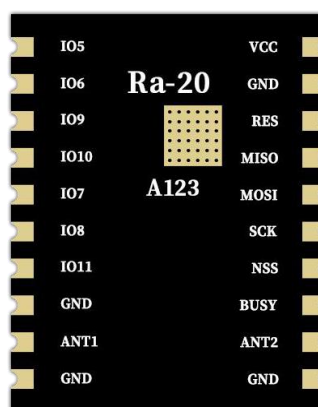


Ra-20 Specification



Product Series: LoRa Series

Product Model: Ra-20

Version: V1.0.0

Copyright: ©2026

Document Language: English

Release Date: 2026-06-08

Confidentiality Level: Public Document

Manufacturer: Shenzhen Ai-Thinker Technology Co., Ltd.

Keywords: LoRa, SEMTECH LR2021, Sub-GHz, 2.4GHz, RF Module, LR-FHSS, IoT, Satellite Communication

Document Revision History

Version	Date	Created / Revised Content	Prepared by	Approved by
V1.0.0	2026-05-07	First edition	Qiao Rongxin	Guan Ning

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1 Product Overview

The Ra-20 is an ultra-high-performance RF front-end module designed for IoT, short-range wireless communication, and Industry 4.0 wireless sensor networks, featuring the SEMTECH fourth-generation LoRa Plus™ LR2021 RF chip as its core. Its key advantage lies in an ultra-compact package and extreme RF performance. By optimizing the collaborative design of power amplifier, low-noise amplifier, filter, and peripheral matching network, it achieves high power, low loss, low spurious emissions, and strong anti-interference capability, while meeting mainstream global regulatory certification requirements.

The Ra-20 module supports Sub-GHz and 2.4GHz ISM bands. It features three key capabilities: ultra-long-range transmission, high-speed data throughput, and global single-SKU adaptability.

Figure 1 shows the LR2021 main chip architecture.

1.1 Features

Operating Bands

- Sub-GHz: China default 470 – 510MHz (433MHz can be customized)
- 2.4GHz: China default 2402 – 2480MHz

Power Consumption

- Sleep current: $\leq 2\mu\text{A}$ (average value: 1.65)
- Receive current: $\leq 6\text{mA}$
- Transmit current: Sub-GHz 2.4GHz

Communication and Protocols

- Data rate: FLRC up to 2.6Mbps; LoRa up to 125kbps
- Supports fourth-generation LoRa IP technology and LR-FHSS
- Protocol compatibility (Only the physical layer is supported; the protocol layer needs to be developed by the customer):
 - LoRa/LoRaWAN[®] (Sub-GHz + 2.4GHz)
 - Bluetooth[®] LE 5.0

- Wi-SUN, Wireless M-BUS, Z-Wave, etc.

Physical Characteristics

- Package: SMD-20
- Module dimensions (L × W × H): 20.00 × 16.00 × 3.20mm
- Antenna type: IPEX Gen 1 connector
- Operating temperature: -40 – 85°C
- Storage conditions: -40 – 125°C, < 90% RH

Electrical Characteristics

- Supply voltage: 1.8 – 3.6V (typical value 3.3V)
- Supply current: > 200mA
- Communication interface: standard SPI interface
- Available I/Os: 7 GPIOs are brought out by default
- Protection: built-in ESD protection circuit

Note: For features not marked, please refer to the SEMTECH (LR2021) chip datasheet.

1.2 Application Scenarios

- Smart Industry
- Energy Monitoring
- Outdoor IoT
- Consumer Electronics

2 Key Specifications

Table 1 summarizes the key electrical and physical parameters of the Ra-20 module.

Table 1 Key Specifications

Model	Ra-20
Package	SMD-20
Dimensions	20.00 × 16.00 × 3.20mm
Antenna Type	IPEX Gen 1 connector
Frequency Range	470 – 510MHz, 2402 – 2480MHz
Operating Temperature	-40 – 85℃
Storage Conditions	-40 – 125℃, <90% RH
Power Supply Range	Supply voltage: 1.8–3.6V, typical 3.3V; supply current > 200mA
Communication Interface	SPI
Available I/Os	7 by default

3 Electrical Characteristics

3.1 Recommended Operating Conditions

Table 2 lists the recommended operating electrical parameters of the Ra-20 module. Operating outside these ranges may cause device damage.

Table 2 Recommended Operating Conditions

Symbol	Parameter	Min	Typ	Max	Unit
VCC	Supply Voltage	1.8	3.3	3.6	V
I	Supply Current	200	-	-	mA

3.2 I/O DC Electrical Characteristics

Table 3 lists the I/O DC characteristics of the Ra-20 module. These parameters are mainly used for external interface level matching and GPIO circuit design.

Table 3 I/O DC Electrical Characteristics

Symbol	Parameter	Min	Typ	Max	Unit
VIH	High-level Input Voltage	$0.7 \times VCC$	-	$VCC + 0.3$	V
VIL	Low-level Input Voltage	-0.3	-	$0.3 \times VCC$	V
VOH	High-level Output Voltage	-	$0.9 \times VCC$	-	V
VOL	Low-level Output Voltage	-	-	$0.1 \times VCC$	V
ZPUD	Pull-up/Pull-down Resistors	-	40	100	k Ω

3.3 Electrostatic Discharge

Figure 2 shows the ESD protection diagram. Ra-20 is an ESD-sensitive device and requires special precautions during handling.



Figure 2 ESD Protection Diagram

3.4 LoRa RF Performance

Table 4 lists the LoRa RF performance parameters of the Ra-20 module. RF performance parameters are measured under typical test conditions. Actual performance may be affected by the antenna, power supply, PCB layout, test environment, and other factors.

Table 4 LoRa RF Performance

Description	Typ			Unit
Frequency Range	2402 – 2480			MHz
2.4GHz Output Power (Software Setting 12)				
Mode	Min	Typ	Max	Unit
2402MHz	-	-	-	dBm
2440MHz	-	-	-	dBm
2480MHz	-	-	-	dBm
2.4GHz Receiver Sensitivity (BW = 400kHz, SF7, CR4/5)				
Mode	Min	Typ	Max	Unit
2402MHz	-	-	-	dBm
2440MHz	-	-	-	dBm
2480MHz	-	-	-	dBm
2.4GHz Harmonic Suppression RBW/VBW (1MHz/3MHz)				
Mode	Min	Typ	Max	Unit
2440MHz	-	-	-	dBm
2440MHz	-	-	-	dBm
Description	Typ			Unit
Frequency Range	470 – 510			MHz
Sub-GHz Output Power (Software Setting 22)				
Mode	Min	Typ	Max	Unit
470MHz	-	-	-	dBm

490MHz	-	-	-	dBm
510MHz	-	-	-	dBm
Sub-GHz Receiver Sensitivity (BW = 400kHz, SF7, CR4/5)				
Mode	Min	Typ	Max	Unit
470MHz	-	-	-	dBm
490MHz	-	-	-	dBm
510MHz	-	-	-	dBm
Sub-GHz Harmonic Suppression RBW/VBW (1MHz/3MHz)				
Mode	Min	Typ	Max	Unit
490MHz	-	-	-	dBm
490MHz	-	-	-	dBm

3.5 Power Consumption

Table 5 lists the power consumption data of the Ra-20 module in different modes. The following power consumption data are measured under a 3.3V power supply and 25°C ambient temperature.

- The P_{OUT} power for all transmit modes is measured at the antenna interface.
- All transmission data are measured at 100% duty cycle in continuous transmit mode.

Table 5 Instantaneous Power Consumption

Mode	Min	Avg	Max	Unit
2.4GHz	-	-	-	mA
Sub-GHz	-	-	-	mA
2.4GHz@RX	-	-	-	mA
Sub-GHz@RX	-	-	-	mA
Standby Current	-	-	-	mA
Sleep Current	-	-	-	μA

4 Mechanical Specifications

4.1 Module Dimensions

Figure 3 shows the outline dimensions of the Ra-20 module. The outline dimensions (L × W × H) are 20.00 × 16.00 × 3.20mm. The dimensional tolerance is ± 0.20 mm.

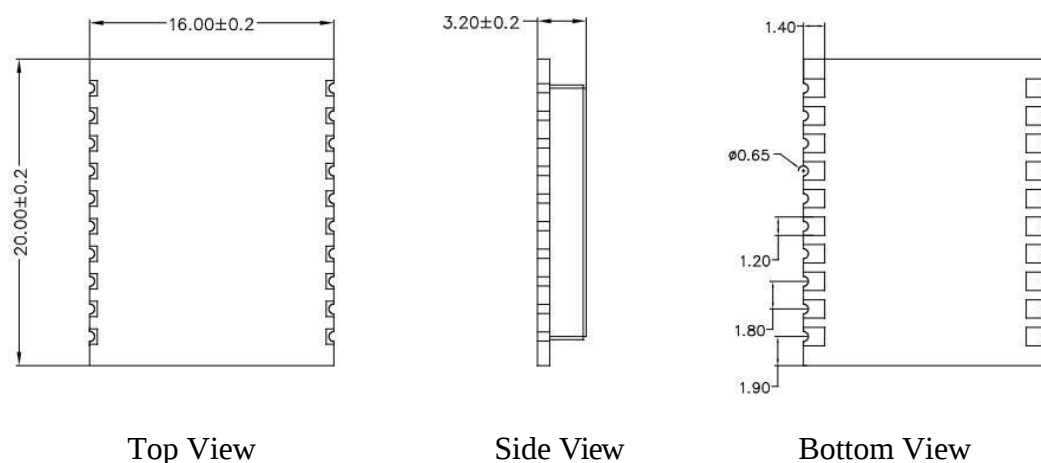


Figure 3 Module Dimensions (Unit: mm)

4.2 External Antenna Connector Dimensions

Figure 4 shows the engineering drawing of the IPEX antenna connector used with Ra-20. This connector is used to connect an external 50Ω RF antenna.

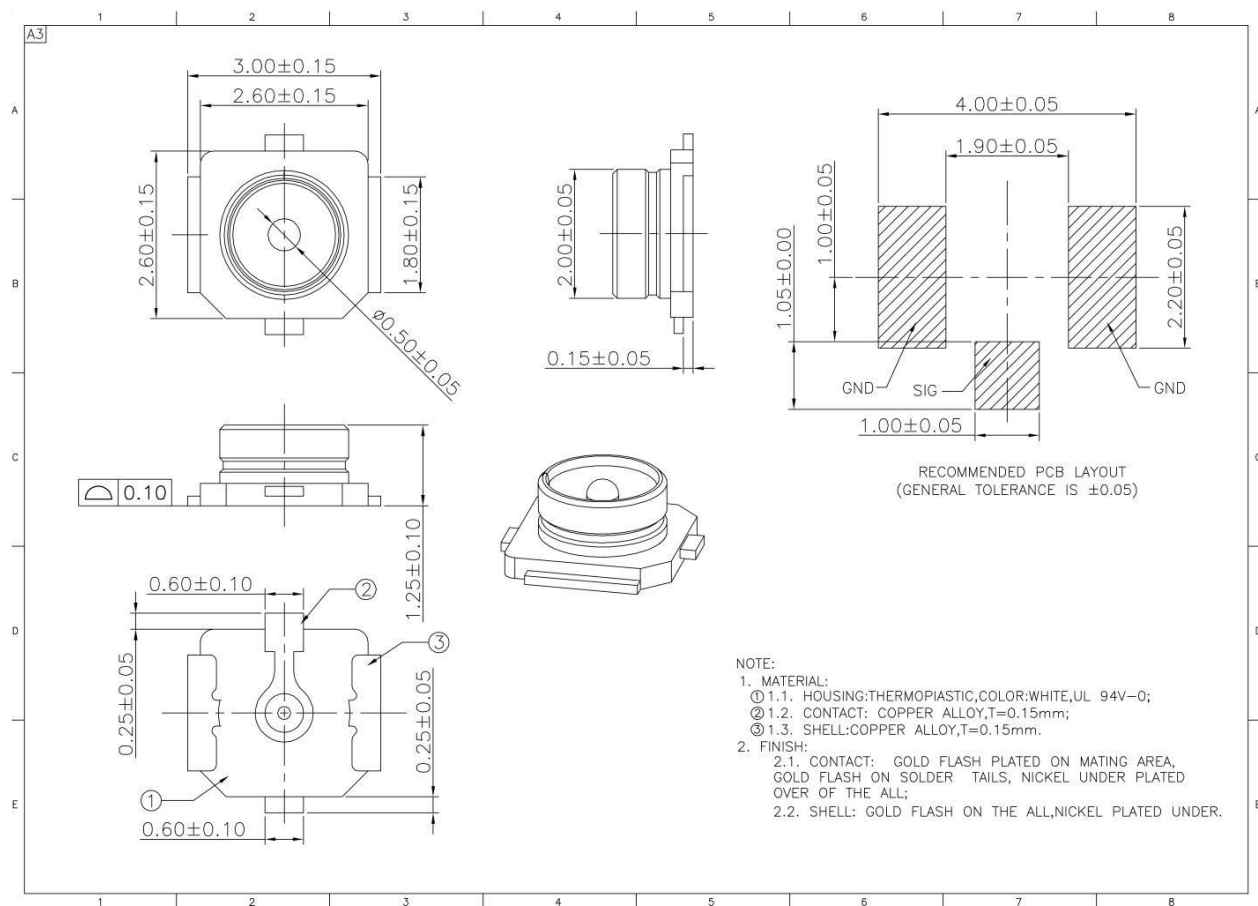


Figure 4 External Antenna Connector Dimensions (Unit: mm)

5 Pin Definition

Figure 5 shows the top and bottom views of the Ra-20 module's pin layout, with a total of 20 pins exposed.

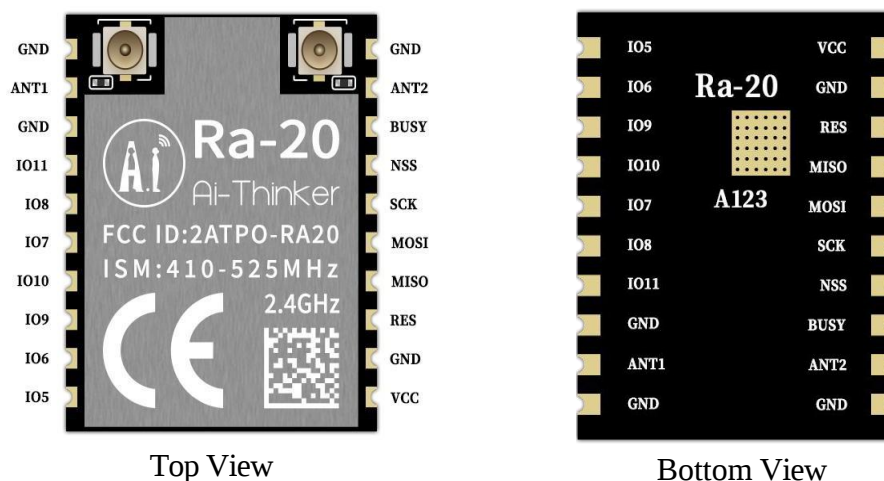


Figure 5 Pin Diagram

Table 6 defines the pin functions of the Ra-20 module, including pin number, pin name, and function description.

Table 6 Pin Function Definition

No.	Name	Function
1	GND	Module ground
2	ANT1	2.4GHz and S-band antenna interface, external 50Ω antenna
3	GND	Module ground
4	IO11	Multi-purpose digital interface; refer to the chip datasheet for details
5	IO8	Multi-purpose digital interface; refer to the chip datasheet for details
6	IO7	Multi-purpose digital interface; refer to the chip datasheet for details
7	IO10	Multi-purpose digital interface; refer to the chip datasheet for details
8	IO9	Multi-purpose digital interface; refer to the chip datasheet for details
9	IO6	Multi-purpose digital interface; refer to the chip datasheet for details
10	IO5	Multi-purpose digital interface; refer to the chip datasheet for details

11	VCC	Connect to the positive terminal of the power supply
12	GND	Connect to the negative terminal of the power supply
13	RES	Reset trigger input; refer to the chip datasheet for details
14	MISO	SPI data output
15	MOSI	SPI data input
16	SCK	SPI clock input
17	NSS	SPI chip select input
18	BUSY	Used for status indication; refer to the chip datasheet for details
19	ANT2	Sub-GHz antenna interface, external 50Ω antenna
20	GND	Module ground

6 Design Guide

6.1 Application Reference Circuit

Figure 7 shows the hardware application reference circuit of the Ra-20 module. The numbers in parentheses correspond to the module pin numbers.

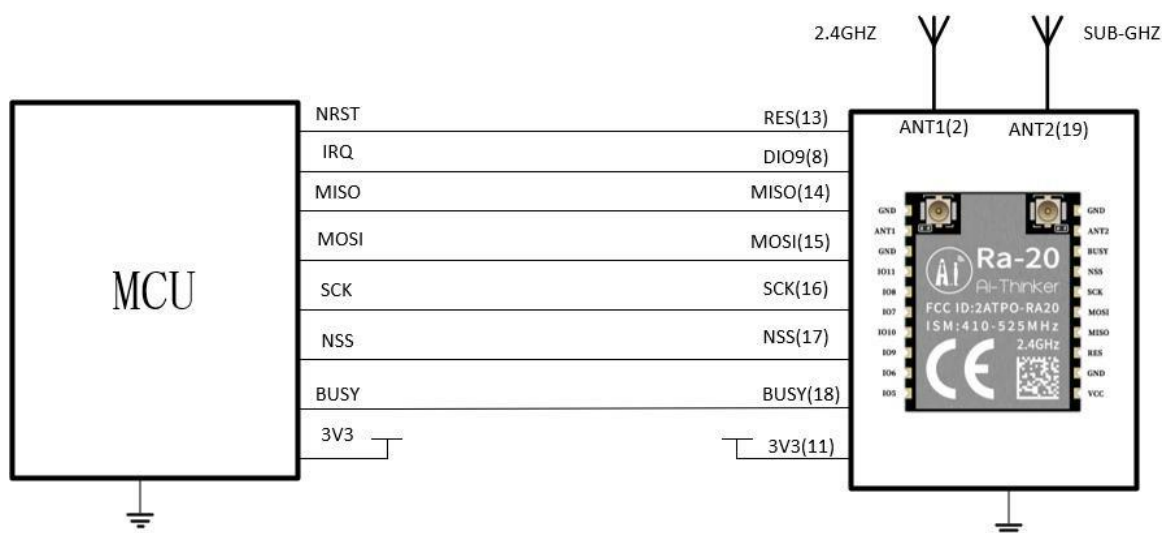


Figure 7 Application Reference Circuit

Notes on the Application Reference Circuit:

- VCC supply voltage: 1.8 – 3.6V. The external power supply output current is recommended to be above 200mA.
- RF specifications: LoRa ISM 410 – 525MHz; 2.4GHz wireless band.
- Communication interface: standard SPI communication (NSS/SCK/MOSI/MISO), compatible with host MCU SPI peripherals.
- Ra-20 is a LoRa Sub-GHz + 2.4GHz dual-mode wireless module. The two antennas are independent for transmission and reception and must not share the same antenna.

6.2 Recommended PCB Footprint Dimensions

Figure 8 shows the recommended PCB footprint dimensions of the Ra-20 module. The pad dimensions (L × W) are 2.60 × 1.20mm. The center-to-center spacing between adjacent pads is 1.80mm.

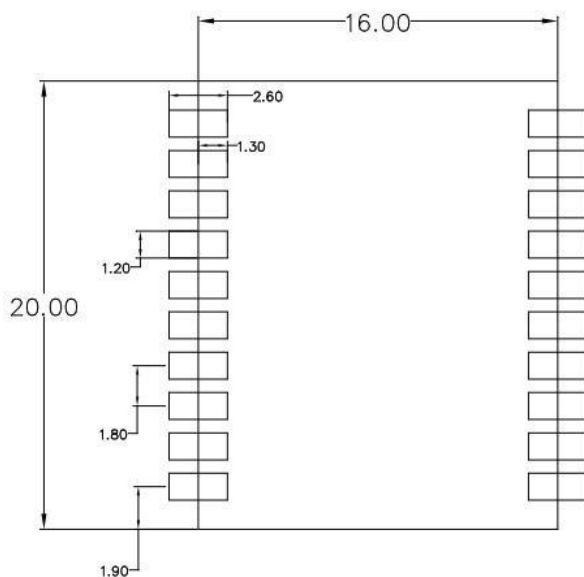


Figure 8 Recommended PCB Footprint Dimensions (Unit: mm)

6.3 Power Supply

Figure 9 shows a DC-DC buck power supply circuit converting 12V to 3.3V, with a maximum output current of 2A.

Notes on the DC-DC Buck Circuit:

- VDD is recommended as 3.3V, with a peak current above 200mA.
- An LDO is recommended for power supply; if using DC-DC, the ripple should be controlled within 30mV.
- For the DC-DC power supply circuit, it is recommended to reserve space for dynamic response capacitors to optimize output ripple under large load transients.
- It is recommended to add ESD protection devices to the power interface.

6.4 GPIO

Figure 10 shows a 3.3V and 5V bidirectional UART level-shifting circuit, which supports bidirectional serial communication across different voltage levels.

Notes on the Level-Shifting Circuit:

- Some I/O pins are exposed on the module periphery. To use these I/O pins, it is recommended to connect a 10-100Ω resistor in series with each I/O pin. This helps suppress overshoot, stabilize signal levels, and benefits both EMI and ESD protection.
- The pull-up or pull-down configuration for special I/O pins must refer to the instructions in the specification, as it affects the module boot configuration.
- The module I/O pins level is 3.3V. If the host controller I/O voltage level does not match the module, a level-shifting circuit should be added.
- If an I/O pin is directly connected to a peripheral interface or pin headers, it is recommended to reserve space for an ESD protection device near the connector on the I/O trace.

7 Storage Conditions

Products sealed in moisture barrier bags should be stored in a non-condensing atmosphere at $< 40^{\circ}\text{C}$ and $< 90\% \text{ RH}$.

The moisture sensitivity level (MSL) of the module is level 3.

The module must be used within 168 hours after vacuum bag removal under conditions of $25 \pm 5^{\circ}\text{C}$ and $60\% \text{ RH}$. Otherwise, the module requires baking before being returned to production.

8 Reflow Soldering Profile

Figure 11 shows the module reflow soldering process profile. The process is divided into four stages: ramp-up zone, preheat/soak zone, reflow soldering zone and cooling zone.

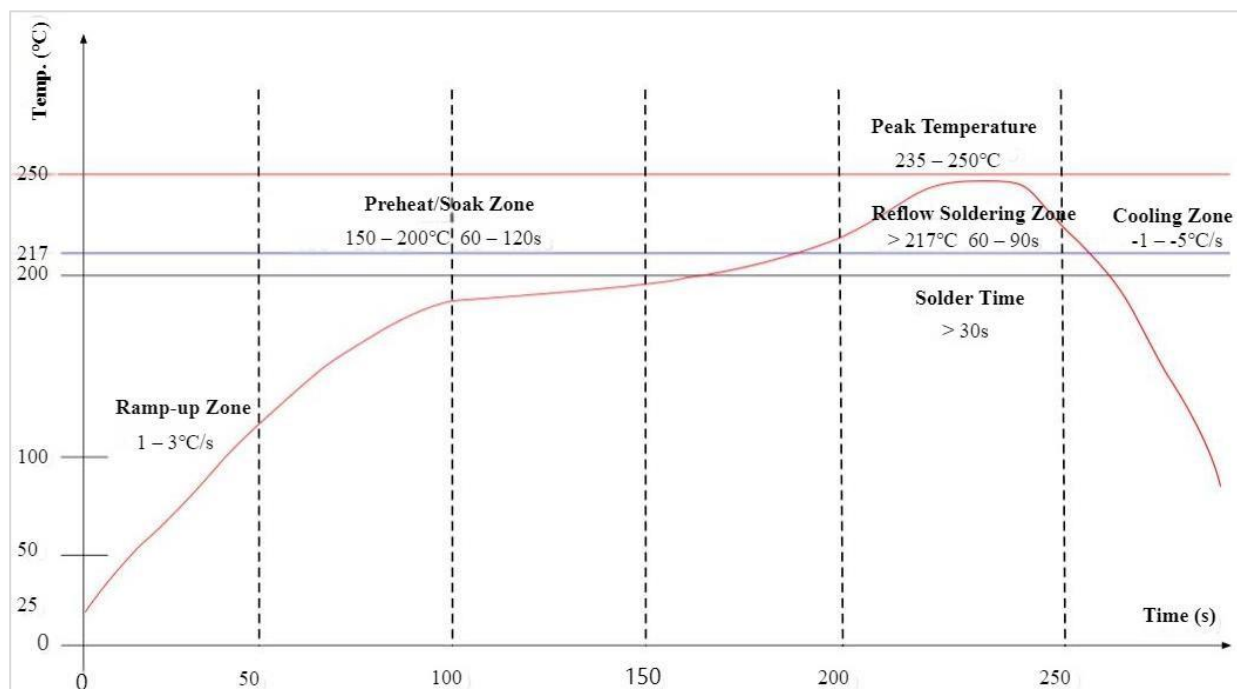


Figure 11 Reflow Soldering Profile

Reflow Soldering Profile Description:

- Ramp-up zone – Temperature: $25 - 150^{\circ}\text{C}$, Time: 60 – 90s, Ramp rate: $1 - 3^{\circ}\text{C/s}$
- Preheat/soak zone – Temperature: $150 - 200^{\circ}\text{C}$, Time: 60 – 120s
- Reflow soldering zone – Temperature: $> 217^{\circ}\text{C}$, Time: 60 – 90s, Peak temperature: $235 - 250^{\circ}\text{C}$, Time: 30 – 70s
- Cooling zone – Temperature: peak temperature to 180°C , Cooling rate: $-1 - -5^{\circ}\text{C/s}$
- Solder – Sn-Ag-Cu lead-free solder alloy (SAC305)

9 Packaging Information

Figure 12 shows the packaging of the Ra-20 module. The module is packed in tape-and-reel, 800 pcs/reel.



Figure 12 Tape and Reel Packaging Diagram

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Disclaimer

The data contained in this specification are typical test values obtained by Ai-Thinker laboratory and are provided for reference only. Actual performance may vary depending on the application environment and shall be subject to actual verification. Ai-Thinker reserves the right to modify this document at any time. Please refer to the official documentation website for the latest version. To the maximum extent permitted by applicable laws and regulations, Ai-Thinker shall not be liable for any losses arising from the use of this specification. All trademarks mentioned herein are the property of their respective owners. No part of this specification may be reproduced or used for commercial promotion without prior written permission. This specification does not grant any license to any intellectual property rights.

FCC WARNING

FCC Caution: Any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate this equipment.

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.

This device and its antenna(s) must not be co-located or operating in conjunction with any other antenna or transmitter.

15.105 Information to the user.

(b) For a Class B digital device or peripheral, the instructions furnished the user shall include the following or similar statement, placed in a prominent location in the text of the manual:

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.

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance 20cm between the radiator and your body.

Radiation Exposure Statement:

This equipment complies with FCC 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.

The availability of some specific channels and/or operational frequency bands are country dependent and are firmware programmed at the factory to match the intended destination.

The firmware setting is not accessible by the end user.

The final end product must be labelled in a visible area with the following: "Contains Transmitter Module "FCC ID: 2ATPO-RA20"

Requirement per KDB996369 D03

2.2 List of applicable FCC rules

List the FCC rules that are applicable to the modular transmitter. These are the rules that specifically establish the bands of operation, the power, spurious emissions, and operating fundamental frequencies. DO NOT list compliance to unintentional-radiator rules (Part 15 Subpart B) since that is not a condition of a module grant that is extended to a host manufacturer. See Section 2.10 below concerning the need to notify host manufacturers that further testing is required.³

Explanation: This module meets the requirements of FCC part 15C (15.247).it Specifically identified AC Power Line Conducted Emission, Radiated Spurious emissions, Band edge and RF Conducted Spurious Emissions, Conducted Peak Output Power, Bandwidth, Power Spectral Density, Antenna Requirement.

2.3 Summarize the specific operational use conditions

Describe use conditions that are applicable to the modular transmitter, including for example any limits on antennas, etc. For example, if point-to- point antennas are used that require reduction in power or compensation for cable loss, then this information must be in the instructions. If the use condition limitations extend to professional users, then instructions must state that this information also extends to the host manufacturer's instruction manual. In addition, certain information may also be needed, such as peak gain per frequency band and minimum gain, specifically for master devices in 5 GHz DFS bands.

Explanation: The product antenna uses an irreplaceable antenna with a gain of 2.4GHz: 2dBi, 433MHz:-1.80dBi

2.4 Single Modular

If a modular transmitter is approved as a "Single Modular," then the module manufacturer is responsible for approving the host environment that the Single Modular is used with. The manufacturer of a Single Modular must describe, both in the filing and in the installation instructions, the alternative means that the Single Modular manufacturer uses to verify that the host meets the necessary requirements to satisfy the module limiting conditions.

A Single Modular manufacturer has the flexibility to define its alternative method to address the conditions that limit the initial approval, such as: shielding, minimum signaling amplitude, buffered modulation/data inputs, or power supply regulation. The alternative method could include that the limited

module manufacturer reviews detailed test data or host designs prior to giving the host manufacturer approval.

This Single Modular procedure is also applicable for RF exposure evaluation when it is necessary to demonstrate compliance in a specific host. The module manufacturer must state how control of the product into which the modular transmitter will be installed will be maintained such that full compliance of the product is always ensured. For additional hosts other than the specific host originally granted with a limited module, a Class II permissive change is required on the module grant to register the additional host as a specific host also approved with the module.

Explanation: The module is a single module.

2.5 Trace antenna designs

For a modular transmitter with trace antenna designs, see the guidance in Question 11 of KDB Publication 996369 D02 FAQ – Modules for Micro-Strip Antennas and traces. The integration information shall include for the TCB review the integration instructions for the following aspects: layout of trace design, parts list (BOM), antenna, connectors, and isolation requirements.⁴

- a) Information that includes permitted variances (e.g., trace boundary limits, thickness, length, width, shape(s), dielectric constant, and impedance as applicable for each type of antenna);
- b) Each design shall be considered a different type (e.g., antenna length in multiple(s) of frequency, the wavelength, and antenna shape (traces in phase) can affect antenna gain and must be considered);
- c) The parameters shall be provided in a manner permitting host manufacturers to design the printed circuit (PC) board layout;
- d) Appropriate parts by manufacturer and specifications;
- e) Test procedures for design verification; and
- f) Production test procedures for ensuring compliance.

The module grantee shall provide a notice that any deviation(s) from the defined parameters of the antenna trace, as described by the instructions, require that the host product manufacturer must notify the module grantee that they wish to change the antenna trace design. In this case, a Class II permissive change application is required to be filed by the grantee, or the host manufacturer can take responsibility through the change in FCC ID (new application) procedure followed by a Class II permissive change application.

2.6 RF exposure considerations

It is essential for module grantees to clearly and explicitly state the RF exposure conditions that permit a host product manufacturer to use the module. Two types of instructions are required for RF exposure information: (1) to the host product manufacturer, to define the application conditions (mobile, portable – xx cm from a person's body); and (2) additional text needed for the host product manufacturer to provide to end users in their end-product manuals. If RF exposure statements and use conditions are not provided, then the host product manufacturer is required to take responsibility of the module through a change in FCC ID (new application).

Explanation: The module complies with FCC radiofrequency radiation exposure limits for uncontrolled environments. The device is installed and operated with a distance of more than 20 cm between the radiator and your body." This module follows FCC statement design, FCC ID: 2ATPO-RA20

2.7 Antennas

A list of antennas included in the application for certification must be provided in the instructions. For modular transmitters approved as limited modules, all applicable professional installer instructions must be included as part of the information to the host product manufacturer. The antenna list shall also identify the antenna types (monopole, PIFA, dipole,

etc. (note that for example an “non-directional antenna” is not considered to be a specific “antenna type”).

For situations where the host product manufacturer is responsible for an external connector, for example with an RF pin and antenna trace design, the integration instructions shall inform the installer that unique antenna connector must be used on the Part 15 authorized transmitters used in the host product.

The module manufacturers shall provide a list of acceptable unique connectors.

Explanation: The product antenna uses an irreplaceable antenna with a gain of 2.4GHz: 2dBi, 433MHz:-1.80dBi

2.8 Label and compliance information

Grantees are responsible for the continued compliance of their modules to the FCC rules.

This

includes advising host product manufacturers that they need to provide a physical or e-label stating “Contains FCC ID” with their finished product. See Guidelines for Labeling and User Information for RF Devices – KDB Publication 784748.

Explanation: The host system using this module, should have label in a visible area indicated the following texts: "Contains FCC ID: 2ATPO-RA20

2.9 Information on test modes and additional testing requirements⁵

Additional guidance for testing host products is given in KDB Publication 996369 D04 Module Integration Guide. Test modes should take into consideration different operational conditions for a stand-alone modular transmitter in a host, as well as for multiple simultaneously transmitting modules or other transmitters in a host product.

The grantee should provide information on how to configure test modes for host product evaluation for different operational conditions for a stand-alone modular transmitter in a host, versus with multiple, simultaneously transmitting modules or other transmitters in a host.

Grantees can increase the utility of their modular transmitters by providing special means, modes, or instructions that simulates or characterizes a connection by enabling a transmitter. This can greatly simplify a host manufacturer’s determination that a module as installed in a host complies with FCC requirements.

Explanation: Shenzhen Ai-Thinker Technology Co., Ltd can increase the utility of our modular transmitters by providing instructions that simulates or characterizes a connection by enabling a transmitter.

2.10 Additional testing, Part 15 Subpart B disclaimer

The grantee should include a statement that the modular transmitter is only FCC authorized for the specific rule parts (i.e., FCC transmitter rules) listed on the grant, and that the host product manufacturer is responsible for compliance to any other FCC rules that apply to the host not covered by the modular transmitter grant of certification. If the grantee markets their product as being Part 15 Subpart B compliant (when it also contains unintentional-radiator digital circuitry), then the grantee shall provide a notice stating that the final host product still requires Part 15 Subpart B compliance testing with the modular transmitter installed.

Explanation: The module without unintentional-radiator digital circuitry, so the module does not require an evaluation by FCC Part 15 Subpart B. The host should be evaluated by the FCC Subpart B.