



# Ai-WV02-32S Specification

Version V1.1.1

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## Document Resume

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## Content

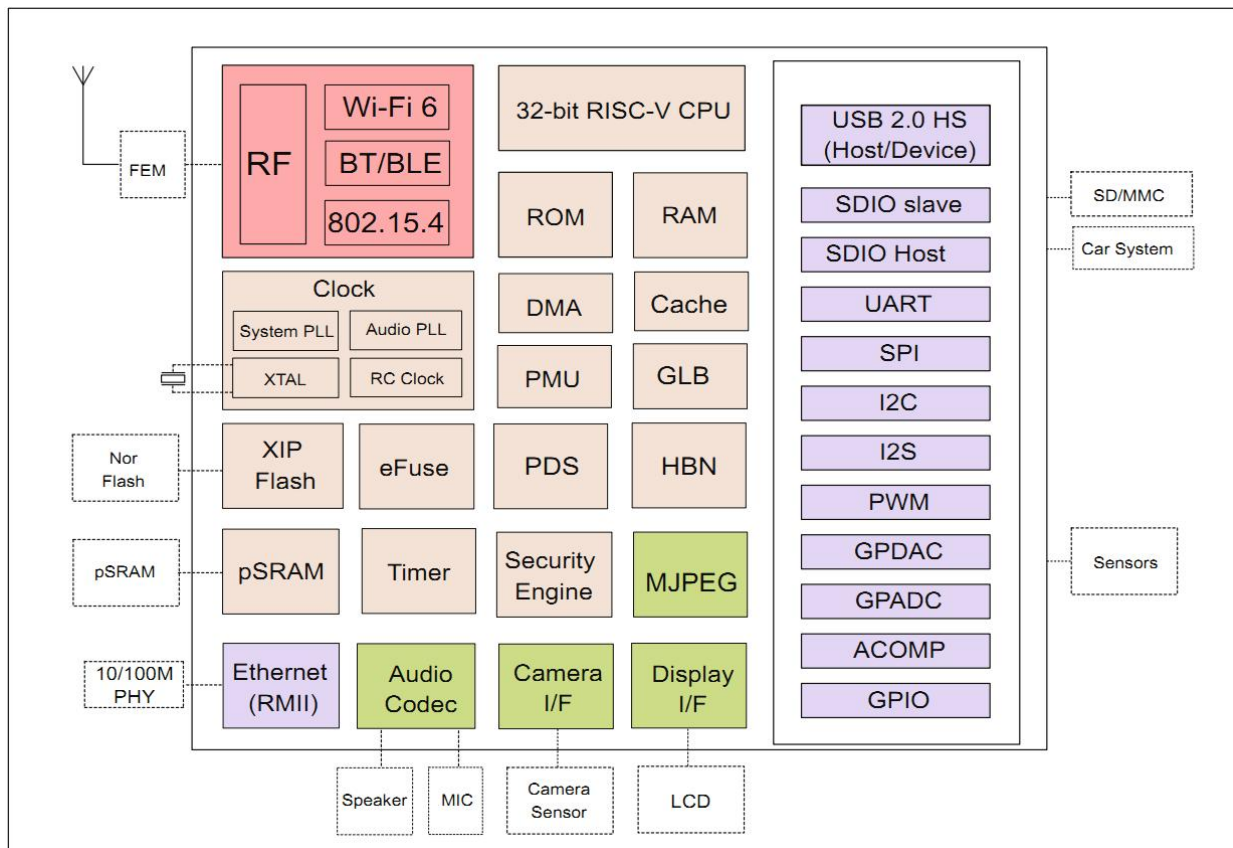
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## 1. Product Overview

Ai-WV02-32S is an artificial intelligence AIoT voice module developed by Shenzhen Ai-Thinker Technology Co., Ltd. This module is equipped with the BL618 chip as the core processor and the VB6824 chip as the voice algorithm processor. BL618 chip supports Wi-Fi 6+BLE5.3, Wi-Fi 802.11b/g/n/ax protocols and BLE protocol, and Thread protocol. The BL618 system features a low-power 32-bit RISC-V CPU with a floating-point unit, DSP unit, cache and memory, with a maximum clock speed of up to 320M.

VB6824 is a high-performance 32-bit RISC core CPU with a main control frequency of up to 240MHz, supporting hardware floating-point computing and featuring an integrated 1MB Flash.

Ai-WV02-32S module features a rich array of peripheral interfaces, specifically including SPI, UART, I2C, I2S, PWM, GPDAC, GPADC, ACOMP and GPIO, etc. It can be widely applied in fields such as audio and video multimedia, Internet of Things (IoT), mobile devices, wearable electronic devices, and smart home.



**Figure 1 Main chip architecture diagram**

## 1.1. Characteristic

- SMD-40 package
- Supports the 2.4GHz operating frequency band
- Supports IEEE 802.11 b/g/n/ax
- Supports BLE5.3
- Supports Thread
- Supports Wi-Fi/BLE/Thread coexist
- Wi-Fi Security Support WPS/WEP/WPA/WPA2/WPA3
- Supports 20/40 MHz bandwidth, 1T1R, with a maximum rate of 229.4 Mbps
- Supports STA, SoftAP, STA+SoftAP and sniffer modes
- 32-bit RISC-V CPU with FPU and DSP, with a maximum main frequency of up to 320M
- 4MB PSRAM, 532KB SRAM, 128KB ROM, 4Kb eFuse
- Supports USB、SPI、UART、I2C、I2S、PWM、GPDAC、GPADC、ACOMP and GPIO
- Integrated RF Balun、PA/LNA
- Supports safe startup; safe debugging
- Supports XIP QSPI On-The-Fly AES decode (OTFAD)
- Supports TrustZone
- Supports AES-CBC/CCM/GCM/XTS model
- Supports MD5、SHA-1/224/256/384/512
- Supports TRNG (True Random Number Generator)
- Support PKA (Public Key Accelerator) for RSA/ECC
- BLE-enabled Wi-Fi fast connection
- Supports secondary development and integrates Windows and Linux development environments
- Supports offline voice recognition
- Supports voice noise reduction algorithms

## 2. Main parameters

**Table 1 Description of main parameters**

|                              |                                                                                                                    |
|------------------------------|--------------------------------------------------------------------------------------------------------------------|
| <b>Model</b>                 | Ai-WV02-32S                                                                                                        |
| <b>Package</b>               | SMD-40                                                                                                             |
| <b>Size</b>                  | 25.5*18.0*3.1mm                                                                                                    |
| <b>Antenna type</b>          | On-board /PAD antenna                                                                                              |
| <b>Spectrum range</b>        | 2400 ~ 2483.5MHz                                                                                                   |
| <b>Operating temperature</b> | -40℃~ 85℃                                                                                                          |
| <b>Storage Environment</b>   | -40℃~ 125℃, < 90%RH                                                                                                |
| <b>Power supply</b>          | VDD: 2.97V to 3.6V, supply current $\geq 500\text{mA}$ ; DACR/5V:2.5V to 6V, power supply current $\geq 1\text{A}$ |
| <b>Supported interfaces</b>  | Support USB、SPI、UART、I2C、I2S、PWM、GPDAC、GPADC、ACOMP and GPIO etc.                                                   |
| <b>Available IO</b>          | Default 23                                                                                                         |
| <b>Serial port rate</b>      | Default 2000000 bps                                                                                                |
| <b>Security</b>              | WPS/WEP/WPA/WPA2/WPA3                                                                                              |
| <b>Flash</b>                 | Default 8MByte, Max support 16MByte                                                                                |

### 2.1. Static electricity requirements

Ai-WV02-32S is an electrostatic sensitive device, and special precautions need to be taken during transportation.



**Figure 2 ESD anti-static diagram**

## 2.2. Electrical characteristics

Table 2 Electrical characteristics

| Parameter      |         | Pins | Minimum | Typical values | Maximum | Unit |
|----------------|---------|------|---------|----------------|---------|------|
| Supply voltage | VDD     |      | 2.97    | 3.3            | 3.6     | V    |
|                | DACR/5V |      | 2.5     | 5              | 6       | V    |
| I/O            | VIL     | -    | -       | -              | 0.3*VDD | V    |
|                | VIH     | -    | 0.7*VDD | -              | -       | V    |
|                | VOL     | -    | -       | 0.1*VDD        | -       | V    |
|                | VOH     | -    | -       | 0.9*VDD        | -       | V    |
|                | IMAX    | -    | -       | -              | 15      | mA   |

## 2.3. Wi-Fi RF performance

Table 3 Wi-Fi RF performance

| Describe                        | Typical values   |         |         | Unit |
|---------------------------------|------------------|---------|---------|------|
| Spectrum range                  | 2400 ~ 2483.5MHz |         |         | MHz  |
| Output power                    |                  |         |         |      |
| Model                           | Minimum          | Typical | Maximum | unit |
| 11ax mode HE40, PA output power | -                | 14      | -       | dBm  |
| 11ax mode HE20, PA output power | -                | 15      | -       | dBm  |
| 11n mode HT40, PA output power  | -                | 17      | -       | dBm  |
| 11n mode HT20, PA output power  | -                | 17      | -       | dBm  |
| PA output power in 11g mode     | -                | 17      | -       | dBm  |
| PA output power in 11b mode     | -                | 21      | -       | dBm  |
| Receive sensitivity             |                  |         |         |      |
| Model                           | Minimum          | Typical | Maximum | Unit |
| 11b, 1 Mbps                     | -                | -99     | -       | dBm  |
| 11b, 11 Mbps                    | -                | -90     | -       | dBm  |
| 11g, 6 Mbps                     | -                | -93     | -       | dBm  |
| 11g, 54 Mbps                    | -                | -76     | -       | dBm  |
| 11n, HT20 (MCS7)                | -                | -73     | -       | dBm  |
| 11ax, HE20 (MCS9)               | -                | -70     | -       | dBm  |
| 11ax, HE40 (MCS9)               | -                | -67     | -       | dBm  |

## 2.4. BLE RF performance

**Table 4 BLE radio frequency performance**

| Describe                   | Typical values   |         |         | Unit |
|----------------------------|------------------|---------|---------|------|
| Spectrum range             | 2400 ~ 2483.5MHz |         |         | MHz  |
| Output Power               |                  |         |         |      |
| Rate Mode                  | Minimum          | Typical | Maximum | Unit |
| 1Mbps                      | -                | 10      | 15      | dBm  |
| 2Mbps                      | -                | 10      | 15      | dBm  |
| Receive Sensitivity        |                  |         |         |      |
| Rate Mode                  | Minimum          | Typical | Maximum | Unit |
| 1Mbps Sensitivity@30.8%PER | -                | -99     | -       | dBm  |
| 2Mbps Sensitivity@30.8%PER | -                | -97     | -       | dBm  |

## 2.5. Power consumption

The following power consumption data is measured based on a 3.3V power supply and an ambient temperature of 25° C.

- The POUT power of all transmission modes is the measured value at the antenna interface.
- All emission data were measured in a continuous emission mode based on a 100% duty cycle.

**Table 5 Power consumption**

| Model                                       | Minimum | Average | Maxim | Unit |
|---------------------------------------------|---------|---------|-------|------|
| Transmit 802.11b, 11Mbps, POUT=+22dBm       | -       | 419     | -     | mA   |
| Transmit 802.11g, 54Mbps, POUT =+19dBm      | -       | 328     | -     | mA   |
| Transmit 802.11n, MCS7, POUT =+19dBm        | -       | 326     | -     | mA   |
| Transmit 802.11ax, MCS9, POUT =+17dBm       | -       | 294     | -     | mA   |
| Receive 802.11b , packet length 1024 bytes  | -       | 92      | -     | mA   |
| Receive 802.11g , packet length 1024 bytes  | -       | 92      | -     | mA   |
| Receive 802.11n , packet length 1024 bytes  | -       | 92      | -     | mA   |
| Receive 802.11ax , packet length 1024 bytes | -       | 92      | -     | mA   |

### 3. Appearance dimensions

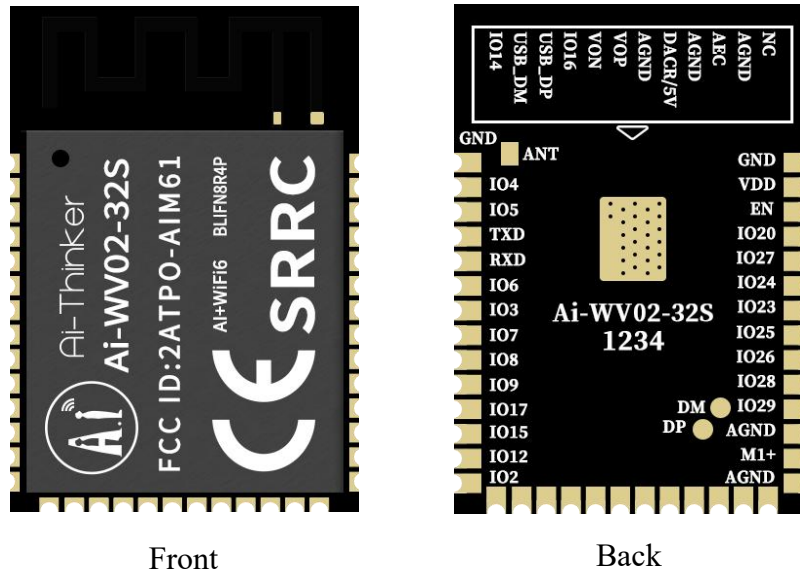


Figure 3 Appearance (rendering is for reference only, the actual product shall prevail)

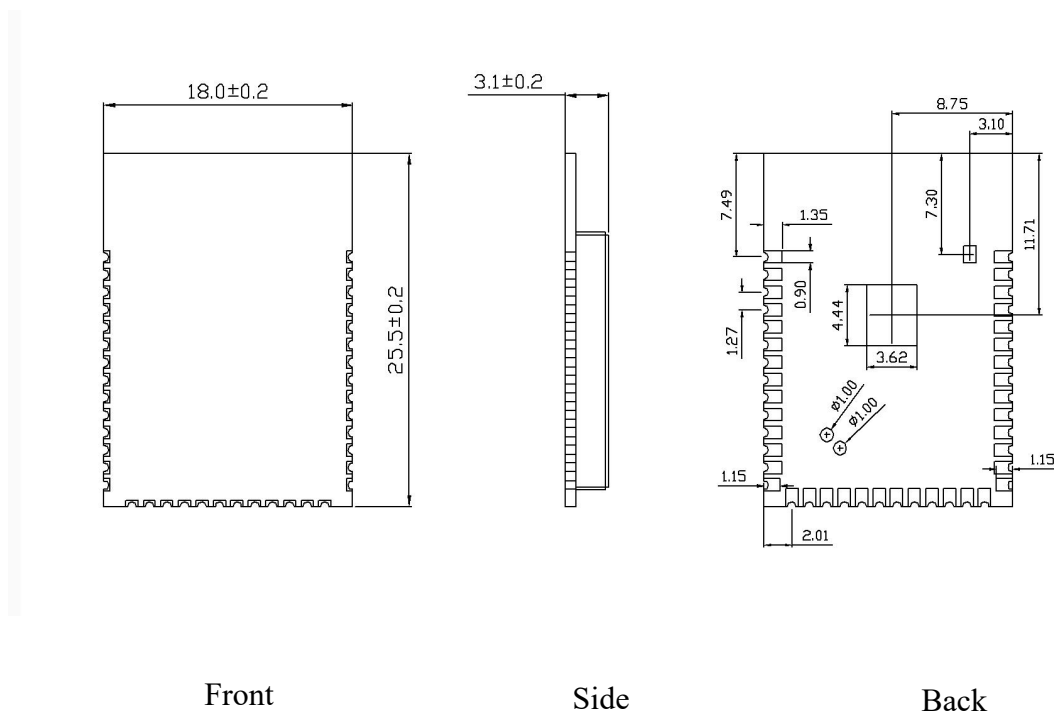
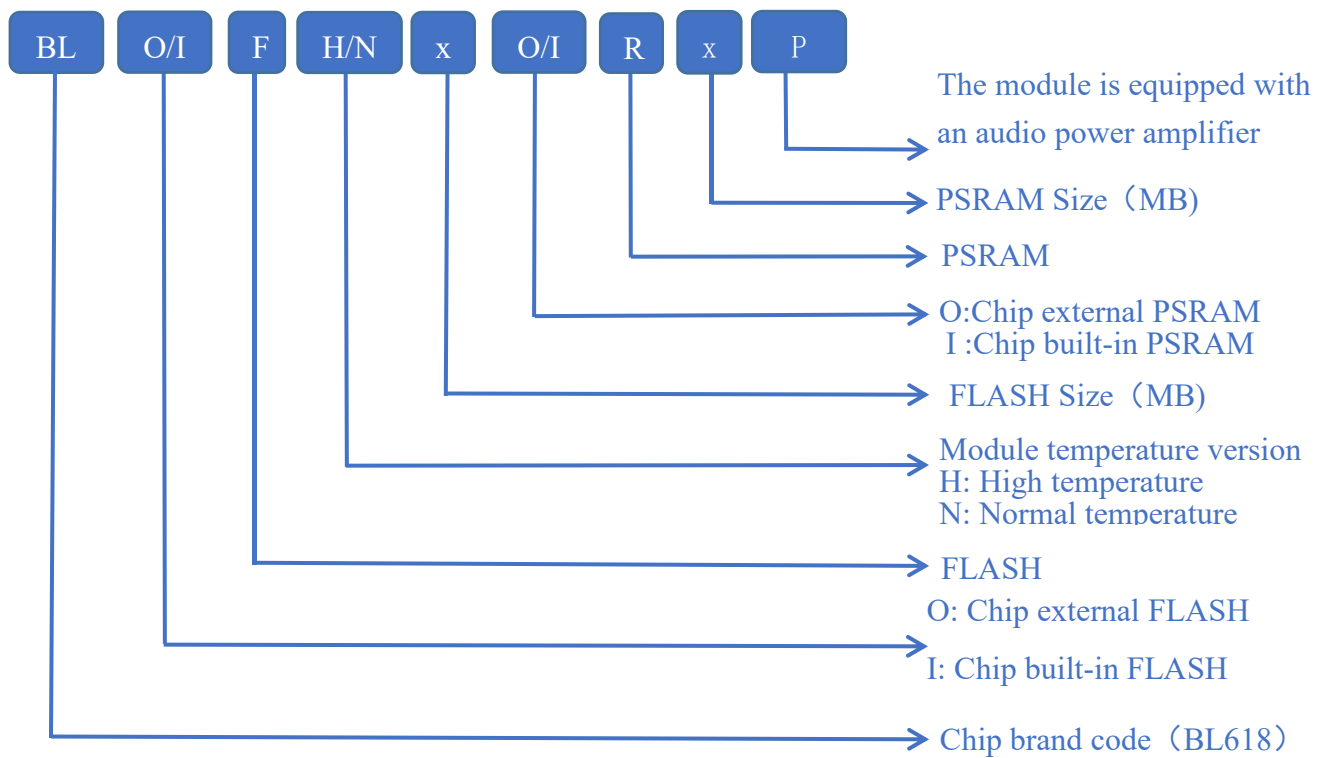


Figure 4 Dimensional drawing



**Figure 5 Shielding cover silk screen representative information**

## 4. Pin Definition

Ai-WV02-32S module has a total of 41 pins connected. As shown in the pin diagram, the pin function definition table is the interface definition.

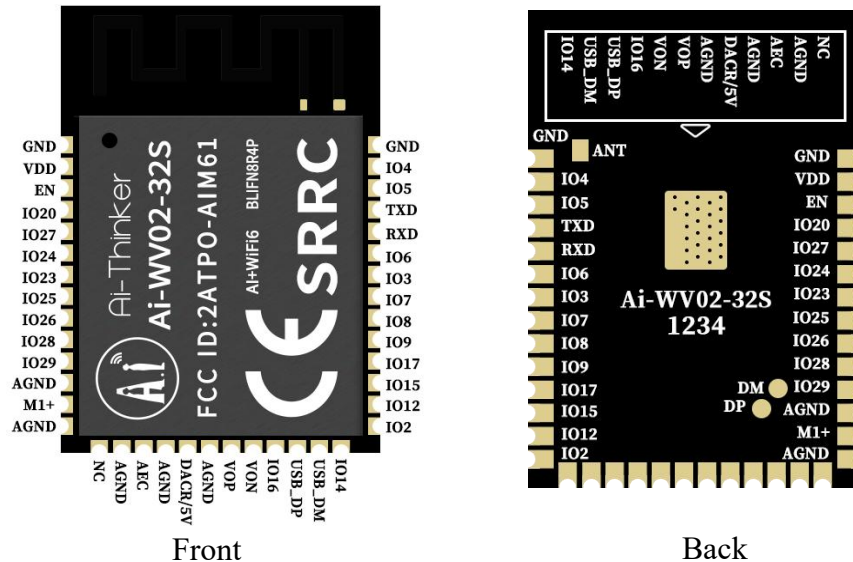


Figure 6 Schematic diagram of pins

Table 6 Pin Function Definition Table

| No. | Name | Function                                                                                                 |
|-----|------|----------------------------------------------------------------------------------------------------------|
| 1   | GND  | Ground                                                                                                   |
| 2   | VDD  | 3.3V power supply; It is recommended that the output current of the external power supply be above 500mA |
| 3   | EN   | By default, it is enabled as a chip, and high levels are effective                                       |
| 4   | IO20 | GPIO20/SPI_SS/I2S_BCLK/I2C_SCL/PWM0/ADC_CH0                                                              |
| 5   | IO27 | GPIO27/SPI_MOSI/I2S_DO/I2S_RCLK_O/I2C_SDA/PWM0/ADC_CH10                                                  |
| 6   | IO24 | GPIO24/SPI_SS/I2S_BCLK/I2C_SCL/PWM0                                                                      |
| 7   | IO23 | GPIO23/SPI_MOSI/I2S_DO/I2S_RCLK_O/I2C_SDA/PWM0                                                           |
| 8   | IO25 | GPIO25/SPI_SCLK/I2S_FS/I2C_SDA/PWM0                                                                      |
| 9   | IO26 | GPIO26/SPI_MISO/I2S_DI/I2S_RCLK_O/I2C_SCL/PWM0                                                           |
| 10  | IO28 | GPIO28/SPI_SS/I2S_BCLK/I2C_SCL/PWM0/ADC_CH11                                                             |
| 11  | IO29 | GPIO29/SPI_SCLK/I2S_FS/I2C_SDA/PWM0                                                                      |
| 12  | AGND | AGND; It is recommended to connect the negative terminal of Microphone 1 input                           |
| 13  | M1+  | The positive terminal of microphone 1 input                                                              |
| 14  | AGND | AGND                                                                                                     |
| 15  | NC   | NC                                                                                                       |

|    |         |                                                                                                                                                                                                                                                                                                       |
|----|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 16 | AGND    | AGND                                                                                                                                                                                                                                                                                                  |
| 17 | AEC     | When an external power amplifier is connected to the module, this pin can be used as the audio capture input                                                                                                                                                                                          |
| 18 | AGND    | AGND                                                                                                                                                                                                                                                                                                  |
| 19 | DACR/5V | DAC Right Channel/ Power amplifier 5V input. When using a DAC output external power amplifier, the function is DACR. When using the internal power amplifier of the module, the function is power input for the power amplifier. Input: 2.5-6V. 5V is recommended, and it is suggested to be above 1A |
| 20 | AGND    | AGND                                                                                                                                                                                                                                                                                                  |
| 21 | VOP     | Amplifier out P                                                                                                                                                                                                                                                                                       |
| 22 | VON     | Amplifier out N                                                                                                                                                                                                                                                                                       |
| 23 | IO16    | GPIO16/SPI_SS/I2S_BCLK/I2C_SCL/PWM0                                                                                                                                                                                                                                                                   |
| 24 | USB_DP  | USB_DP Pin                                                                                                                                                                                                                                                                                            |
| 25 | USB_DM  | USB_DM Pin                                                                                                                                                                                                                                                                                            |
| 26 | IO14    | GPIO14/SPI_MISO/I2S_DI/I2S_RCLK_O/I2C_SCL/PWM0                                                                                                                                                                                                                                                        |
| 27 | IO2     | GPIO2/SPI_MISO/I2S_DI/I2S_RCLK_O/I2C_SCL/PWM0/ADC_CH2                                                                                                                                                                                                                                                 |
| 28 | IO12    | GPIO12/SPI_SS/I2S_BCLK/I2C_SCL/PWM0                                                                                                                                                                                                                                                                   |
| 29 | IO15    | GPIO15/SPI_MOSI/I2S_DO/I2S_RCLK_O/I2C_SDA/PWM0                                                                                                                                                                                                                                                        |
| 30 | IO17    | GPIO17/SPI_SCLK/I2S_FS/I2C_SDA/PWM0                                                                                                                                                                                                                                                                   |
| 31 | IO9     | GPIO9/SPI_SCLK/I2S_FS/I2C_SDA/PWM0/QSPI_SDA3                                                                                                                                                                                                                                                          |
| 32 | IO8     | GPIO8/SPI_SS/I2S_BCLK/I2C_SCL/PWM0/QSPI_SDA2                                                                                                                                                                                                                                                          |
| 33 | IO7     | GPIO7/SPI_MOSI/I2S_DO/I2S_RCLK_O/I2C_SDA/PWM0/QSPI_SDA1                                                                                                                                                                                                                                               |
| 34 | IO3     | GPIO3/SPI_MOSI/I2S_DO/I2S_RCLK_O/I2C_SDA/PWM0/ADC_CH3                                                                                                                                                                                                                                                 |
| 35 | IO6     | GPIO6/SPI_MISO/I2S_DI/I2S_RCLK_O/I2C_SCL/PWM0/QSPI_SDA0                                                                                                                                                                                                                                               |
| 36 | RXD     | RXD/GPIO22/SPI_MOSI/SPI_MISO/I2S_DI/I2S_RCLK_O/I2C_SCL/PWM0                                                                                                                                                                                                                                           |
| 37 | TXD     | TXD/GPIO21/SPI_SCLK/I2S_FS/I2C_SDA/PWM0                                                                                                                                                                                                                                                               |
| 38 | IO5     | GPIO5/SPI_SCLK/I2S_FS/I2C_SDA/PWM0/QSPI_CSN                                                                                                                                                                                                                                                           |
| 39 | IO4     | GPIO4/SPI_SS/I2S_BCLK/I2C_SCL/PWM0/QSPI_SCL                                                                                                                                                                                                                                                           |
| 40 | GND     | Ground                                                                                                                                                                                                                                                                                                |
| 41 | ANT     | ANT pin. When not in use, leave it suspended. Do not pass through the surface of the bottom plate of the ANT pin foot.                                                                                                                                                                                |

Note: 1. When GPIO2 is used as Bootstrap and the power-on moment is at a high level, the module enters the burning mode. When the power is low at the moment of power-on, the module starts up normally.

2. If you need to use DACR to output an external power amplifier, please contact Ai-Thinker.

## 5. Schematic

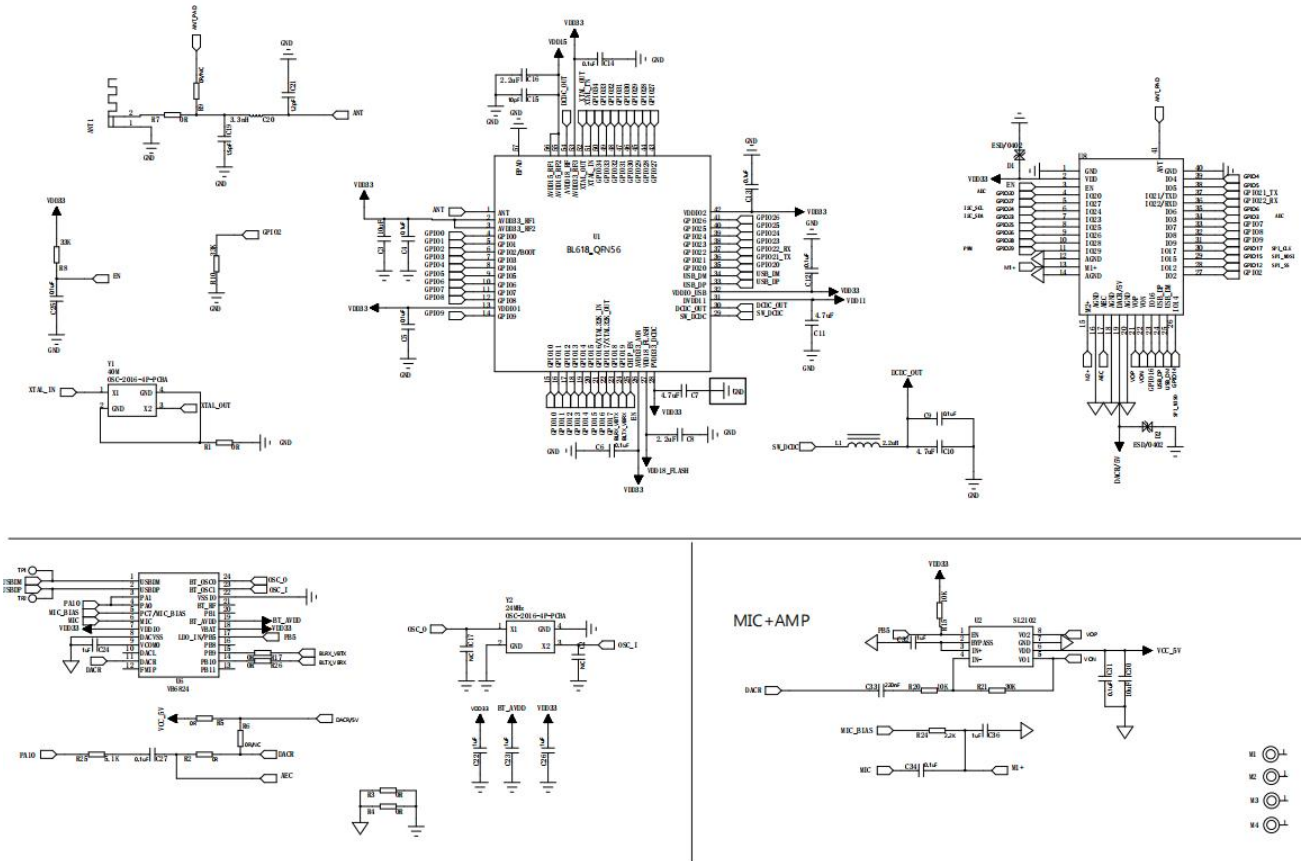


Figure 7 Schematic diagram

## 6. Antenna parameters

### 6.1. Schematic diagram of the antenna test prototype

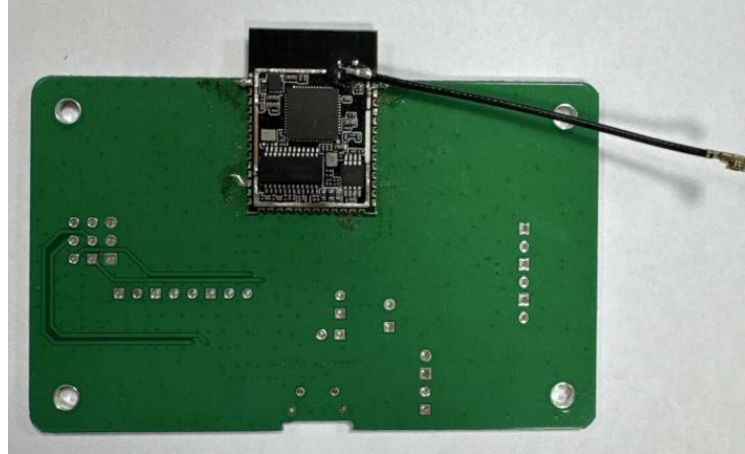


Figure 8 Schematic diagram of the antenna test prototype antenna

### 6.2. Antenna S parameters

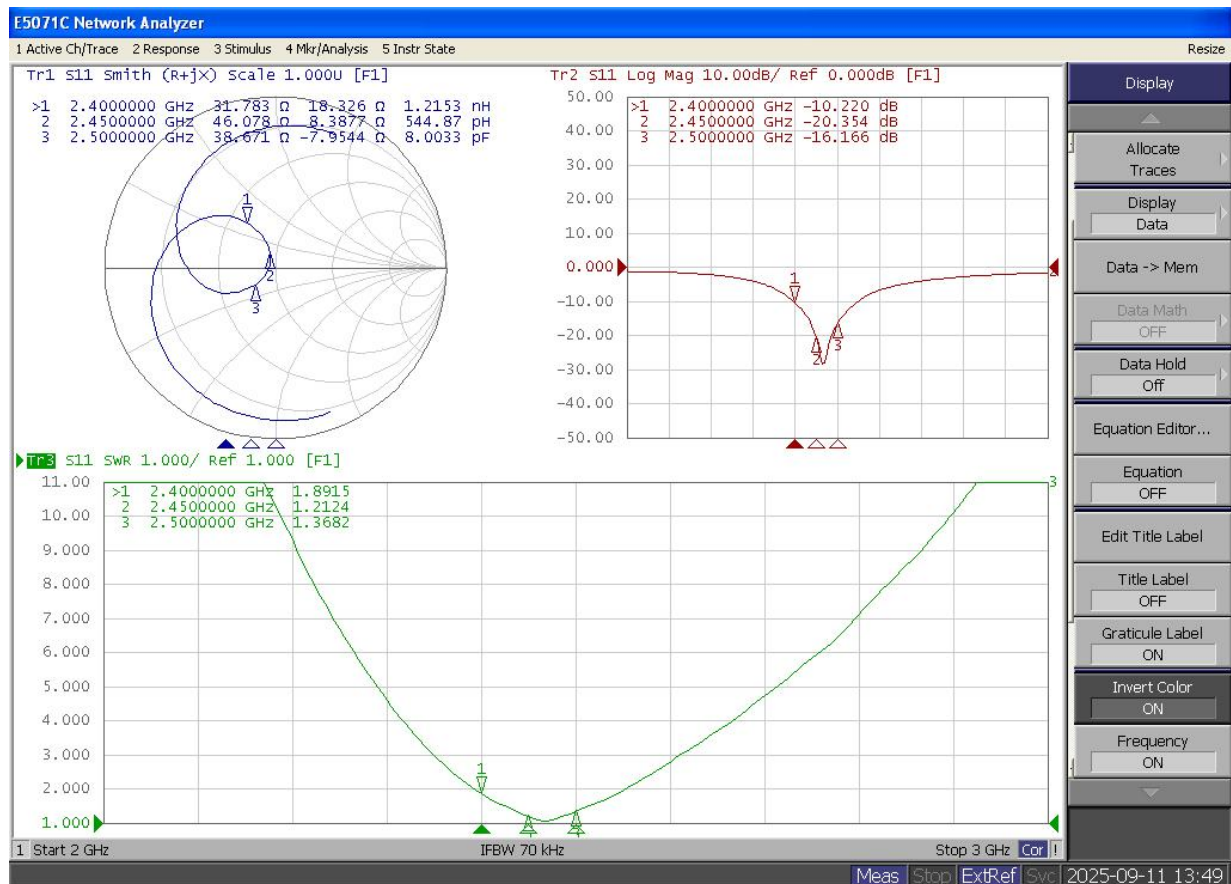


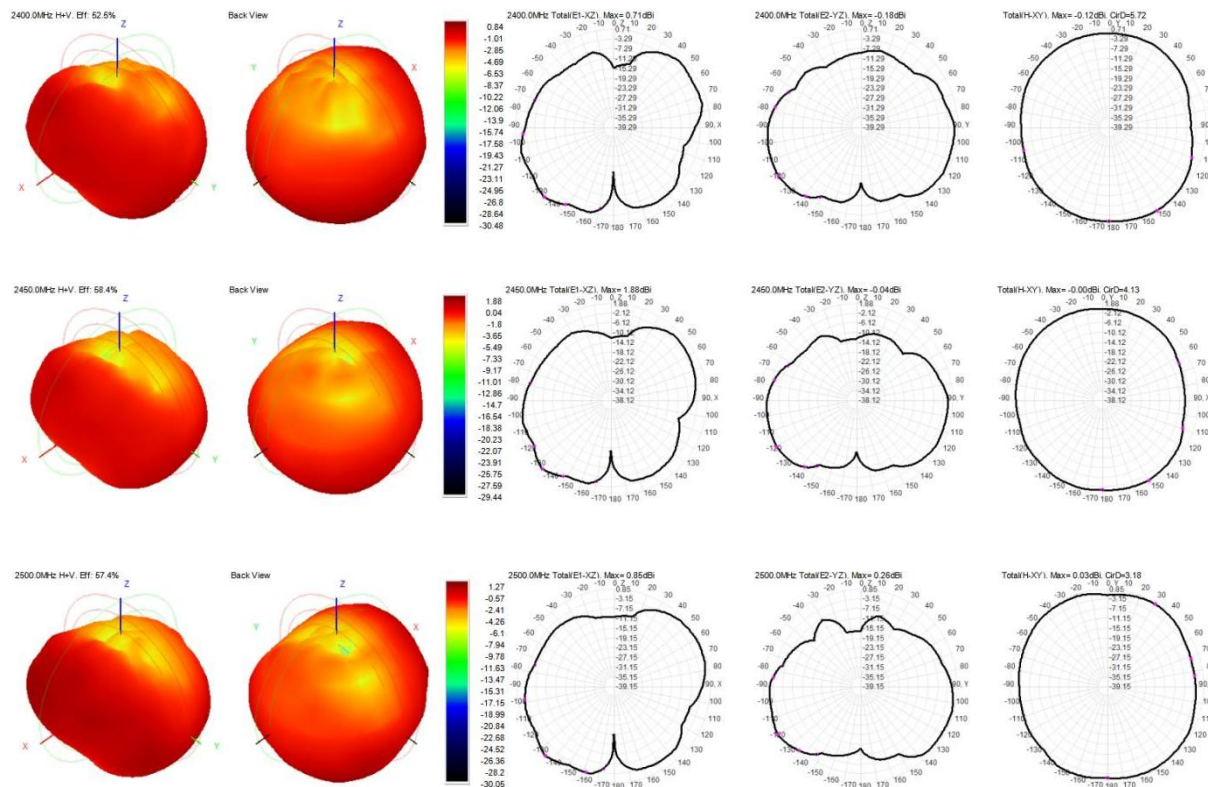
Figure 9 Antenna S parameters

## 6.3. Antenna gain and efficiency

**Table 7 Antenna gain and efficiency**

| Frequency ID   | 1      | 2      | 3      | 4      | 5      | 6      | 7      | 8      | 9      | 10     | 11     |
|----------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| Frequency(MHz) | 2400.0 | 2410.0 | 2420.0 | 2430.0 | 2440.0 | 2450.0 | 2460.0 | 2470.0 | 2480.0 | 2490.0 | 2500.0 |
| Gain (dBi)     | 0.84   | 1.05   | 1.02   | 0.98   | 1.14   | 1.88   | 1.59   | 1.24   | 1.63   | 1.33   | 1.27   |
| Efficiency (%) | 52.46  | 54.94  | 55.73  | 56.51  | 57.45  | 58.41  | 58.81  | 58.26  | 56.97  | 56.69  | 57.38  |

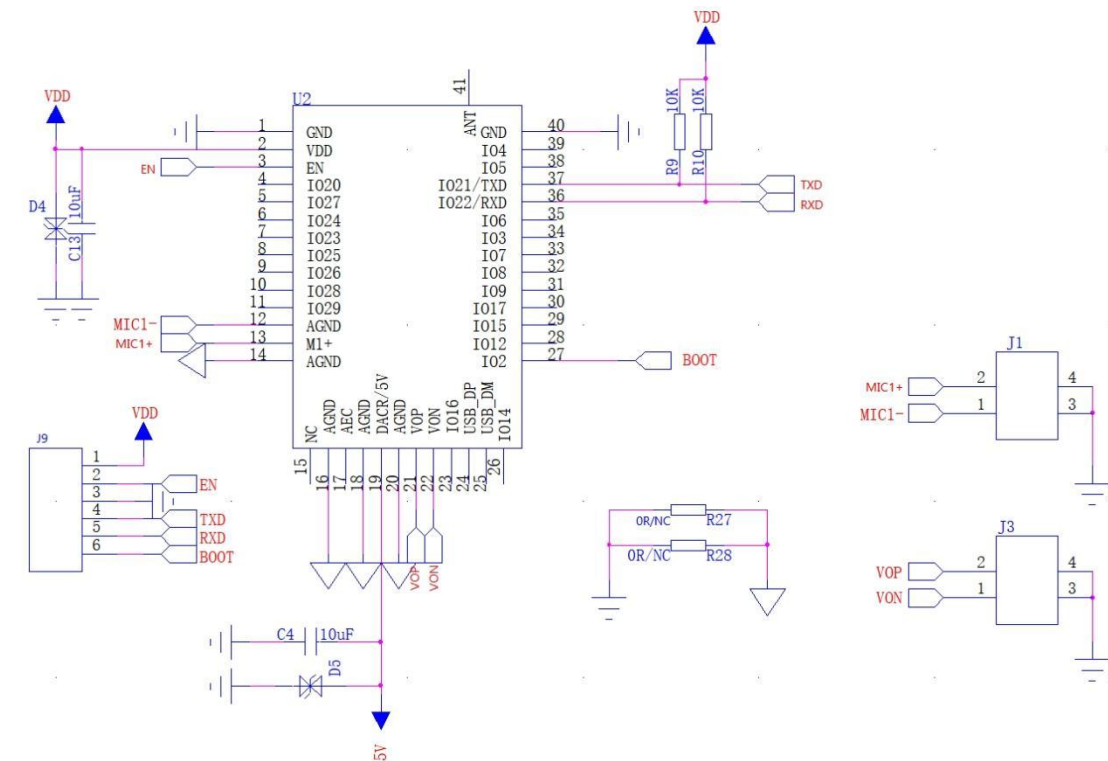
## 6.4. Antenna pattern



**Figure 10 Antenna field pattern**

## 7. Design Guidance

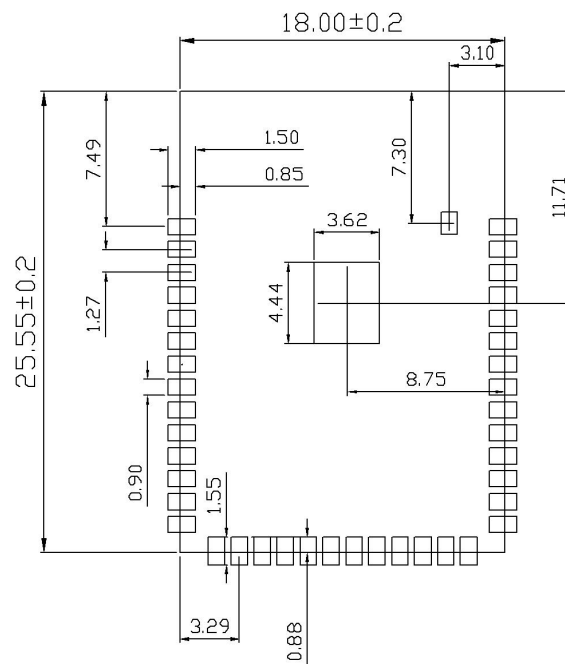
### 7.1. Application Guidance Circuit



**Figure 11 Application guidance circuit**

- GPIO2 is the module start control pin. It operates in normal mode at low levels and in firmware burning mode at high levels. The chip defaults to a low level internally.
- Connect M1+ to the positive end of the microphone
- Connect the VOP and VON speakers. The recommended speakers are 4R3W and 8R2W
- The power supply voltage for VDD is 2.97 to 3.6V. It is recommended that the output current of the external power supply be above 500mA
- DACR/5V: The power supply voltage is 2.5 to 6V, and the output current of the external power supply is recommended to be above 1A

## 7.2. Recommended PCB package size



**Figure 12 Recommended PCB package size**

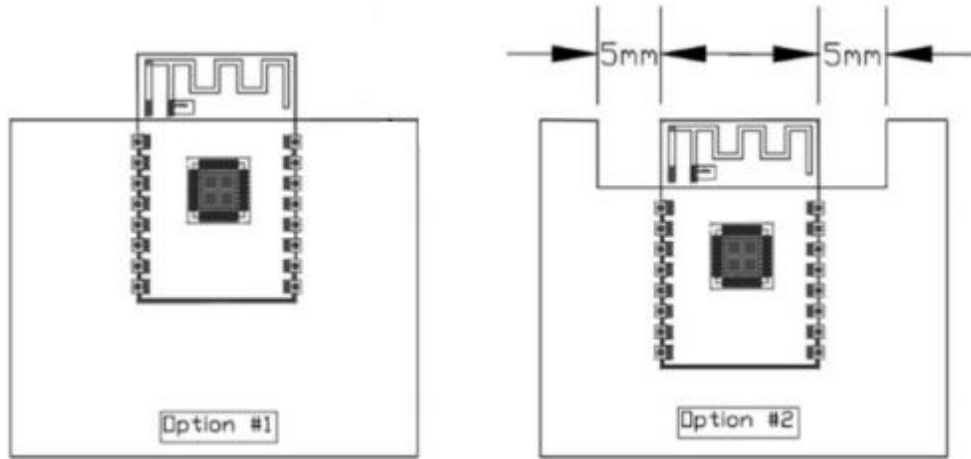
## 7.3. Antenna layout requirements

- The following two methods are recommended for the installation position on the motherboard:

Solution 1: Place the module along the edge of the motherboard, with the antenna area extending beyond the edge.

Solution 2: Place the module along the edge of the motherboard and hollow out an area along the edge of the motherboard at the antenna position.

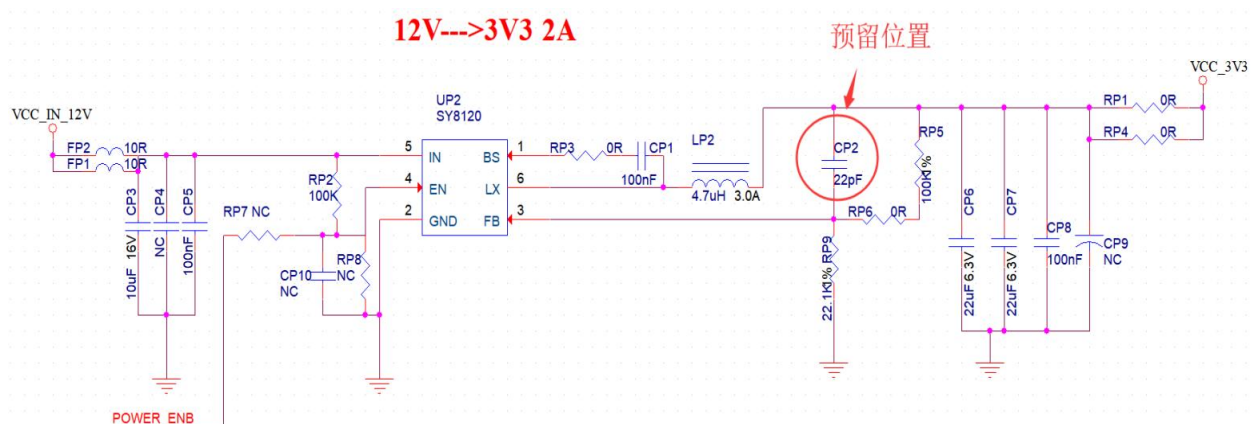
- To meet the performance requirements of the on-board antenna, no metal parts should be placed around the antenna and it should be kept away from high-frequency devices.



**Figure 13 Antenna layout diagram**

## 7.4. Power supply

- VDD is recommended to have a voltage of 3.3V and a peak current of over 500mA.
- DACR/5V is recommended to have a voltage of 5V and a peak current of over 1A.
- It is recommended to use LDO for power supply. If DC-DC is used, it is recommended that the ripple be controlled within 30mV.
- It is recommended to reserve the position for dynamic response capacitors in the DC-DC power supply circuit, which can optimize the output ripple when the load changes significantly.
- It is recommended to add ESD devices to the power interface.



**Figure 14 DC-DC step-down circuit diagram**

## 7.5. GPIO

- Some IO ports are led out from the periphery of the module. If you need to use them, 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. It is helpful for both EMI and ESD.
- For the up and down pulling of special IO ports, please refer to the usage instructions in the specification sheet. This will affect the startup configuration of the module.
- The IO port of the module is 3.3V. If the IO port level of the main control does not match that of the module, a level conversion circuit needs to be added.
- If the IO port is directly connected to peripheral interfaces or terminals such as pin headers, it is recommended to reserve ESD devices near the terminals in the IO port traces.

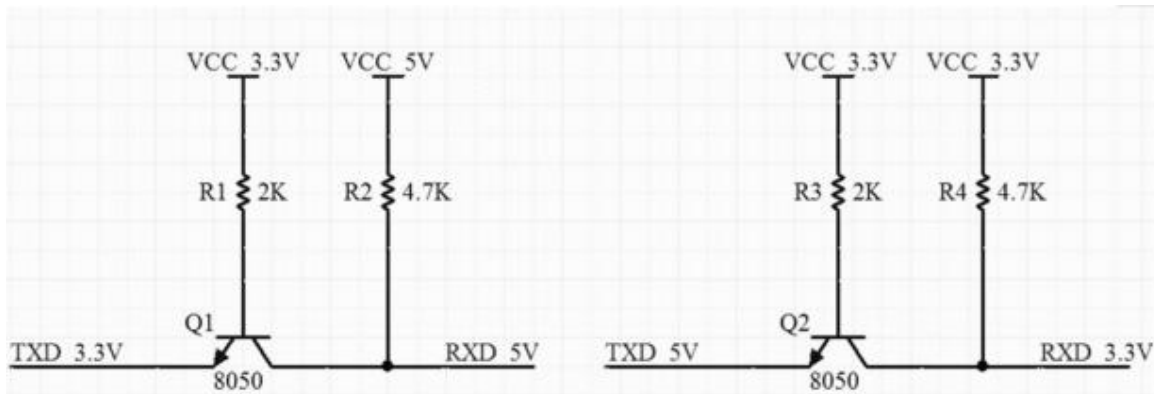


Figure 15 Level conversion circuit

## 8. Storage conditions

Products sealed in moisture-proof bags should be stored in a non-condensing atmospheric environment with a temperature below 40°C and a humidity of 90%RH.

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

After opening the vacuum bag, it must be used up within 168 hours at  $25 \pm 5^\circ\text{C}/60\%\text{RH}$ ; otherwise, it needs to be baked before being put back on the line for the second time.

## 9. Reflow Oven Profile

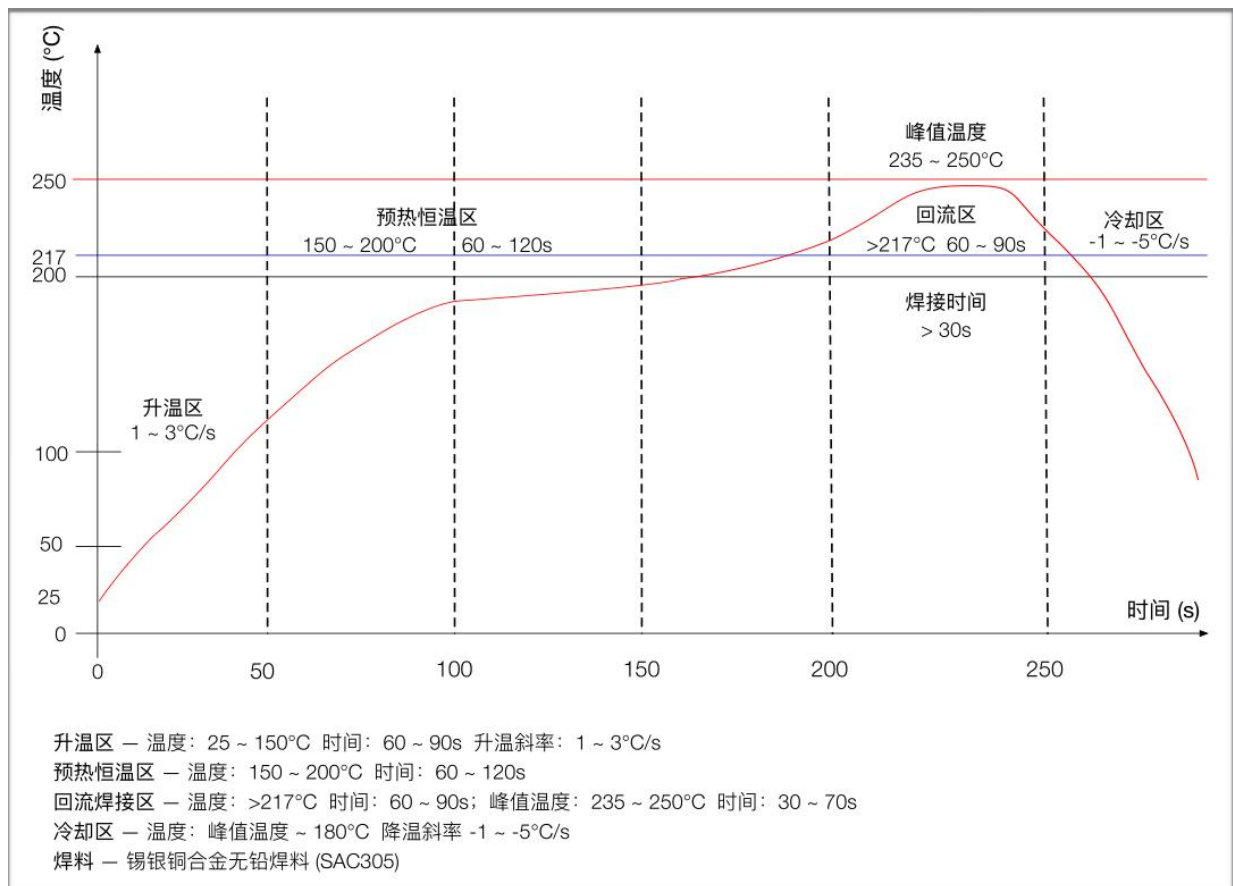


Figure 16 Reflow soldering curve graph

## 10. Product packaging information

Ai-WV02-32S module is packaged in tape, 800 pcs/reel. As shown below:



Figure 17 Packaging Taping Diagram

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WeChat mini program



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