antenna 9
4.3.1 Antenna Design Recommendation 9
4.4 Basic Operation of Hardware Design 9
4.5 Trouble Shooting 10
4.5.1 Unsatisfactory Transmission Distance 10
4.5.2 Vulnerable Module 11
4.5.3 High Bit Error Rate 11
4.6 Electrostatics Discharge Warnings 11
4.7 Soldering and Reflow Condition 11
4.8 Optional Packaging 13
6 Revision History 14
7 Contact Us 15

2 Module Configuration and Functions

2.1 Module Parameters

Table 2. Parameters of RF-BM-BG22B1

Chipset	EFR32BG22C112F352GM32-C
Supply Power Voltage	2.2 V ~ 3.8 V, recommended to 3.3 V
Frequency	2402 MHz ~ 2480 MHz
Transmit Power	-28.0 dBm ~ 0 dBm (typical: 0 dBm)
Receiving Sensitivity	-98.9 dBm sensitivity @ 1 Mbit/s GFSK -96.2 dBm sensitivity @ 2 Mbit/s GFSK
Power Consumption	3.6 mA RX current (1 Mbps GFSK) 4.1 mA TX current @ 0 dBm output power
GPIO	18
Crystal	38.4 MHz
RAM	32 kB
Flash	352 kB
Package	SMT Packaging
Frequency Error	±24 kHz
Dimension	16.6 * 11.2 * 2.10 mm
Type of Antenna	PCB antenna, half-hole antenna interface
Operating Temperature	-40 ℃ ~ +85 ℃
Storage Temperature	-40 ℃ ~ +125 ℃

2.2 Module Pin Diagram

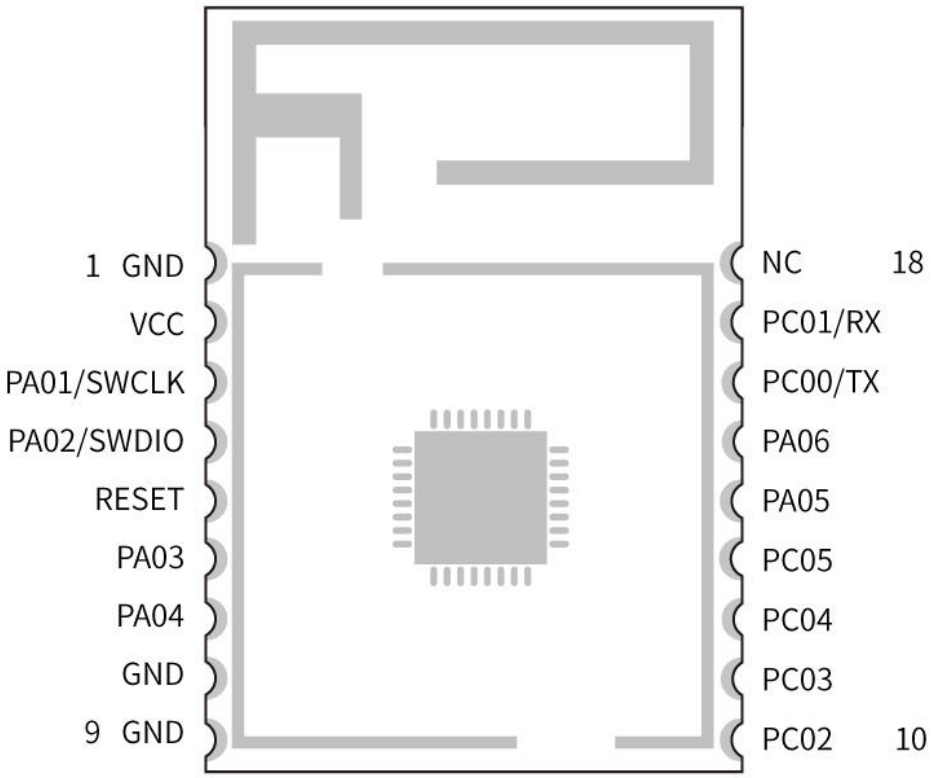

Figure 3. Pin Diagram of RF-BM-BG22B1

2.3 Pin Functions

Table 3. Pin Functions of RF-BM-BG22B1

Pin	Name	Pin Type	Description
Pin1	GND	—	Ground
Pin2	VCC	—	2.2 V ~ 3.8 V, recommended to 3.3 V
Pin3	PA01/SWCLK	I/O	GPIO/SWCLK(connect jlink)
Pin4	PA02/SWDIO	I/O	GPIO/SWDIO(connect jlink)
Pin5	RESET	I	Reset, active low, internal pull-up.
Pin6	PA03	I/O	GPIO
Pin7	PA04	I/O	GPIO
Pin8	GND	—	Ground
Pin9	GND	—	Ground
Pin10	PC02	I/O	GPIO
Pin11	PC03	I/O	GPIO
Pin12	PC04	I/O	GPIO

Pin13	PC05	I/O	GPIO
Pin14	PA05	I/O	GPIO
Pin15	PA06	I/O	GPIO
Pin16	PC00	I/O	GPIO
Pin17	PC01	I/O	GPIO
Pin18	NC	—	—

3 Specifications

3.1 Recommended Operating Conditions

The 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-BM-BG22B1

Items	Condition	Min.	Typ.	Max.	Unit
Operating Supply Voltage	Battery Mode	2.2	3.3	3.8	V
Frequency Range		2402		2480	MHz
Operating Temperature	/	-40	+25	+85	℃
Environmental Hot Pendulum	/	-20		+20	℃/min

3.2 Handling Ratings

Table 5. Handling Ratings of RF-BM-BG22B1

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 4. Photos of RF-BM-BG22B1

4.2 Recommended PCB Footprint

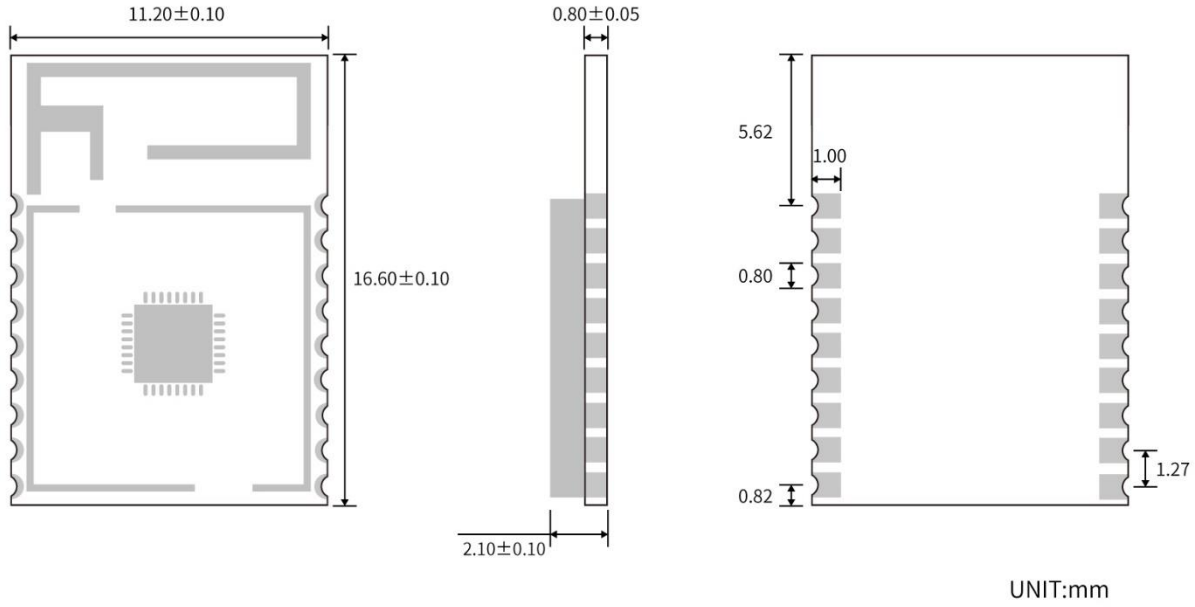

Figure 5. Recommended PCB Footprint of RF-BM-BG22B1 (mm)

4.3 Antenna

4.3.1 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 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 best to hollow out the antenna position in the following figure to ensure that the S11 of the module is minimally affected.

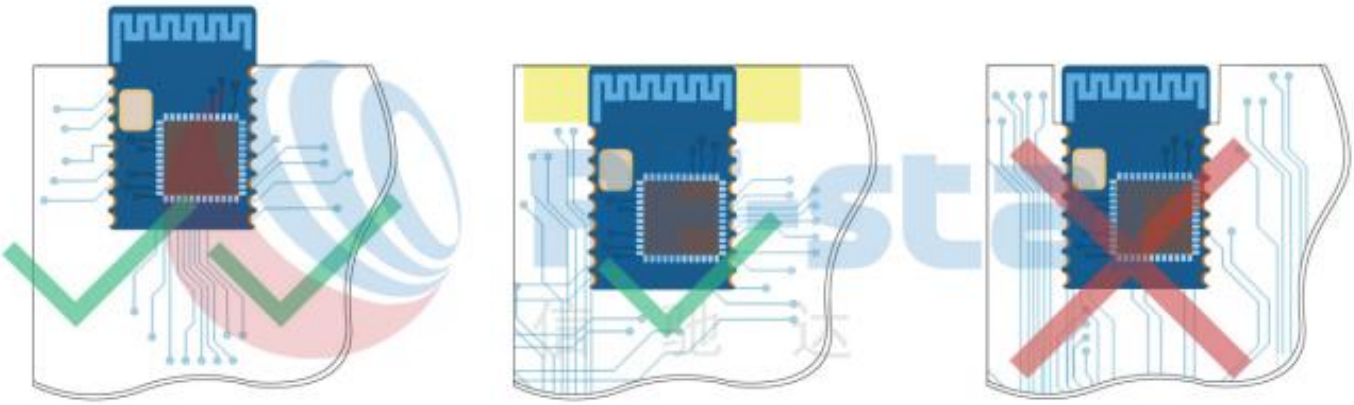

Figure 6. Recommendation of Antenna Layout

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

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 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 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 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 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.

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 the 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 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 modules or the poor quality of the 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 a 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 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's reliability.
3. If the extension wire or feeder wire is of poor quality or too long, the bit error rate will be high.

4.6 Electrostatics Discharge Warnings

The module will be damaged for 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 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 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

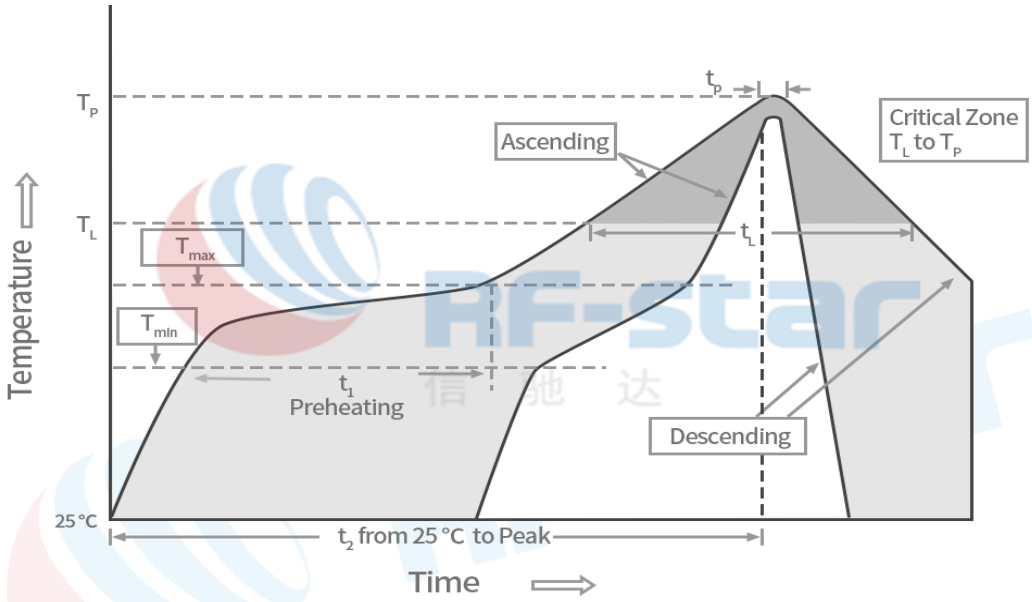

Figure 7. Recommended Reflow for Lead-Free Solder

4.8 Optional Packaging

Figure 8. Optional Packaging Mode

Note: Default tray packaging.

5 FCC Warning

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 undesiredoperation.

6 Revision History

Date	Version No.	Description
2022.06.10	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.

7 Contact Us

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FCC Statement
FCC standards: FCC CFR Title 47 Part 15 Subpart C Section 15.247
PCB antenna , 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.

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-BG22B1 Or Contains FCC ID: 2ABN2-BG22B1 ”

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 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.