



# Ra-09 Specification

Version V1.0.0

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**Document resume**

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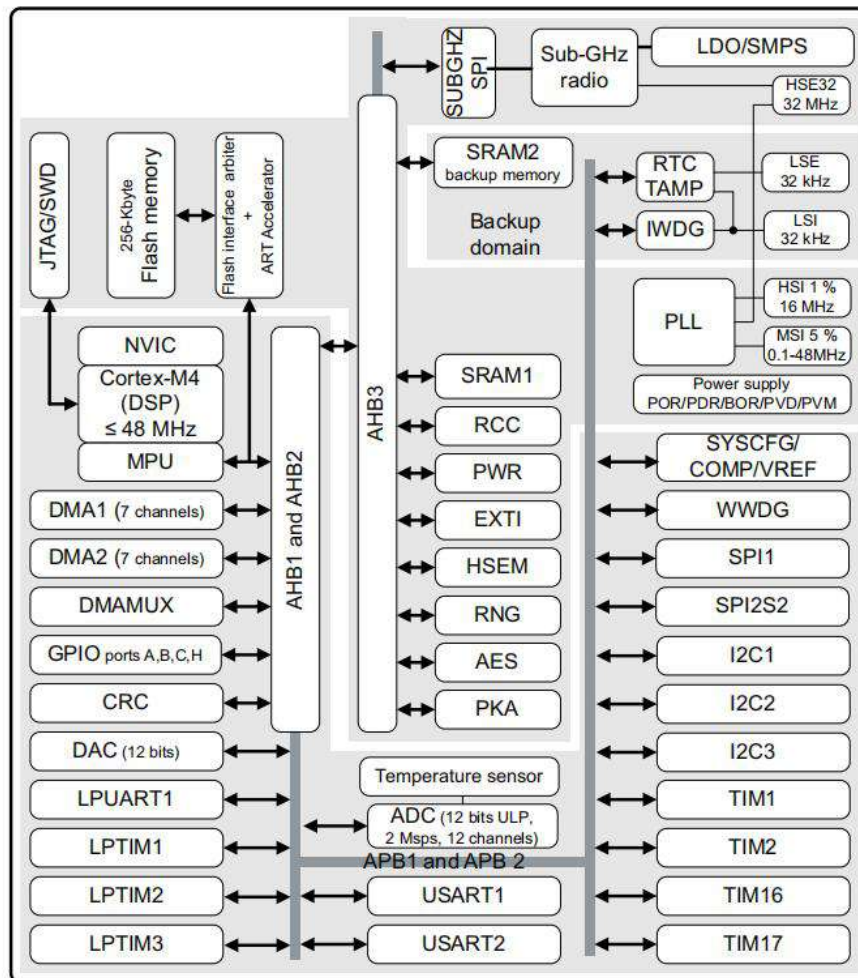
## Content

|  |    |
|--|----|
| 1. Product Overview .....                                | 4  |
| 1.1. Characteristic .....                                | 5  |
| 2. Main parameters .....                                 | 6  |
| 2.1. Static electricity requirements .....               | 6  |
| 2.2. Electrical characteristics .....                    | 7  |
| 2.3. Digital port characteristics .....                  | 7  |
| 2.4. RF parameters .....                                 | 8  |
| 3. Appearance dimensions .....                           | 9  |
| 4. Pin definition .....                                  | 10 |
| 5. Schematic .....                                       | 12 |
| 6. Design Guide .....                                    | 13 |
| 6.1. Module Application Guidance Circuit .....           | 13 |
| 6.2. Antenna Interface .....                             | 13 |
| 6.3. Power supply .....                                  | 14 |
| 6.4. GPIO .....  | 15 |
| 7. Common issues .....                                   | 16 |
| 7.1. Effect of transmission distance factors .....       | 16 |
| 7.2. Attention item for using module .....               | 16 |
| 7.3. Factors that cause interference to the module ..... | 17 |
| 8. Storage conditions .....                              | 18 |
| 9. Flow welding curve diagram .....                      | 18 |
| 10. Product packaging information .....                  | 19 |
| 11. Contact us .....                                     | 19 |
| Disclaimer and copyright notice .....                    | 20 |
| Notice .....   | 20 |
| Important Statement .....                                | 21 |

# 1. Product Overview

Ra-09 is a LoRa module designed and developed by Shenzhen Ai-Thinker Technology Co., Ltd., which is used for ultra-long-distance spread spectrum communication. Its chip STM32WLE5CCU6 is a general-purpose LPWAN wireless communication SoC that integrates a radio frequency transceiver, a modem and a 32-bit Arm® Cortex®-M4 MCU. The MCU adopts ARM core, and its operating frequency can reach 48MHz. The Ra-09 module supports LoRa modulation and traditional (G)FSK modulation under LPWAN use cases; at the same time, the transmitter also supports BPSK modulation and (G)MSK modulation, and the receiver supports (G)MSK modulation.

The Ra-09 module provides ultra-long range and ultra-low power communication for LPWAN applications, and can be widely used in smart meters, supply chain and logistics, home building automation, security systems, remote irrigation systems and other scenarios.



**Figure 1 Main chip architecture diagram**

## 1.1. Characteristic

- Adopt SMD-48 package
- Support frequency: 410MHz-525MHz
- Working voltage is 3.3V, and the theoretical maximum transmit power is +22dBm
- High sensitivity: -140dBm @125KHz SF12
- Support spread spectrum factor SF5/SF6/SF7/SF8/SF9/SF10/SF11/SF12
- Embedded memory, 256KB FLASH,64KB RAM
- Support LoRa/(G)FSK/BPSK/(G)MSK modulation
- The antenna interface is a half-hole pad and an IPEX connector, which supports a variety of external antenna connections and supports more program selection
- Support multiple sleep modes: depth sleep current is low to 0.1uA

## 2. Main parameters

**Table 1 Description of the main parameters**

|                              |  |
|------------------------------|--|
| <b>Model</b>                 | Ra-09  |
| <b>Package</b>               | SMD-48   |
| <b>Size</b>                  | 18.0*18.0*2.6(±0.2)mm                                  |
| <b>Antenna</b>               | Compatible with half-hole pad /IPEX connector          |
| <b>Frequency</b>             | 410-525MHz   |
| <b>Operating temperature</b> | -40 °C ~ 85 °C   |
| <b>Storage temperature</b>   | -40 °C ~ 125 °C , < 90%RH                              |
| <b>Power supply</b>          | Voltage 1.8V ~ 3.6V, Current >500mA                    |
| <b>Interface</b>             | UART/GPIO/ADC/DAC/I2C/I2S/SPI/PWM                      |
| <b>IO</b>                    | 24   |
| <b>UART rate</b>             | Support 110 ~ 4608000 bps, Default 9600 bps            |
| <b>Crystal frequency</b>     | 32MHz  |
| <b>SPI Flash</b>             | 256KB  |
| <b>Transfer Protocol</b>     | LoRaWAN  |
| <b>Transmission Distance</b> | The open field is equipped with a sucker antenna 4.8km |

### 2.1. Static electricity requirements

Ra-09 is an electrostatic sensitive device, and special precautions must be taken when handling it.



**Figure 2 ESD anti-static diagram**

## 2.2. Electrical characteristics

**Table 2 Electrical characteristics table**

| Parameter             | Name                      | Min.                | Typical value | Max.  | Unit | Remark                           |   |
|-----------------------|---------------------------|---------------------|---------------|-------|------|----------------------------------|---|
| Operating temperature | TOPR                      | -40                 | 25            | 85    | °C   |                                  |   |
| Supply voltage        | VDD                       | 1.8                 | 3.3           | 3.6   | V    | ≥3.3V can guarantee output power |   |
| Power consumption     | Sleep mode                | Power consumption 1 | -             | 0.113 | -    | uA                               | Deep Sleep(LDO and SMPS regulator off, MCU regulator off) |
|                       |                           | Power consumption 2 | -             | 0.2   | -    | uA                               | STANDBY(without RTC)                                      |
|                       | Operation mode            | -                   | 3.83          | -     | mA   | Power on                         |   |
|                       | Full load mode (TX:22dBm) | -                   | 119           | -     | mA   | DC-DC mode                       |   |
|                       | Receive mode (RX:SF9)     | -                   | 5.15          | -     | mA   | DC-DC mode                       |   |

## 2.3. Digital port characteristics

**Table 3 Digital port**

| Type                   | Name | Min.     | Typical value | Max.                            | Unit |
|------------------------|------|----------|---------------|---------------------------------|------|
| IO level (VDD)         | VIO  | 1.8      | 3.3           | 3.6                             | V    |
| Enter logic level low  | VIL  | -        | -             | VDD*0.3                         | V    |
| Enter logic level high | VIH  | 0.7*VDD  | -             | -                               | V    |
| Enter logic level low  | VOL  | -        | -             | 0.4 ( IO  = 8 mA, VDD ≥ 2.7 V)  | V    |
| Enter logic level low  | VOL  | -        | -             | 1.3 ( IO  = 20 mA, VDD ≥ 2.7 V) | V    |
| Enter logic level high | VOH  | VDD-0.45 | -             | -                               | V    |

## 2.4. RF parameters

**Table 4 RF parameters**

| <b>Output Power</b>                                    |                       |             |                      |             |             |
|--|-----------------------|-------------|----------------------|-------------|-------------|
| <b>PA parameter</b>                                    | <b>Frequency band</b> | <b>Min.</b> | <b>Typical value</b> | <b>Max.</b> | <b>Unit</b> |
| Transmit power   | 433MHz                | -           | 21                   | 22          | dBm         |
| Transmit power   | 470MHz                | -           | 21                   | 22          | dBm         |
| Transmit power   | 490MHz                | -           | 21                   | 22          | dBm         |
| Transmit power   | 510MHz                | -           | 21                   | 22          | dBm         |
| <b>Receive sensitivity modulation bandwidth 125kHz</b> |                       |             |                      |             |             |
| <b>Mode</b>  |                       | <b>Min.</b> | <b>Typical value</b> | <b>Max.</b> | <b>Unit</b> |
| SF7  |                       | -           | -123                 | -           | dBm         |
| SF8  |                       | -           | -126                 | -           | dBm         |
| SF9  |                       | -           | -128                 | -           | dBm         |
| SF10   |                       | -           | -131                 | -           | dBm         |
| SF11   |                       | -           | -135                 | -           | dBm         |
| SF12   |                       | -           | -140                 | -           | dBm         |



### 3. Appearance dimensions

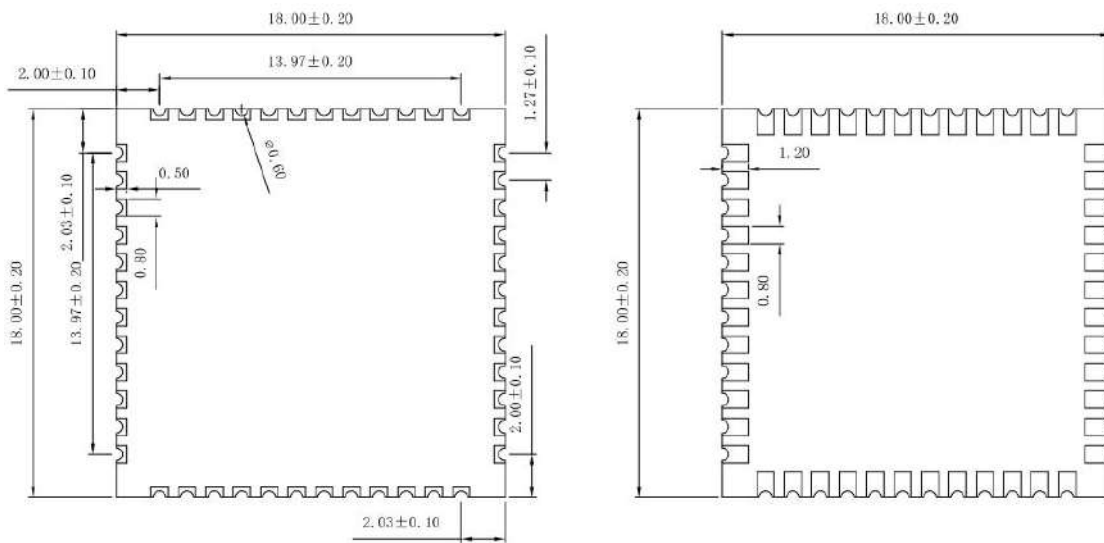


Front



Back

**Figure 3 Appearance of the module (the rendering is for reference only, the actual object shall prevail)**



Front

Back

**Figure 4 Module size diagram**

## 4. Pin definition

The Ra-09 module has a total of 48 pins, such as the pin schematic diagram, and the pin function definition table is the interface definition.

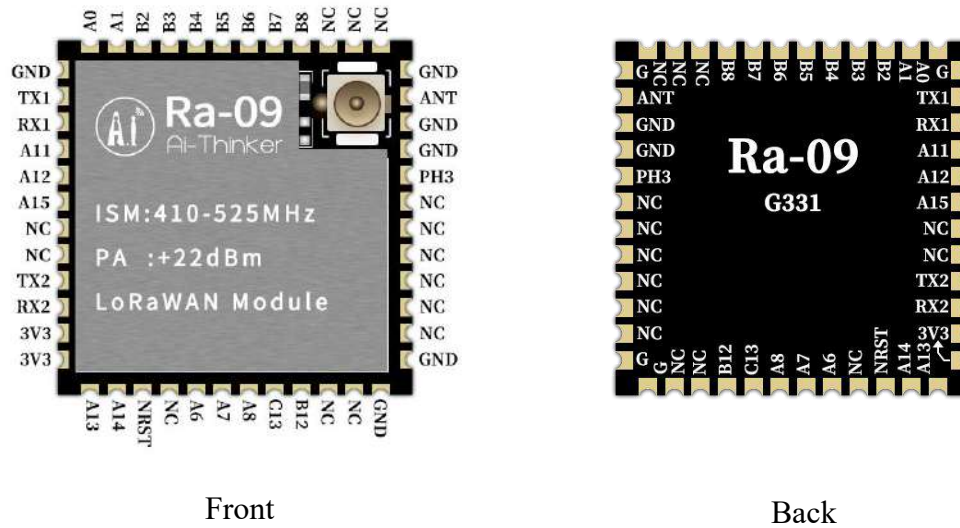


Figure 5 Schematic diagram of module pins

Table 5 Pin function definition table

| No.                                | Name | Function                               |
|------------------------------------|------|--|
| 1, 2, 3, 19, 20, 28, 34, 35, 38-44 | NC   | Not connected                          |
| 4                                  | PB8  | PB8/I2C1_SCL/PWM                       |
| 5                                  | PB7  | PB7/I2C1_SDA                           |
| 6                                  | PB6  | PB6/I2C1_SCL                           |
| 7                                  | PB5  | PB5/SPI1_MOSI                          |
| 8                                  | PB4  | PB4/SPI1_MISO/ADC_IN3                  |
| 9                                  | PB3  | PB3/ADC_IN2/SPI1_SCK                   |
| 10                                 | PB2  | PB2/SPI1_NSS/ADC_IN4                   |
| 11                                 | PA1  | PA1/SPI1_SCK                           |
| 12                                 | PA0  | PA0                                    |
| 13, 36-37, 45-46, 48               | GND  | Ground                                 |
| 14                                 | TX1  | PA9/UART1_TX/I2C1_SCL/SPI2_SCK/I2S2_CK |
| 15                                 | RX1  | PA10/UART1_RX/DAC_OUT1/ADC_IN6/I2C1_   |

|       |      |   |
|-------|------|---|
| 16    | PA11 | PA11/I2C2_SDA/SPI1_MISO/PWM/ADC_IN7         |
| 17    | PA12 | PA12/I2C2_SCL/SPI1_MOSI/ADC_IN8             |
| 18    | PA15 | PA15/I2C2_SDA/SPI1_NSS/ADC_IN11             |
| 21    | TX2  | PA2/UART2_TX                                |
| 22    | RX2  | PA3/UART2_RX/I2S2_MCK                       |
| 23-24 | 3V3  | 3.3V power supply, recommended supply       |
| 25    | PA13 | PA13/ADC_IN9                                |
| 26    | PA14 | PA14/ADC_IN10                               |
| 27    | NRST | NRST external reset, low power is effective |
| 29    | PA6  | PA6/SPI1_MISO                               |
| 30    | PA7  | PA7/I2C3_SCL/SPI1_MOSI/PWM                  |
| 31    | PA8  | PA8/SPI2_SCK/I2S2_CK                        |
| 32    | PC13 | PC13  |
| 33    | PB12 | PB12/SPI2_NSS/I2S2_WS                       |
| 45    | PH3  | PH3/BOOT0                                   |
| 47    | ANT  | Antenna interface                           |

**Table 6 Module Start Mode Description**

| System start mode |           |                  |                     |
|-------------------|-----------|------------------|---------------------|
| Pin               | Default   | SPI startup mode | Download start mode |
| PH3               | drop down | 0                | 1                   |

Note: Some pins have been pulled inside, please refer to the schematic.

## 5. Schematic

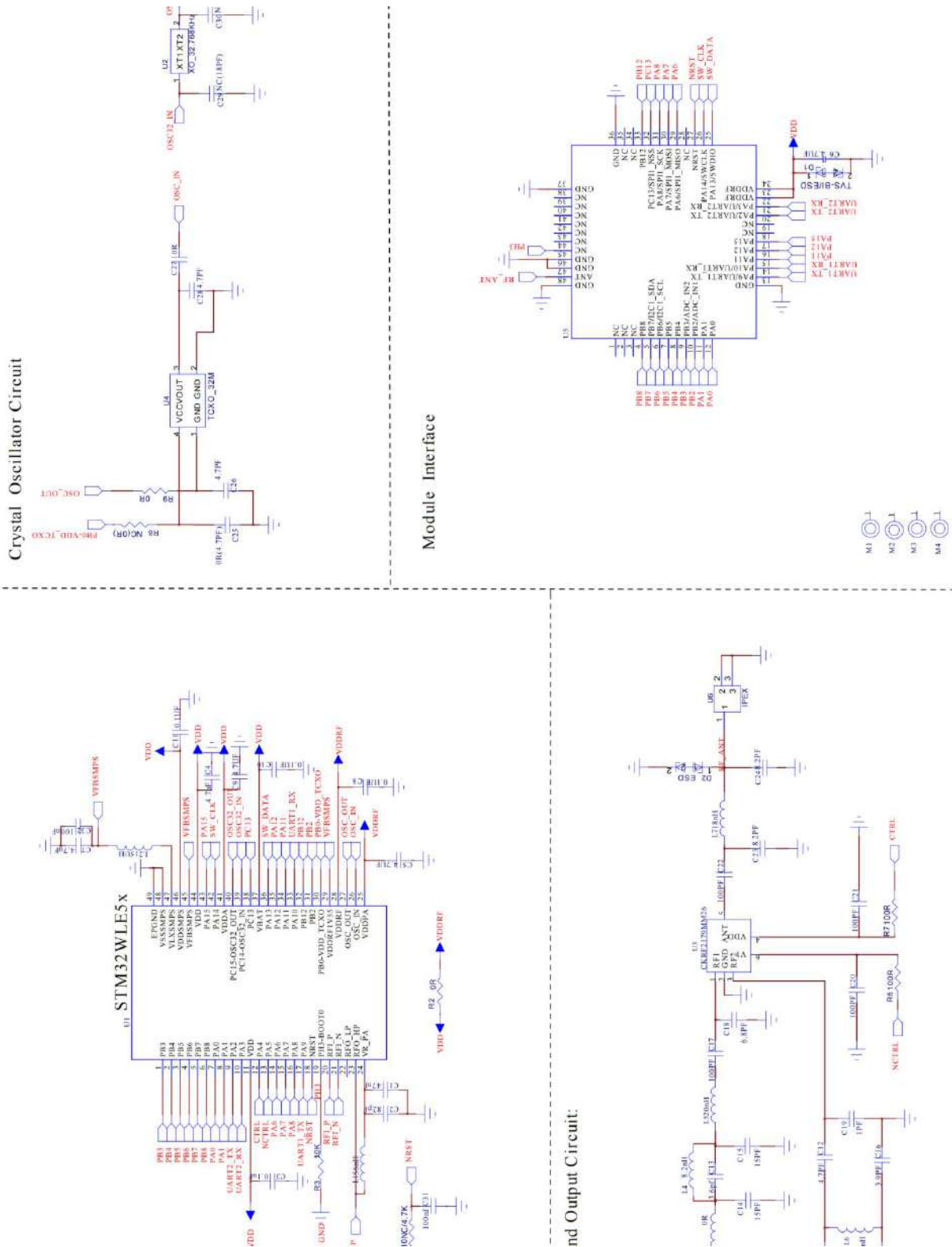
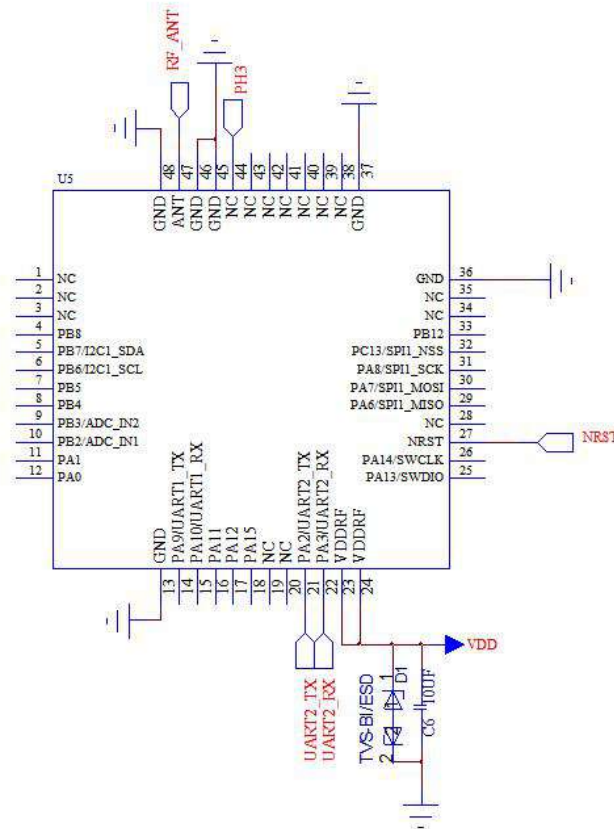


Figure 6 Module Schematic

## 6. Design Guide

### 6.1. Module Application Guidance Circuit



(It is recommended to use DC-DC or LDO for independent power supply, and the current is greater than 500mA)

**Figure 7 application circuit diagram**

Note:

- PH3 is the boot control pin. It is in the normal working mode when it is low level, and it is in the firmware burning mode when it is high level. The default low level inside the chip.

### 6.2. Antenna Interface

- The Ra-09 module requires an external antenna. There are two wiring methods for the antenna, which are compatible with half-hole pads and IPEX connectors, and the standard IPEX connector interface is left on the module. The size chart of the IPEX connector is as follows:

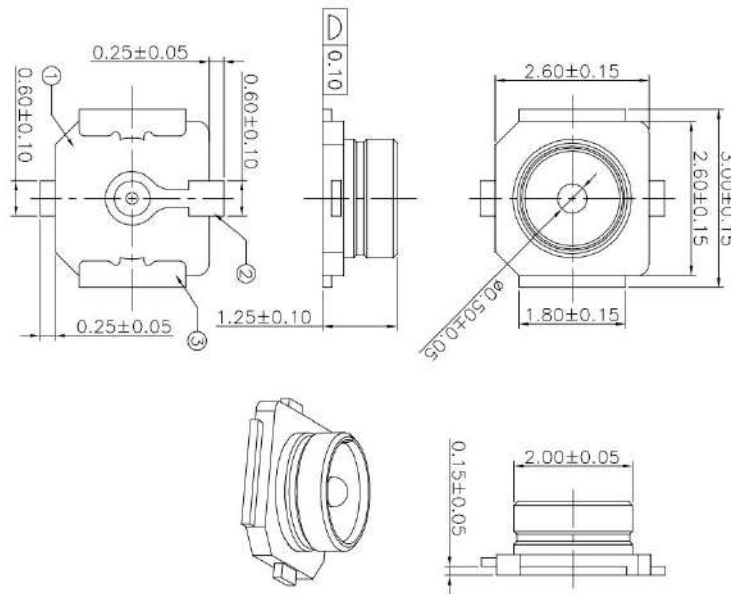


Figure 8 board end IPEX seat size diagram

### 6.3. Power supply

- Recommend 3.3V voltage, current peak  $\geq 500\text{mA}$ .
- It is recommended to use LDO power supply; if using DC-DC, it is recommended to control the ripple within 30mV.
- It is recommended to reserve the position of the dynamic response capacitor for the DC-DC power supply circuit, which can optimize the output ripple when the load changes greatly.
- 3.3V power interface suggestion increase ESD devices.

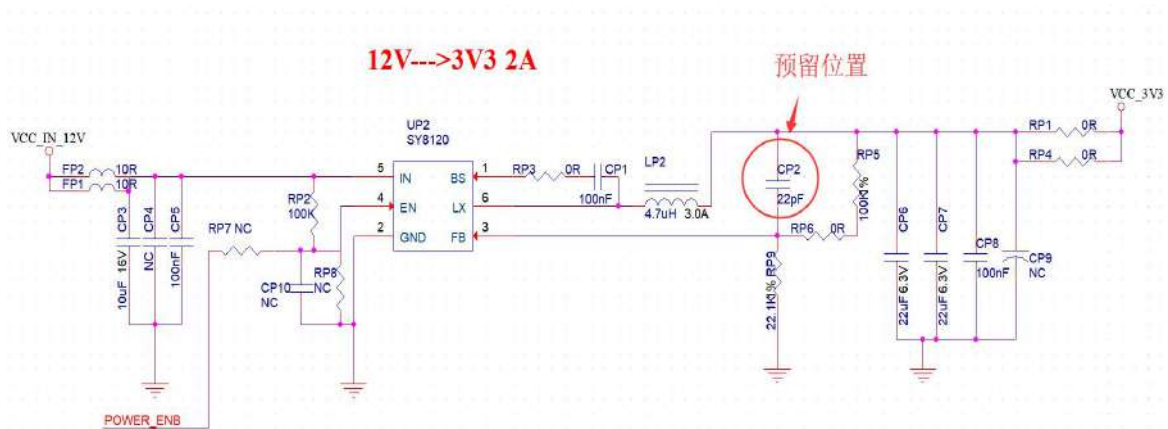


Figure 9 DC-DC step-down circuit diagram

## 6.4. GPIO

- There are some IO ports on the periphery of the module. If you need to use it, it is recommended to connect a 10-100 ohm resistor in series with the IO ports. This can suppress overshoot and make the levels on both sides more stable. Helpful for both EMI and ESD.
- For the pull-up and pull-down of the special IO port, please refer to the instructions in the specification, which will affect the startup configuration of the module.
- The IO port of the module is 3.3V. If the level of the main control and the IO port of the module do not match, a level conversion circuit needs to be added.
- If the IO port is directly connected to the peripheral interface, or terminals such as pin headers, it is recommended to reserve an ESD device near the IO port wiring near the terminal.

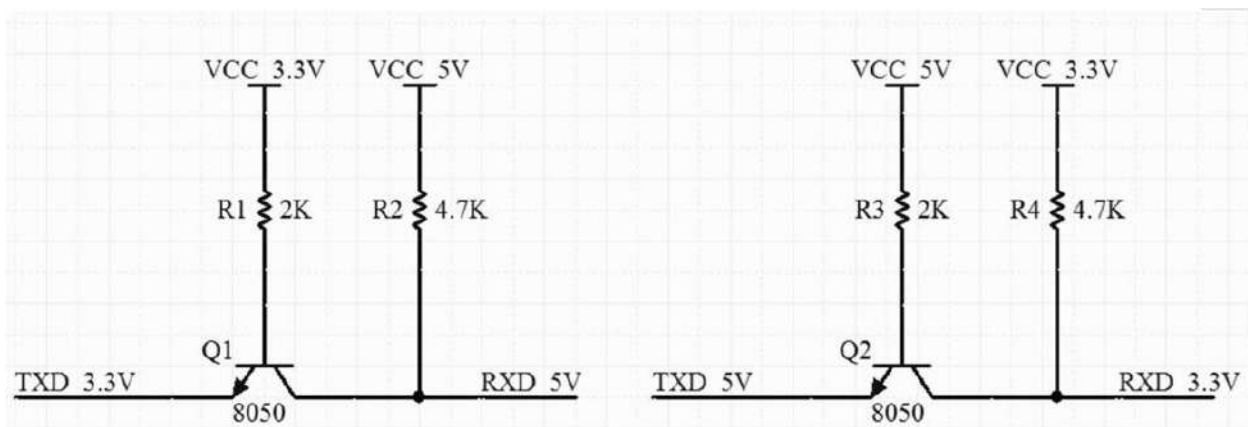


Figure 10 Level conversion circuit

## 7. Common issues

### 7.1. Effect of transmission distance factors

- (1) When there is a straight-line communication obstacle, the communication distance will be attenuated accordingly;
- (2) Temperature, humidity, and co-frequency interference will increase the communication packet loss rate;
- (3) The ground absorbs and reflects radio waves, and the test effect close to the ground is poor;
- (4) Seawater has a strong ability to absorb radio waves, so the seaside test effect is poor;
- (5) There are metal objects near the antenna, or placed in a metal case, the signal attenuation will be very serious;
- (6) The power register is set incorrectly, the air speed is set too high, the higher the air speed, the closer the distance;
- (7) The low voltage of the power supply at room temperature is lower than the recommended value, the lower the voltage, the lower the transmission power;
- (8) The matching degree between the used antenna and the module is poor or the quality of the antenna itself is problematic.

### 7.2. Attention item for using module

- (1) Check the power supply to ensure that it is within the recommended power supply voltage. If it exceeds the maximum value, it will cause permanent damage to the module;
- (2) Check the stability of the power supply, and the voltage cannot fluctuate greatly and frequently;
- (3) Ensure anti-static operation during installation and use, and high-frequency devices are electrostatically sensitive;
- (4) Ensure that the humidity during installation and use should not be too high, and some components are humidity-sensitive devices;
- (5) If there is no special requirement, it is not recommended to use it at too high or too low temperature.



### **7.3. Factors that cause interference to the module**

- (1) There is co-frequency signal interference nearby, stay away from the source of interference or modify the frequency and channel to avoid interference;
- (2) The clock waveform on the SPI is not standard, check whether there is interference on the SPI line, and the SPI bus line should not be too long;
- (3) Unsatisfactory power supply may also cause garbled characters, so be sure to ensure the reliability of the power supply;
- (4) The extension line and feeder line are of poor quality or are too long, which will also cause a high bit error rate.

## 8. Storage conditions

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

The moisture sensitivity level MSL of the module is 3.

After the vacuum bag is unpacked, it must be used within 168 hours at  $25\pm 5^{\circ}\text{C}/60\%\text{RH}$ , otherwise it needs to be baked before it can be put online again.

## 9. Flow welding curve diagram

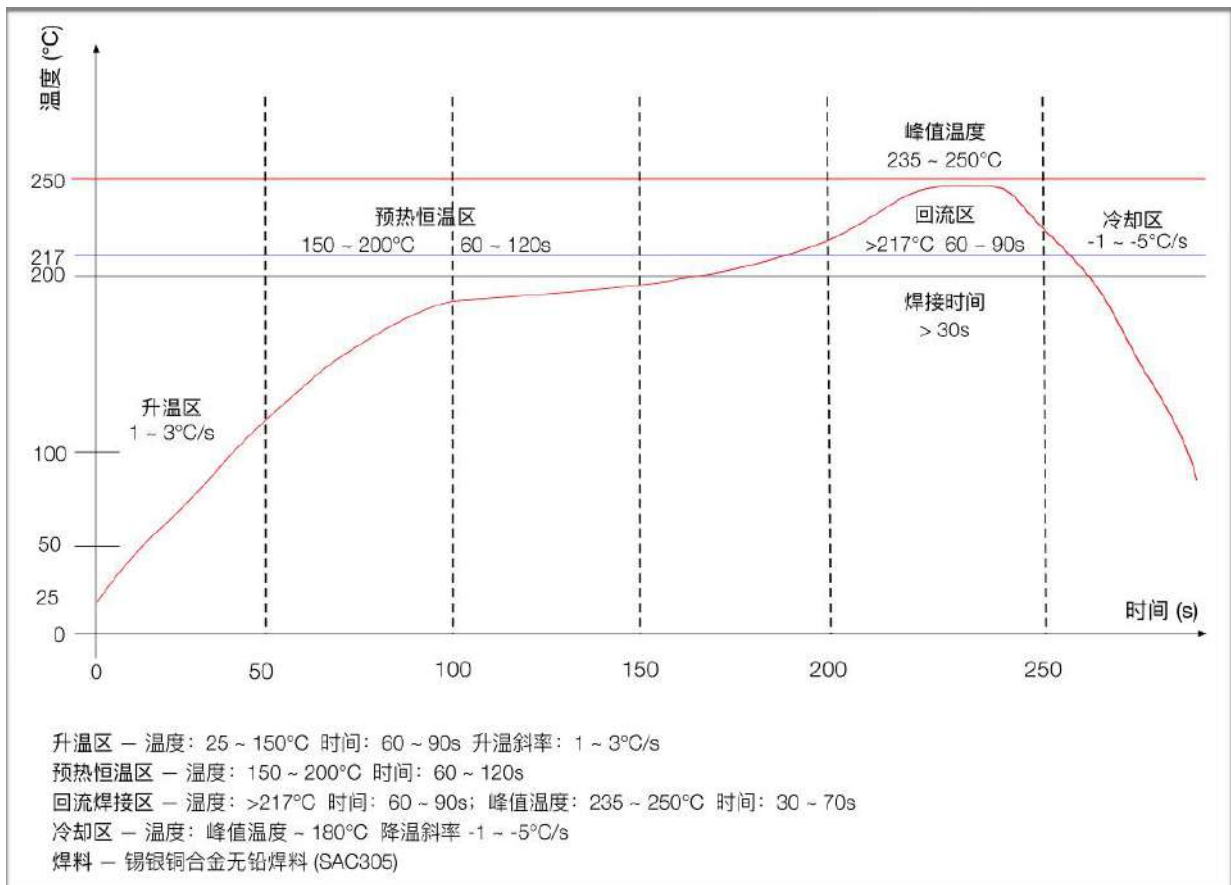


Figure 11 Flow welding diagram

## 10. Product packaging information

Ra-09 module was packaged in a tape, 900pcs/ reel. As shown in the below image:



Figure 12 Package and packing diagram

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