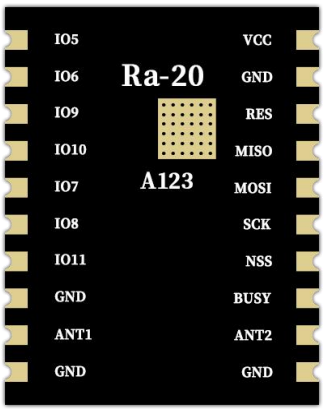
Ra-20 Specification



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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.

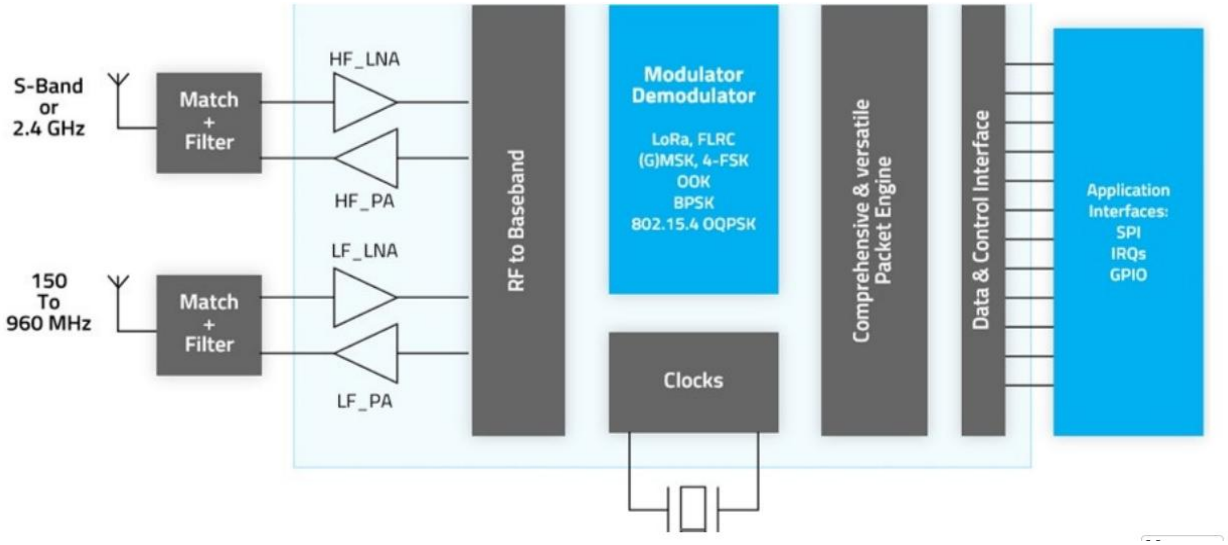


Figure 1 Main Chip Architecture Diagram

1.1 Features

RF Performance

- Transmit power: measured maximum transmit power of 21.5dBm@Sub-GHz, 12dBm@2.4GHz
- Power flatness: ≤ ±0.5dBm. Stable full-band and full-power transmission and the power level is software-adjustable in multiple steps.
- Receiver sensitivity:
  - Sub-GHz: up to -147dBm@BWLORA = 31kHz/SF12/CR4/5 (refer to chip datasheet); measured -122.5dBm@BWLORA = 400kHz/SF7/CR4/5
  - 2.4GHz: up to -137.5dBm@BWLORA = 200kHz/SF12/CR4/5 (refer to chip datasheet); measured -120dBm@BWLORA = 400kHz/SF7/CR4/5
- Frequency offset tolerance: ±33% BW, far exceeding the previous generation's ±25% BW. High-precision frequency stability can be achieved without a TCXO.
- Harmonic suppression: 490MHz@22dBm 2nd and 3rd harmonics ≤ -68dBc, 2450MHz@12dBm 2nd and 3rd harmonics ≤ -66dBc, with sufficient margin to pass CE, FCC and other regulations.

Operating Bands

- Low-frequency band: China default 470 – 510MHz (433MHz can be customized)
- High-frequency band: China default 2400 – 2500MHz

Power Consumption

- Sleep current: ≤ 2μA (average value: 1.65)
- Receive current: ≤ 6mA
- Transmit current: Sub-GHz@12dBm 125.8mA; 2.4GHz@12dBm 27mA

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

- IEEE® 802.15.4 (Thread®/Zigbee™)
- 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 MHF 1 connector
- Operating temperature: -40 – 85℃
- Storage conditions: -40 – 125℃, < 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 MHF 1 connector
Frequency Range	470 – 510MHz, 2400 – 2500MHz
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 × VCC	-	VCC + 0.3	V
VIL	Low-level Input Voltage	-0.3	-	0.3 × VCC	V
VOH	High-level Output Voltage	-	0.9 × VCC	-	V
VOL	Low-level Output Voltage	-	-	0.1 × VCC	V
ZPUD	Pull-up/Pull-down Resistors	-	40	100	kΩ

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	2400 – 2500			MHz
2.4GHz Output Power (Software Setting 12)				
Mode	**Min**	**Typ**	**Max**	**Unit**
2400MHz	-	-	12	dBm
2450MHz	-	-	12	dBm
2500MHz	-	-	12	dBm
2.4GHz Receiver Sensitivity (BW = 400kHz, SF7, CR4/5)				
Mode	**Min**	**Typ**	**Max**	**Unit**
2400MHz	-	-	-120	dBm
2450MHz	-	-	-120	dBm
2500MHz	-	-	-120	dBm
2.4GHz Harmonic Suppression RBW/VBW (1MHz/3MHz)				
Mode	**Min**	**Typ**	**Max**	**Unit**
2450MHz@12dBm@2nd Harmonic	-	-48	-	dBm
2450MHz@12dBm@3rd Harmonic	-	-47.5	-	dBm
Description	**Typ**			**Unit**
Frequency Range	470 – 510			MHz
Sub-GHz Output Power (Software Setting 22)				
Mode	**Min**	**Typ**	**Max**	**Unit**
470MHz	-	-	21.5	dBm

490MHz	-	-	21.5	dBm
510MHz	-	-	21.5	dBm
Sub-GHz Receiver Sensitivity (BW = 400kHz, SF7, CR4/5)				
Mode	**Min**	**Typ**	**Max**	**Unit**
470MHz	-	-	-122.5	dBm
490MHz	-	-	-122.5	dBm
510MHz	-	-	-122.5	dBm
Sub-GHz Harmonic Suppression RBW/VBW (1MHz/3MHz)				
Mode	**Min**	**Typ**	**Max**	**Unit**
490MHz@22dBm@2nd Harmonic	-	-45.5	-	dBm
490MHz@22dBm@3rd Harmonic	-	-46.7	-	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℃ 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.

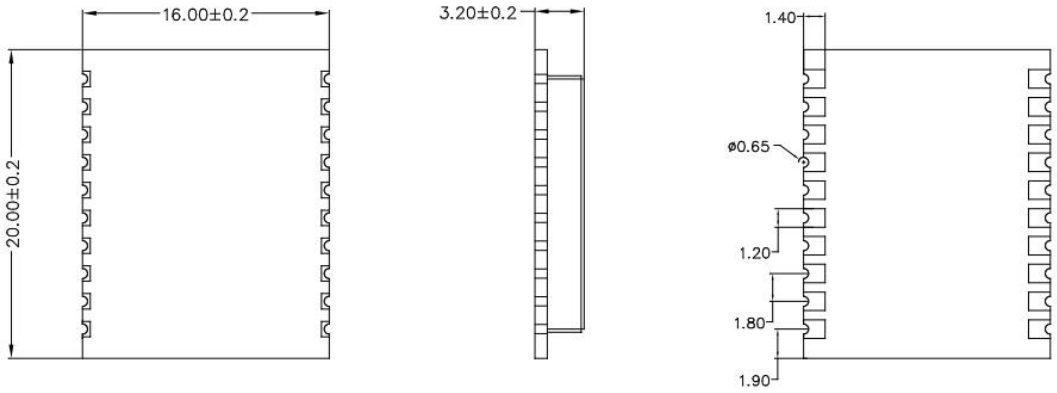
Table 5 Instantaneous Power Consumption

Mode	Min	Avg	Max	Unit
2.4GHz@TX (12dBm)	-	27	-	mA
Sub-GHz@TX (22dBm)	-	125.8	-	mA
2.4GHz@RX	-	6	-	mA
Sub-GHz@RX	-	5.87	-	mA
Standby Current	-	1.16	-	mA
Sleep Current	-	1.65	-	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 ±0.20mm.



Top View Side View Bottom View

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.

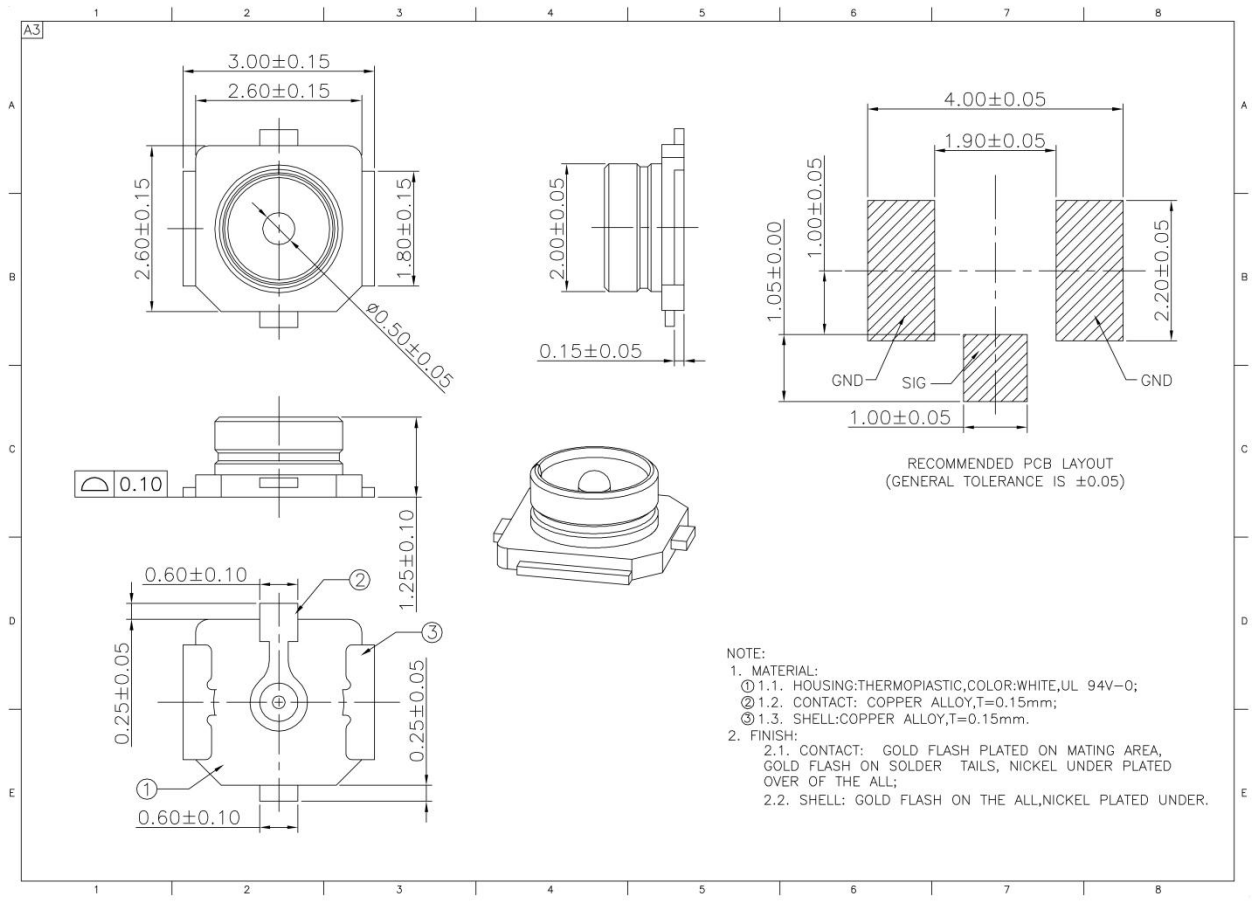
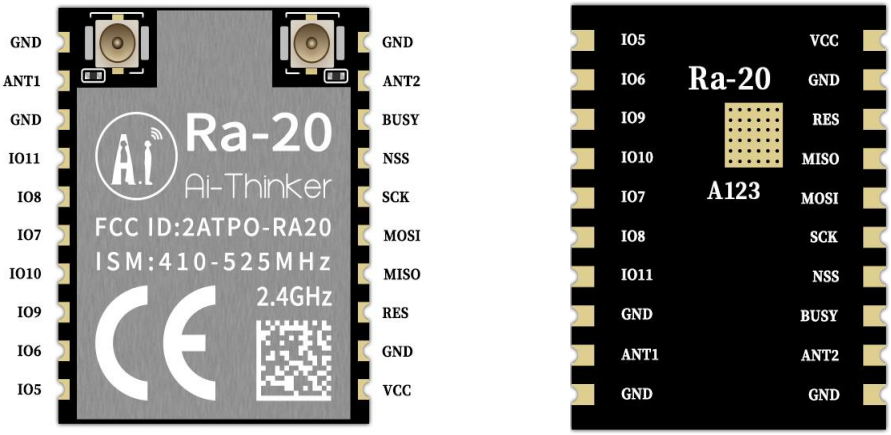


Figure 4 External Antenna Connector Dimensions (Unit: mm)

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.



Top View Bottom View

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 Schematic

Figure 6 shows the schematic of the Ra-20 module, integrating RF antennas, power supply, clock, and reserved peripheral interfaces.

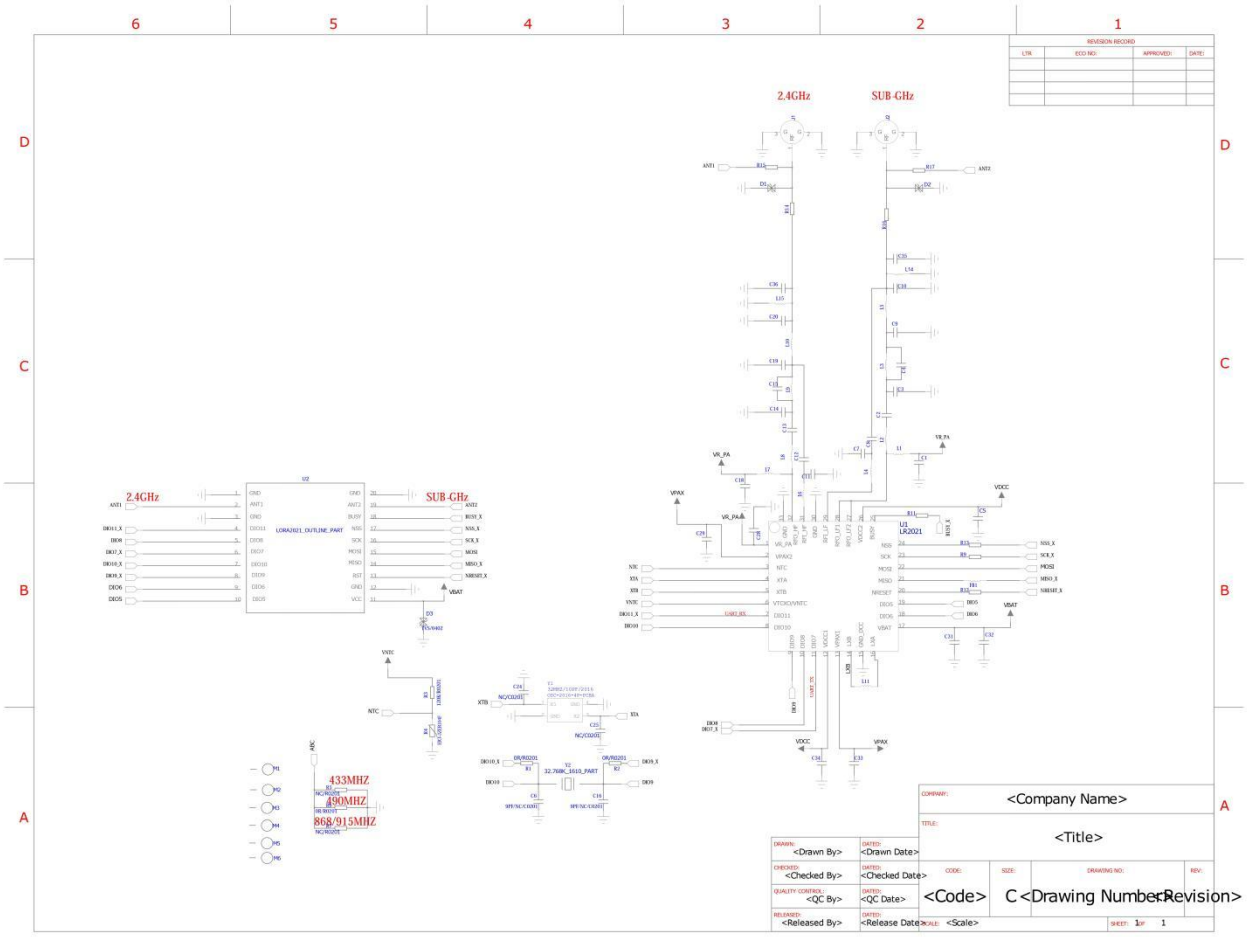


Figure 6 Schematic

7 Design Guide

7.1 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.

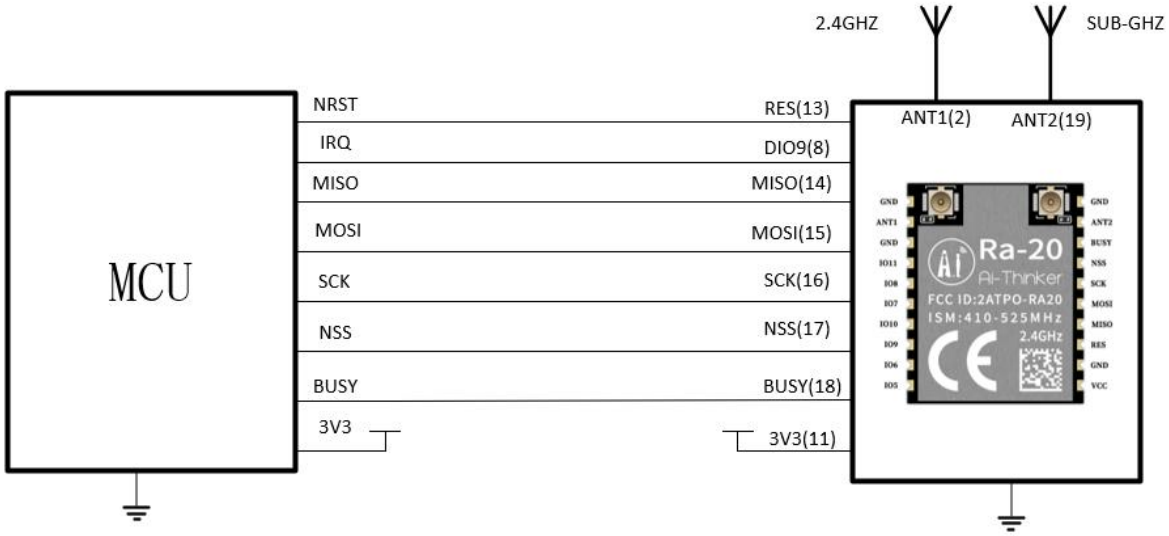


Figure 7 Application Reference Circuit

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.

7.2 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.

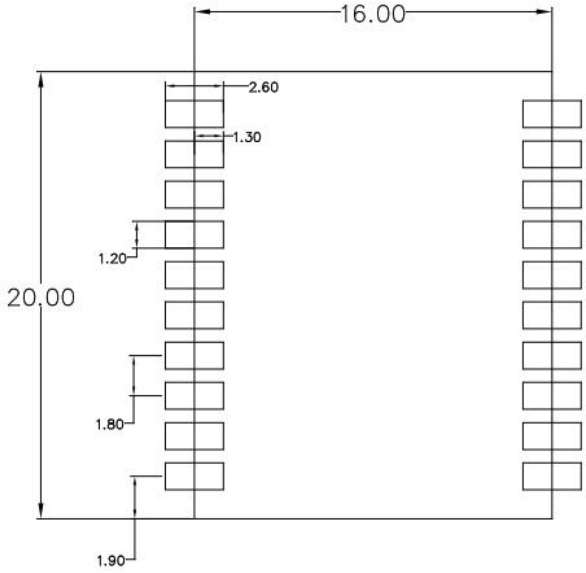


Figure 8 Recommended PCB Footprint Dimensions (Unit: mm)

7.3 Power Supply

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

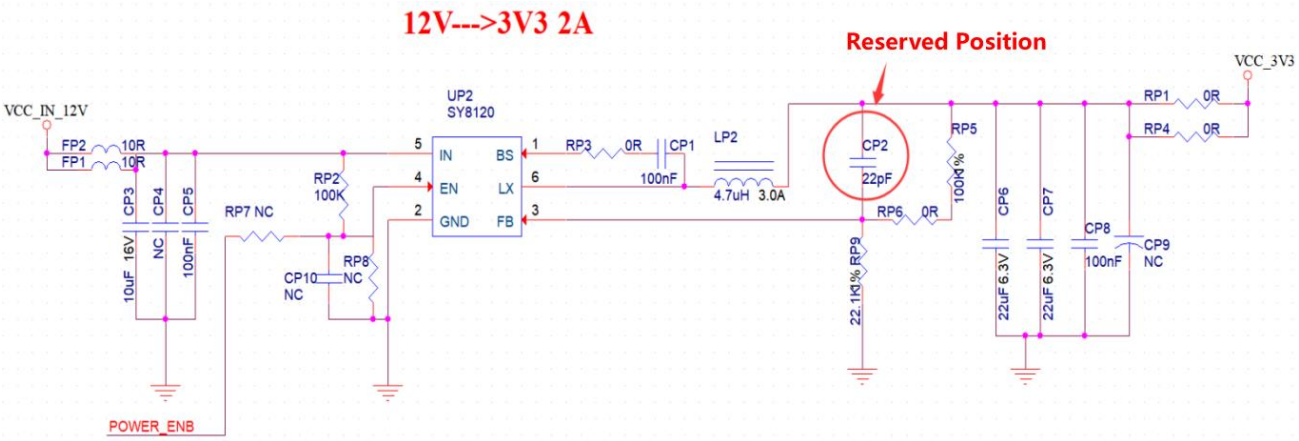


Figure 9 DC-DC Buck Circuit

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.

7.4 GPIO

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

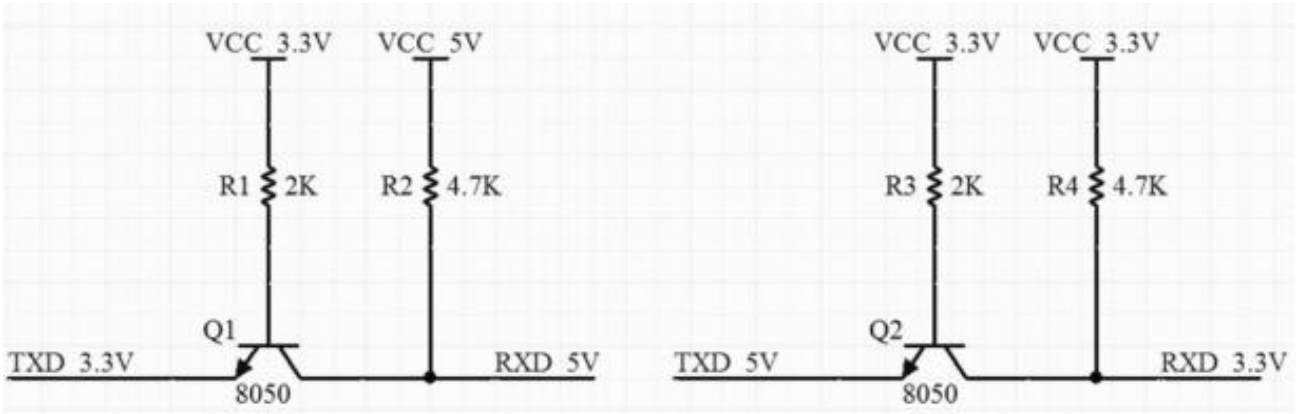


Figure 10 Level-shifting Circuit

Notes on the Level-Shifting Circuit:

- Some I/O pins are brought out from the module. 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.

8 Storage Conditions

Products sealed in moisture barrier bags should be stored in a non-condensing atmosphere at < 40℃ and < 90% 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±5℃ and 60% RH. Otherwise, the module requires baking before being returned to production.

9 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.

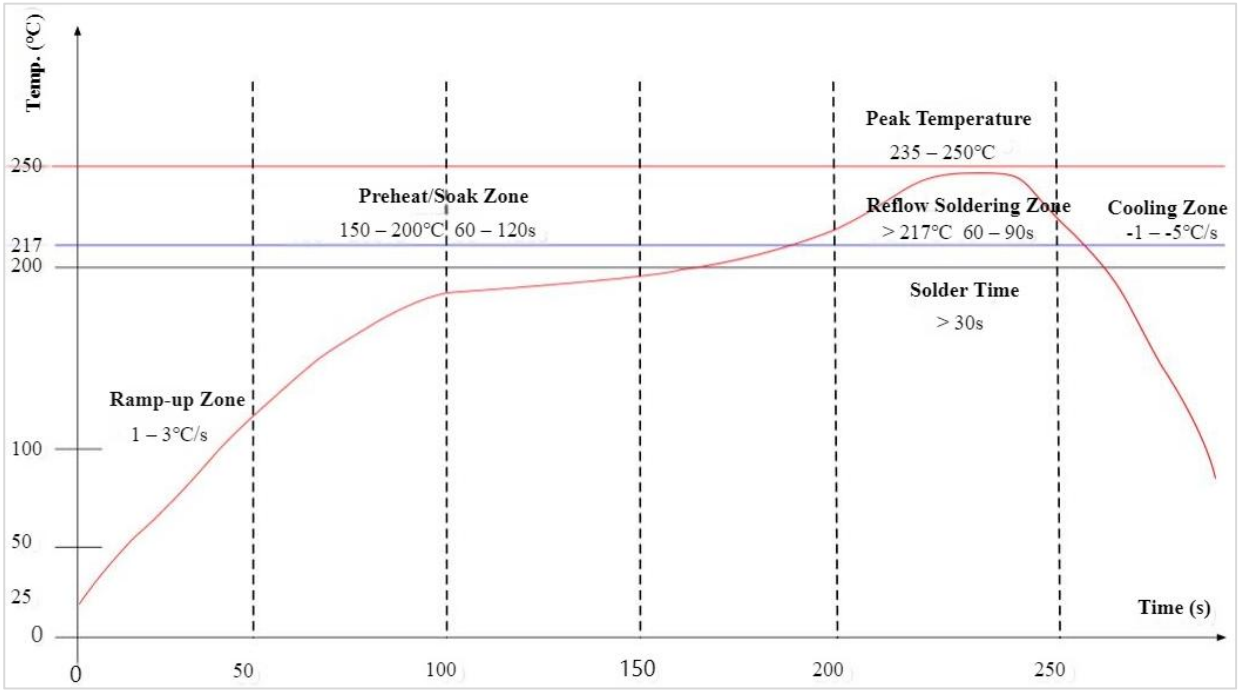


Figure 11 Reflow Soldering Profile

Reflow Soldering Profile Description:

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

10 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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