ESP-S3-32S Specification

Version V1.0.0

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Document Resume

Version	Date	Develop/revise content	Edition	Approve
V1.0.0	2022.01.15	First Edition	ChaoMeiDeng	NingGuan

Content

1. Product Overview

ESP-S3-32S is a Wi-Fi+BLE module developed by Shenzhen Ai-Thinker Technology Co., LTD.The core processor chip ESP32-S3 is a highly integrated, low-power Wi-Fi and Bluetooth system-on-chip (SoC),designed for Internet of Things (IoT), mobile devices, wearable electronics, smart home and other applications

ESP-S3-32S module has industry-leading low-power performance and RF performance, and supports Wi-Fi IEEE802.11b/g/n protocol and Bluetooth 5.0. The module is equipped with an Xtensa-R 32-bit LX7 dual-core processor with a working frequency of up to 240 MHz. Support secondary development without using other microcontrollers or processors. The module has built-in 512 KB SRAM, 384 KB ROM, 16KB RTC SRAM. The module supports a variety of low-power working states, which can meet the power consumption requirements of various application scenarios. The unique features of the chip, such as fine clock gating function, dynamic voltage clock frequency adjustment function, and RF output power adjustment function, can achieve the best balance between communication distance, communication rate and power consumption.

ESP-S3-32S module provides rich peripheral interfaces, including UART, PWM, SPI, I2S, I2C, ADC, LCD, DVP, RMT(TX/RX), pulse counter, USB OTG, USB Serial/JTAG, SDIO, DMA controller, TWAI controller, temperature sensor, capacitive sensor and up to 36 IO ports.

ESP-S3-32S module has a variety of unique hardware security mechanisms. The module hardware cryptographic accelerator supports AES, SHA and RSA algorithms. Among them, RNG, HMAC and digital signature (Digital Signature) provide more security mechanisms for the module. Other security features include Flash encryption and secure boot signature verification. The perfect security mechanism enables the module to be perfectly applied to various encryption products.

ESP-S3-32S module supports Bluetooth Low Energy: Bluetooth5.0, Bluetooth mesh. Bluetooth rate support: 125Kbps, 500Kbps, 1Mbps, 2Mbps. Support broadcast extension, multi-broadcast, channel selection.

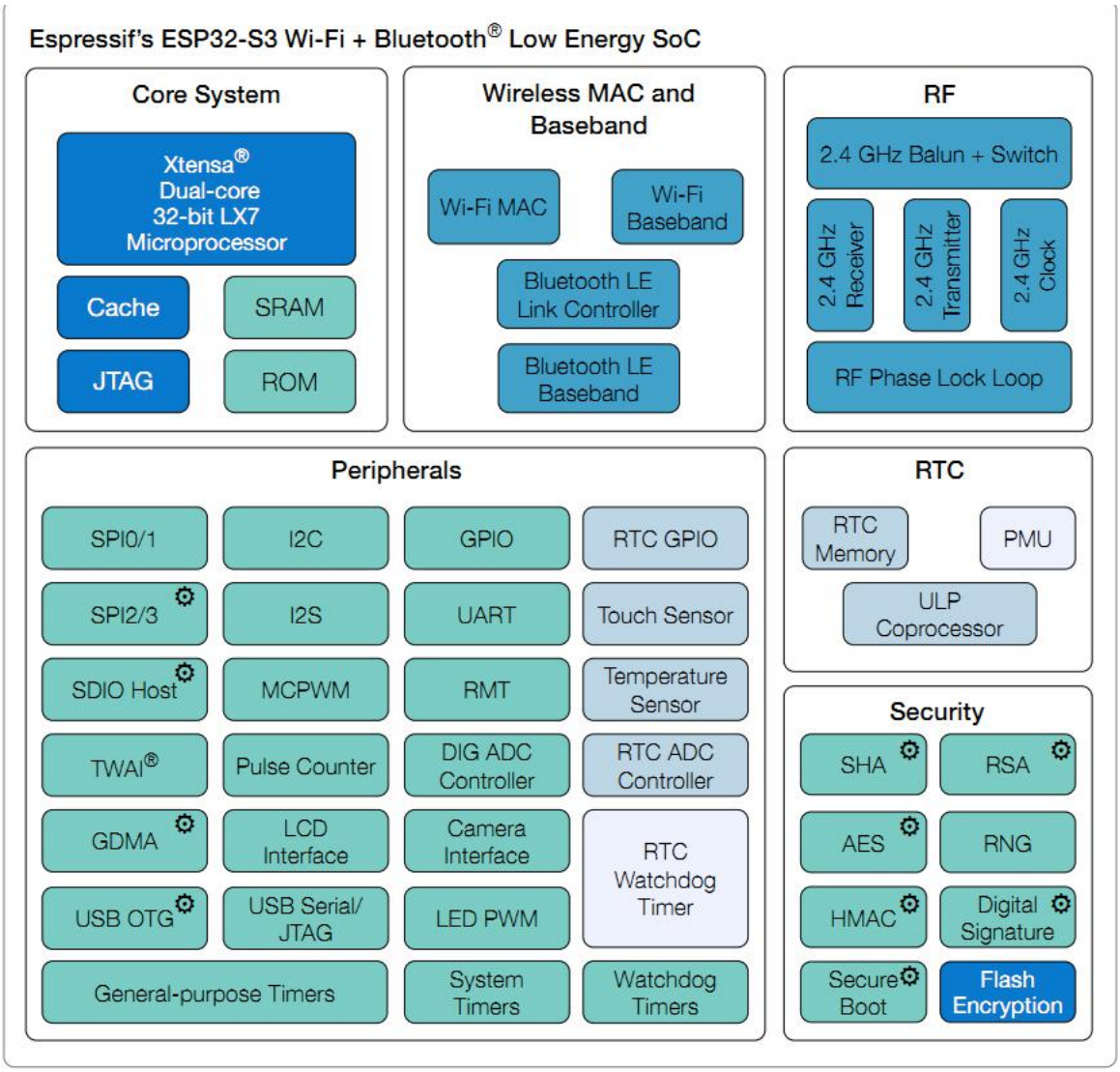

Figure 1 Main chip architecture diagram

1.1. Characteristic

- Support Wi-Fi 802.11b/g/n, 1T1R mode data rate up to 150Mbps
- Support Bluetooth5.0, Bluetooth mesh, rate support: 125Kbps, 500Kbps, 1Mbps, 2Mbps
- Xtensa-R 32-bit LX7 dual-core processor, supports up to 240 MHz clock frequency, has 512KB SRAM, 384KB ROM, 16KB RTC SRAM
- Support UART/GPIO/ADC/PWM/I2C/I2S/SPI/LCD/DVP/RMT/SDIOMCPWM/DMA controller/TWAI /USB OTG/USB Serial/controller interface, temperature sensor, pulse counter, capacitive sensor GPIO
- Using SMD-40 package
- Integrated Wi-Fi MAC/BB/RF/PA/LNA/Bluetooth
- Support multiple sleep modes, deep sleep current is less than 8uA
- Serial port rate up to 5Mbps
- Support STA/AP/STA+AP mode and promiscuous mode
- Support Smart Config (APP)/AirKiss (WeChat) for Android and IOS with one-click network configuration
- Support serial port local upgrade and remote firmware upgrade (FOTA)
- General AT commands can be used quickly
- Support secondary development, integrated Windows and Linux development environment

2. Module configuration specification

ESP-S3-32S module has a variety of configurations to choose from, which can be distinguished according to the laser engraving silk screen on the shield, refer to Table 1 for details.

- Regarding the flash capacity and working temperature of the module, if you have special requirements, you can contact Ai-Thinker for customization.

Table 1 Module configuration description

Silk Screen Printing of shield	Chip	Flash(MB)	PSRAM(MB)	Operating temperature
S3OFN8	ESP32-S3	8	/	-40~85°C
S3IFN8	ESP32-S3FN8	8	/	-40~85°C

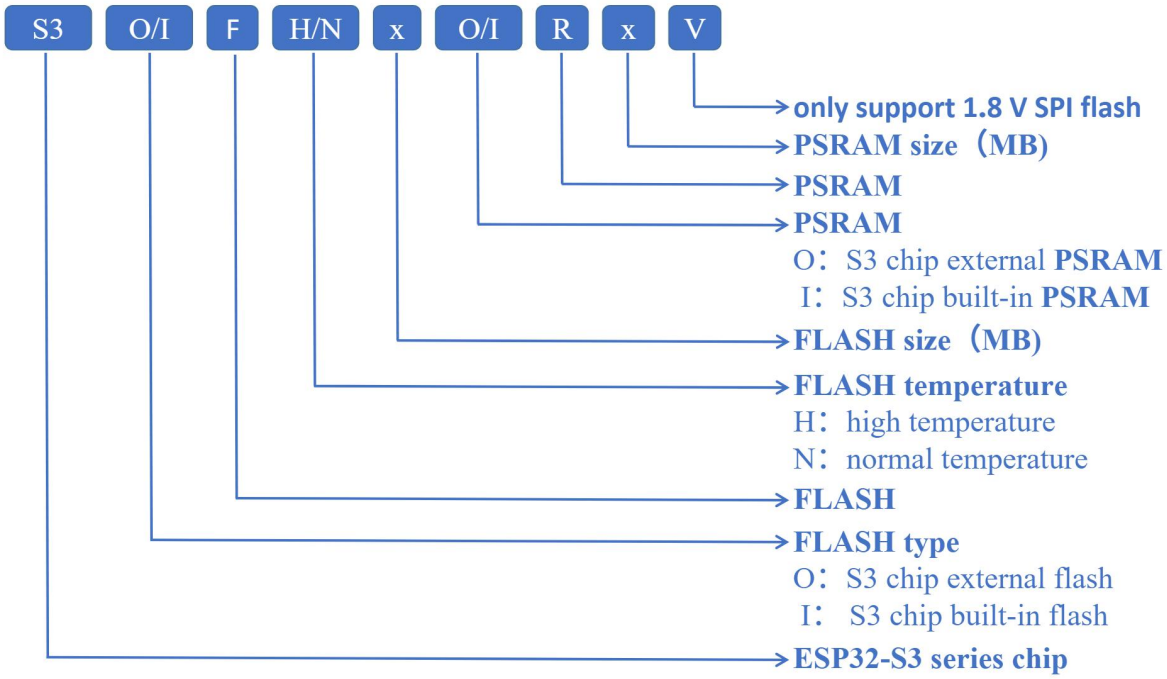

Figure 2 Module Silk Screen Printing of shield naming convention

3. Main parameters

Table 2 Description of the main parameters

Model	ESP-S3-32S
Package	SMD-40
Size	25.5*18.0*3.2(±0.2)mm
Antenna	On-board antenna or IPEX external antenna
Frequency	2400 ~ 2483.5MHz
Operating temperature	-40 ℃ ~ 85 ℃
Storage temperature	-40 ℃ ~ 125 ℃ ， < 90%RH
Power supply	Support voltage: 3.0V ~ 3.6V，supply current >500mA
Interface	UART/GPIO/ADC/PWM/I2C/I2S/SPI/LCD/DVP/RMT/SDIO/ USB OTG/MCPWM/DMA/TWAI
IO	36
UART rate	Support 110 ~ 4608000 bps ，default115200 bps
Bluetooth	Bluetooth5.0，Bluetooth mesh
Security	WEP/WPA-PSK/WPA2-PSK
SPI Flash	8MByte（default）Optional 4/16MByte

3.1. Static electricity requirements

The ESP-S3-32S module is a static-sensitive device and requires special precautions when handling it.

Figure 3 ESD anti-static diagram

3.2. Electrical Characteristics

Table 3 Electrical Characteristics Table

Parameters		Conditio	Min.	Typical	Max.	Unit
Support voltagae		VDD	3.0	3.3	3.6	V
I/O	V_{IL}/V_{IH}	-	-0.3/0.75VDD	-	0.25VDD/VDD+0.3	V
	V_{OL}/V_{OH}	-	N/0.8VIO	-	0.1VIO/N	V
	I_{MAX}	-	-	-	40	mA

3.3. Wi-Fi RF performance

Table 4 Wi-Fi RF performance table

Description	Typical value			Unit
Working Central Frequency	2412 - 2484			MHz
Output Power				
Rate model	**Min.**	**Typical value**	**Max.**	**Unit**
11n model HT40，PA output power	13	15	17	dBm
11n model HT20，PA output power	13	15	17	dBm
11g model，PA output power	14	16	18	dBm
11bmodel，PA output power	16	18	20	dBm
Receive Sensitivity				
Rate model	**Min.**	**Typical value**	**Max.**	**Unit**
11b，1 Mbps	-	-97	-	dBm
11b，11 Mbps	-	-88	-	dBm
11g, 6 Mbps	-	-92	-	dBm
11g，54 Mbps	-	-75	-	dBm
11n，HT20 (MCS7)	-	-73	-	dBm
11n，HT40 (MCS7)	-	-70	-	dBm

3.4. BLE RF performance

Table 5 BLE RF performance table

Description	Typical value			Unit
Working Central Frequency	2402 - 2480			MHz
Output Power				
Rate model	**Min.**	**Typical**	**Max.**	**Unit**
1Mbps	-25	0	19	dBm
2Mbps	-25	0	19	dBm
Receive Sensitivity				
Rate model	**Min.**	**Typical**	**Max.**	**Unit**
1Mbps sensitivity@30.8%PER	-	-96	-	dBm
2Mbps sensitivity@30.8%PER	-	-92	-	dBm

3.5. Power consumption

The following power consumption figures are based on a 3.3V supply, 25°C ambient temperature, and are measured using the internal voltage regulator.

- All measurements are made at the antenna interface with filters.
- All transmit data is based on 100% duty cycle, measured in continuous transmit mode.

Table 6 Power consumption table

Model	Min.	AVG	Max.	Unit
Tx 802.11b，DSSS 1Mbps，POUT=+20dBm	-	350	-	mA
Tx 802.11g， OFDM 54Mbps， POUT =+18dBm	-	290	-	mA
Tx 802.11n，MCS7，POUT =+17dBm	-	280	-	mA
Rx 802.11b，1024 bit	-	97	-	mA
Rx 802.11g，1024 bit	-	97	-	mA
Rx 802.11n，1024 bit	-	100	-	mA
Modem-Sleep①	-	20	-	mA
Light-Sleep②	-	240	-	μA
Deep-Sleep③	-	8	-	μA
Power Off	-	1	-	μA

4. Appearance dimensions

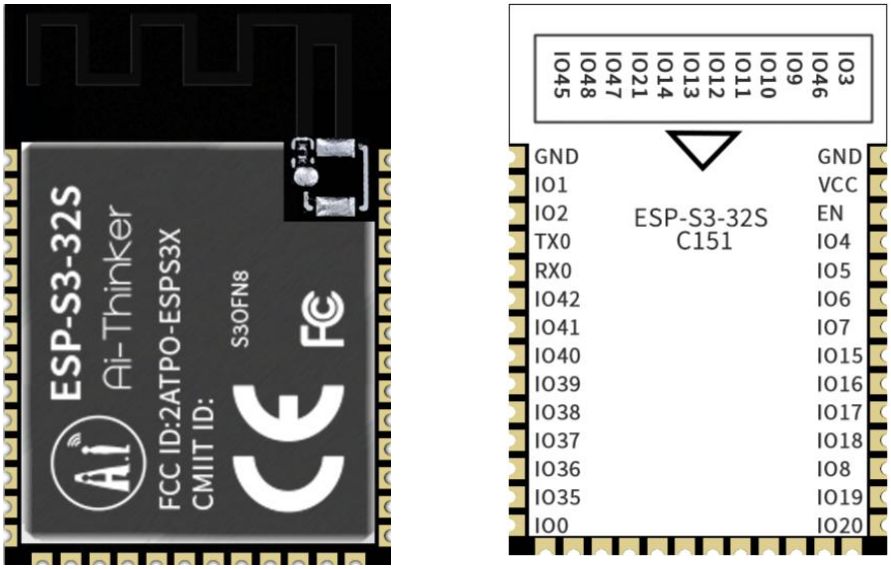

Figure 4 Appearance of the module (the rendering is for reference only, the actual product shall prevail)

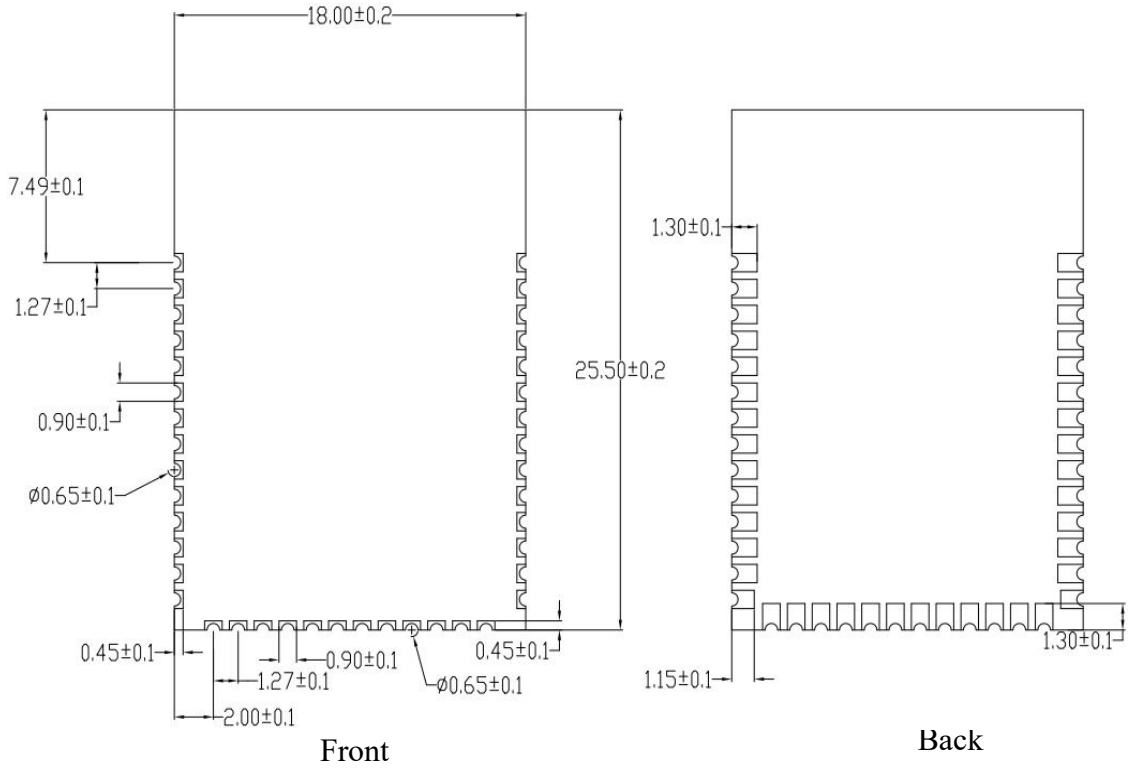

Figure 5 Module Dimensions

5. Pin definition

ESP-S3-32S module has a total of 40 pins, as shown in the pin diagram, the pin function definition table is the interface definition.

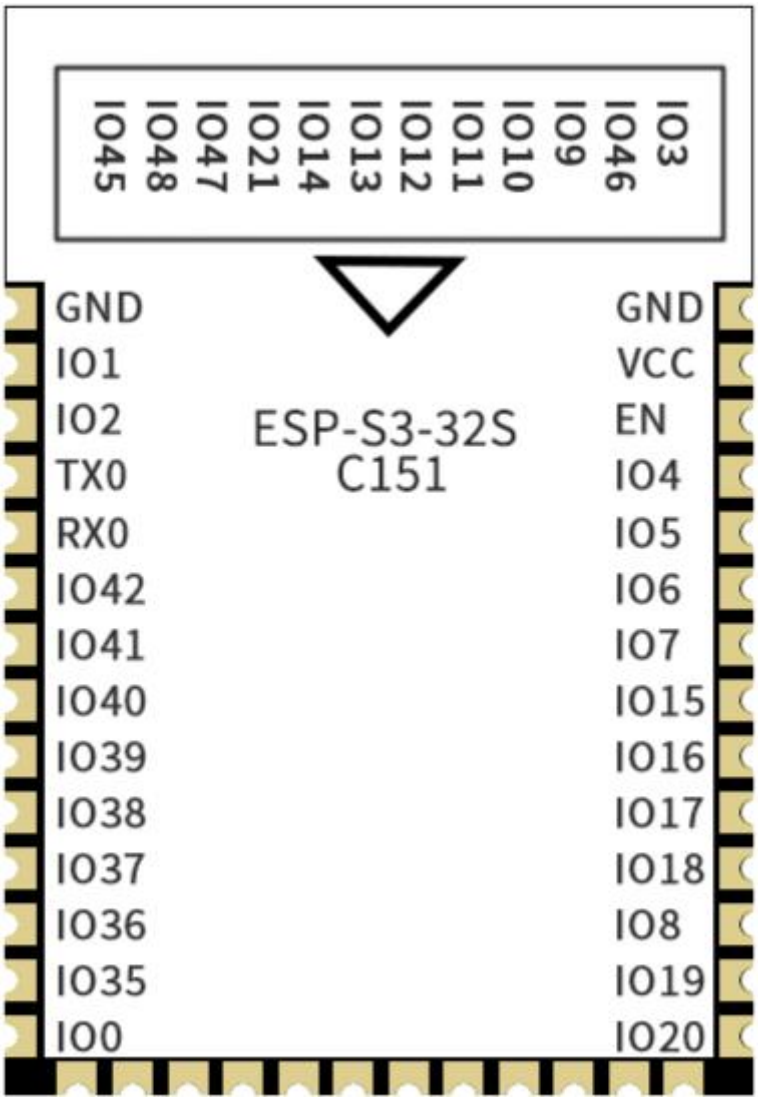

Figure 6 Schematic diagram of module pins (bottom view)

Table 7 Pin function definition table

No.	Name	Function
1，40	GND	GND , Power negative electrode
2	VCC	Power supply, positive electrode
3	EN	High level: module on Low level: module off Be careful not to leave the EN pin floating
4	IO4	RTC_GPIO4,GPIO4,TOUCH4,ADC_CH3
5	IO5	RTC_GPIO5,GPIO5,TOUCH5,ADC1_CH4
6	IO6	RTC_GPIO6,GPIO6,TOUCH6,ADC1_CH5
7	IO7	RTC_GPIO7,GPIO7,TOUCH7,ADC1_CH6
8	IO15	RTC_GPIO15,GPIO15,U0RTS,ADC2_CH4, XTAL_32K_P
9	IO16	RTC_GPIO16,GPIO16,U0CTS,ADC2_CH5, XTAL_32K_N
10	IO17	RTC_GPIO17,GPIO17,U1TXD,ADC2_CH6
11	IO18	RTC_GPIO18,GPIO18,U1RXD,ADC2_CH7, CLK_OUT3
12	IO8	RTC_GPIO8,GPIO8,TOUCH8,ADC1_CH7, SUBSPICS1
13	IO19	RTC_GPIO19,GPIO19,U1RTS,ADC2_CH8, CLK_OUT2,USB_D-
14	IO20	RTC_GPIO20,GPIO20,U1CTS,ADC2_CH9, CLK_OUT1,USB_D+
15	IO3	GPIO3,RTC_GPIO3,TOUCH3,ADC1_CH2
16	NC	Default NC, BOM can be specified as GPIO46
17	IO9	GPIO9,RTC_GPIO9,TOUCH9,ADC1_CH8, SUBSPIHD,FSPIHD
18	IO10	RTC_GPIO10,GPIO10,TOUCH10,ADC1_CH9, FSPIIO4,SUBSPICS0,FSPICS0
19	IO11	RTC_GPIO11,GPIO11,TOUCH11,ADC2_CH0, FSPIIO5,SUBSPID,FSPID
20	IO12	RTC_GPIO12,GPIO12,TOUCH12,ADC2_CH1, FSPIIO6,SUBSPICLK,FSPICLK
21	IO13	RTC_GPIO13,GPIO13,TOUCH13,ADC2_CH2, FSPIIO7,SUBSPIQ,FSPIQ

22	IO14	RTC_GPIO14,GPIO14,TOUCH14,ADC2_CH3, FSPIDQS,SUBSPIWP,FSPIWP
23	IO21	RTC_GPIO21,GPIO21
24	IO47	SPICLK_P_DIFF,GPIO47,SUBSPICLK_P_DIFF
25	IO48	SPICLK_N_DIFF,GPIO48,SUBSPICLK_N_DIFF
26	IO45	GPIO45
27	IO0	GPIO0,RTC_GPIO0
28	IO35	GPIO35,FSPID,SUBSPID,SPIIO6
29	IO36	GPIO36,FSPICLK,SUBSPICLK,SPIIO7
30	IO37	GPIO37,FSPIQ,SUBSPIQ,SPIDQS
31	IO38	GPIO38,FSPIWP,SUBSPIWP
32	IO39	MTCK,GPIO39,CLK_OUT3,SUBSPICS1
33	IO40	MTDO,GPIO40,CLK_OUT2
34	IO41	MTD1,GPIO41,CLK_OUT1
35	IO42	MTMS,GPIO42,
36	U0RX	U0RXD,GPIO44,CLK_OUT2
37	U0TX	U0TXD,GPIO43,CLK_OUT1
38	IO2	RTC_GPIO2,GPIO2,TOUCH2,ADC1_CH1
40	IO1	GPIO1,RTC_GPIO1,TOUCH1,ADC1_CH0

Table 8 Module startup mode description

System boot mode			
Pin	**Default**	**SPI start-up model**	**Reboot download-Mode**
IO0	Pull-Up	1	0
IO46	pull-down	/	0

Note: Some pins have been pulled up internally, please refer to the schematic diagram.

6. Schematic

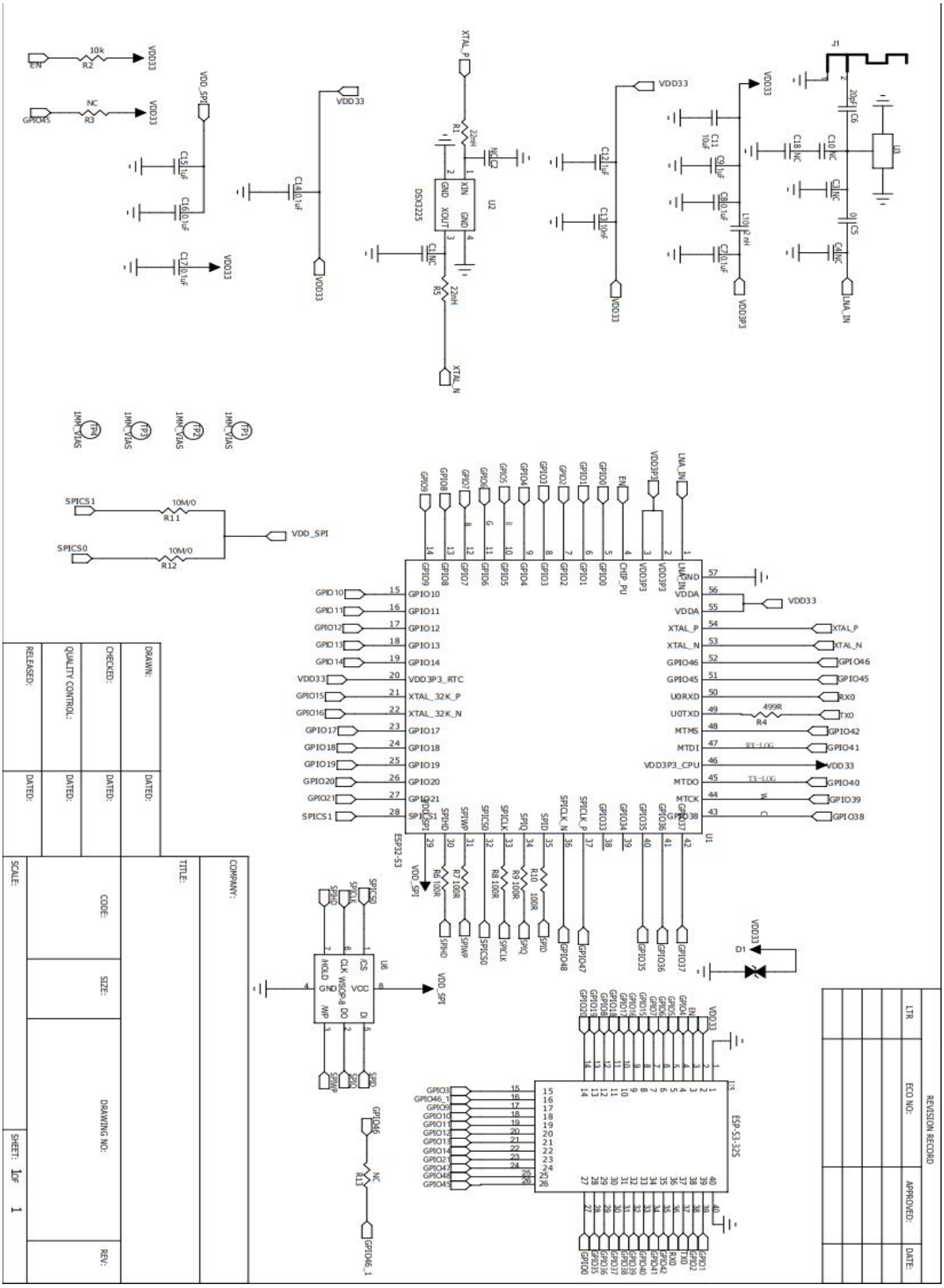

Figure7 Schematic diagram of the module

7. Antenna parameters

7.1. Antenna test diagram

Figure 8 illustrates the use of the user welding the module to the motherboard

7.2. Antenna S parameters

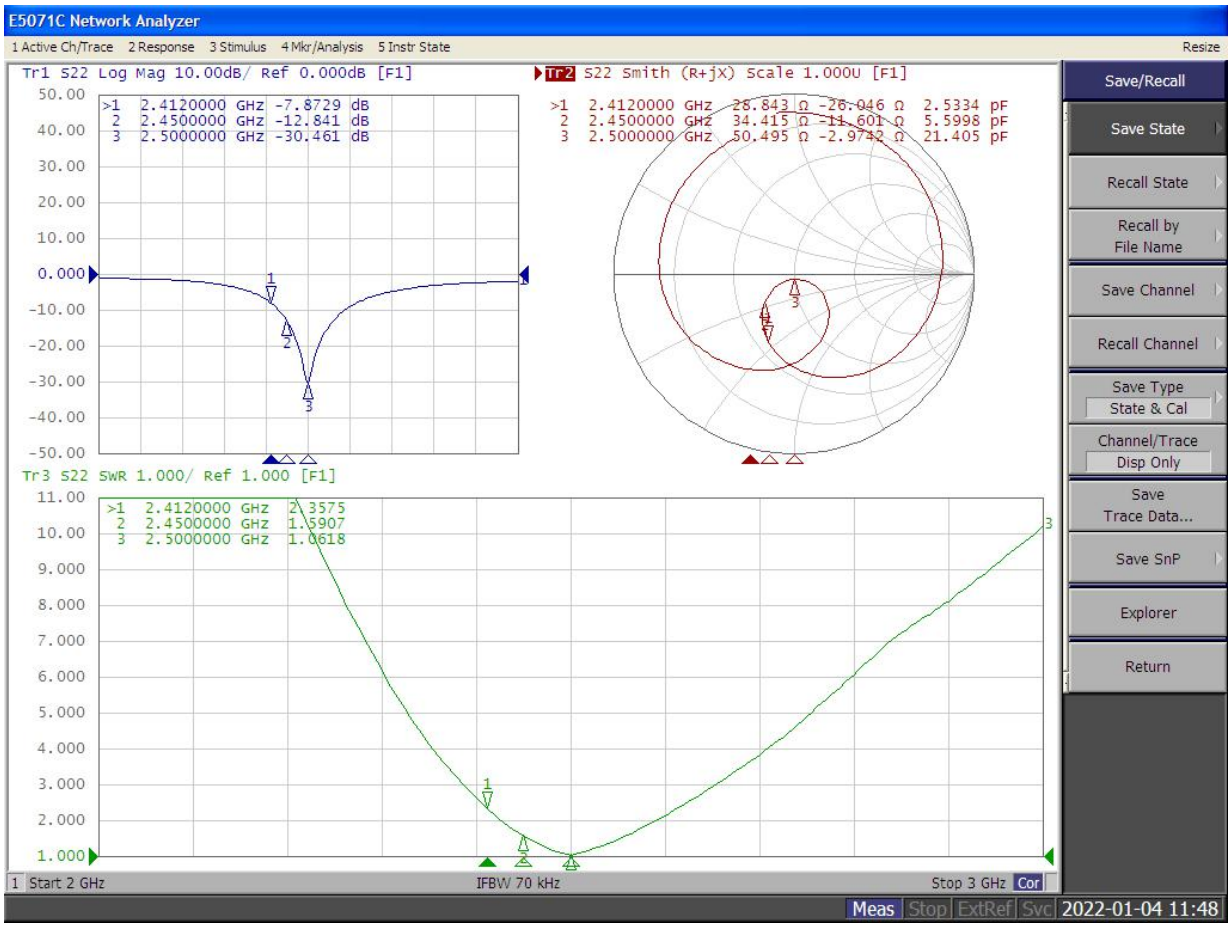

Figure 9 Antenna S parameters

7.3. Antenna Gain and Efficiency

Table 9 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)	2.27	2.44	2.63	2.79	2.89	3.13	3.22	3.26	3.17	3.22	3.04
Efficiency (%)	54.2	55.7	57.1	58.7	60.3	64.6	67.2	68.9	67.5	67.9	63.9

7.4. Antenna pattern

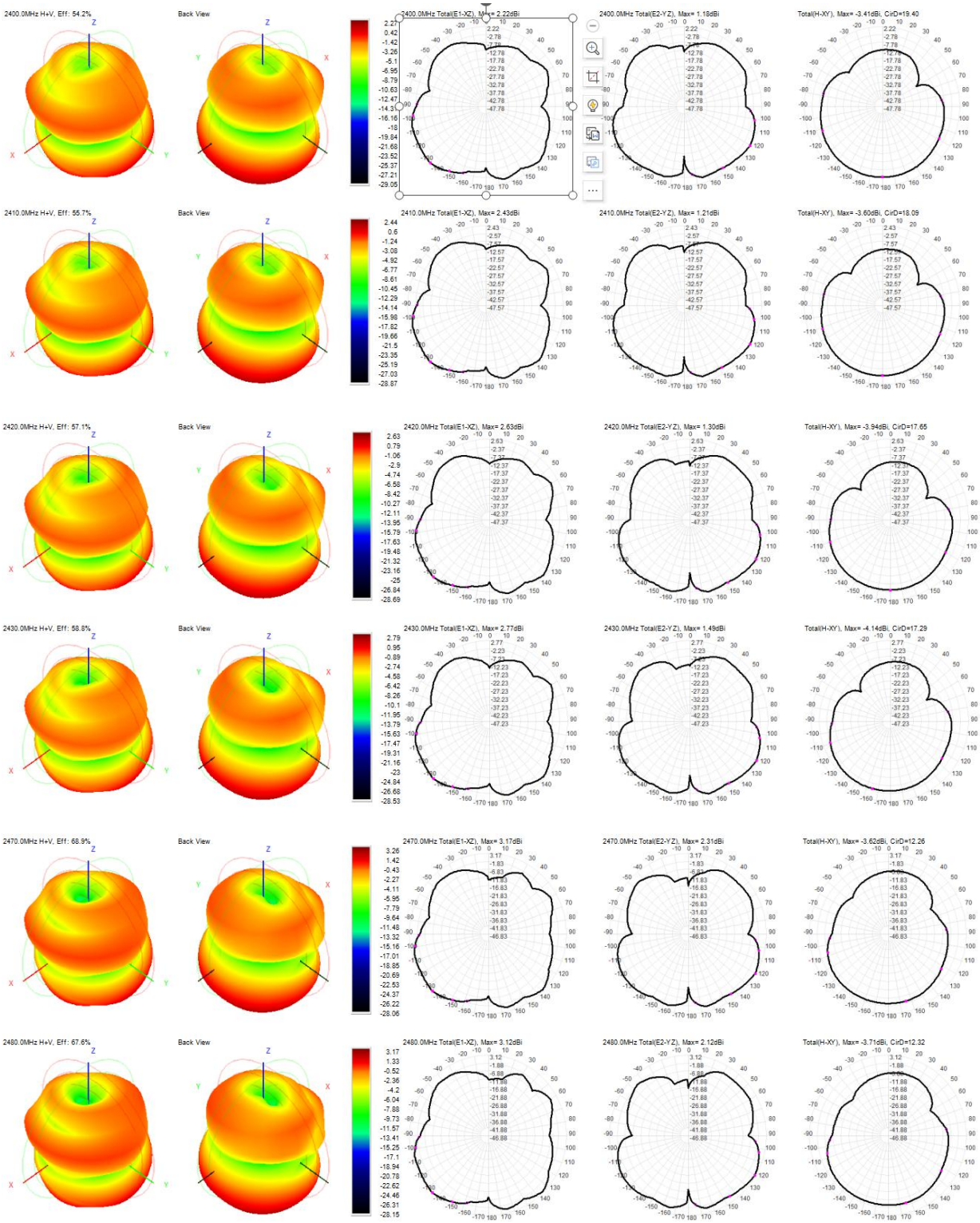

Figure 10 Antenna field pattern

8. Design Guidance

8.1. Module application circuit guidance

(>= 500mA, it is recommended to use DC-DC or LDO for independent power supply)

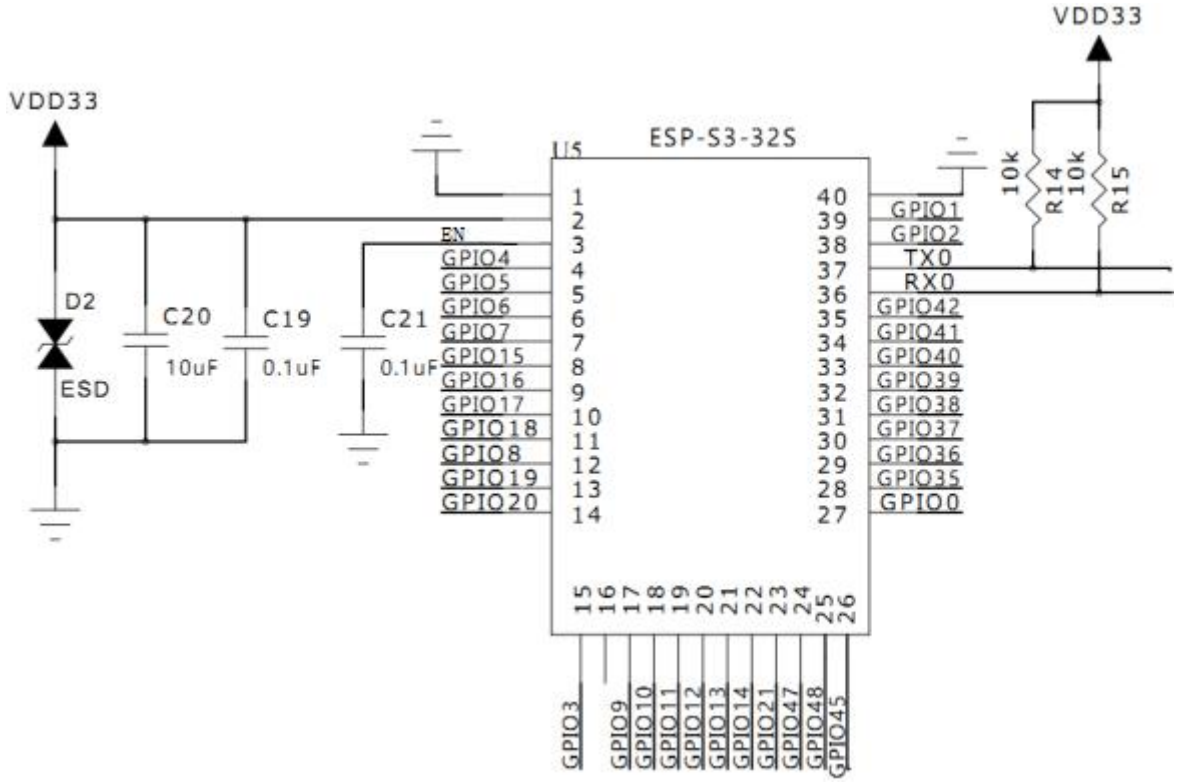

Figure 11 Application circuit diagram

Notice:

- U0RX0 and U0TX0 need to add a pull-up resistor externally, while U0RX0 is connected to the TX of another machine, and U0TX0 is connected to the RX of another machine.

8.2. Antenna layout requirements

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

Solution 1: Put the module on the edge of the motherboard, and the antenna area extends out of the edge of the motherboard.

Option 2: Put the module on the edge of the motherboard, and hollow out an area on the edge of the motherboard at the antenna position.

- In order to meet the performance of the on-board antenna, it is forbidden to place metal parts around the antenna and keep away from high-frequency devices.

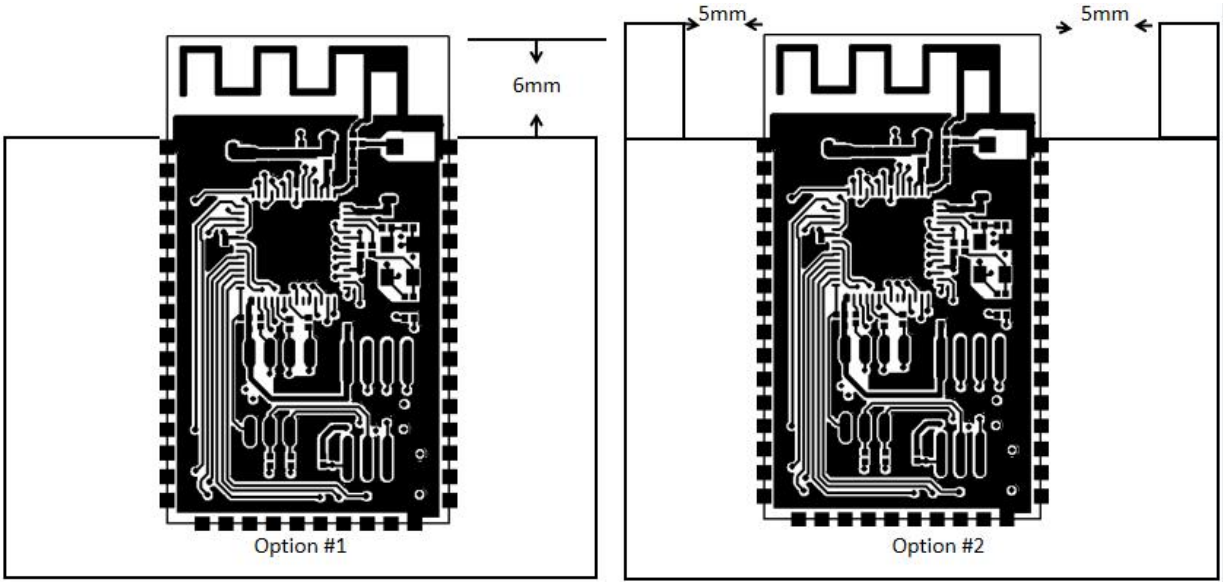

Figure 12 Schematic diagram of antenna layout

8.3. Power supply

- Recommended 3.3V voltage, peak current above 500mA.
- 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 of the dynamic response capacitor for the DC-DC power supply circuit, which can optimize the output ripple when the load changes greatly.
- It is recommended to add ESD devices to the 3.3V power interface.

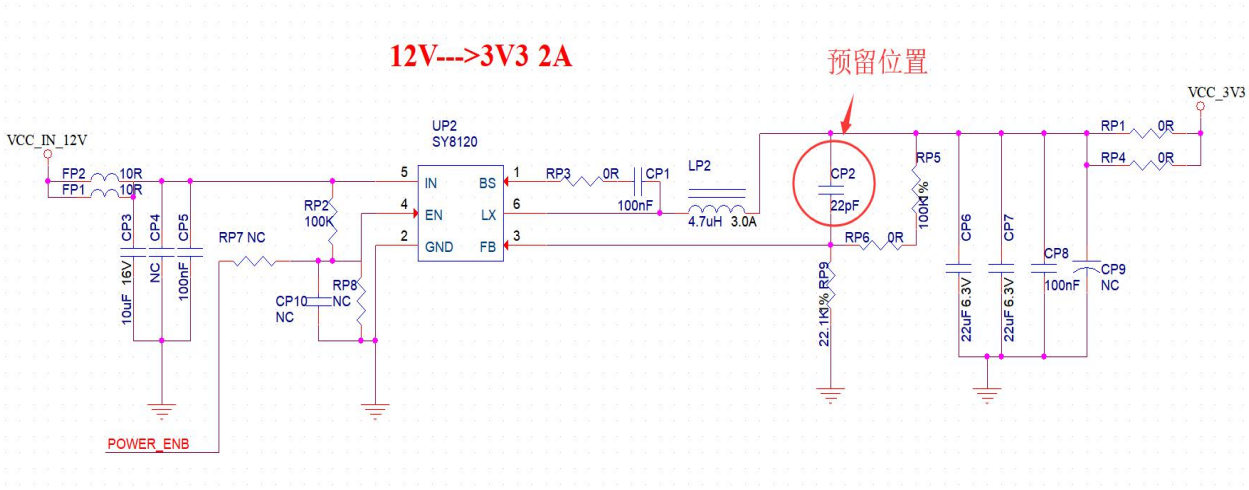

Figure 13 DC-DC step-down circuit diagram

8.4. 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 port. This suppresses overshoot and makes the level on both sides smoother. Helps with both EMI and ESD.
- For the pull-up and pull-down of the special IO port, please refer to the instruction manual of 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 does not match, a level conversion circuit needs to be added.
- If the IO port is directly connected to a peripheral interface, or a terminal such as a pin header, it is recommended to reserve an ESD device near the terminal of the IO port trace.

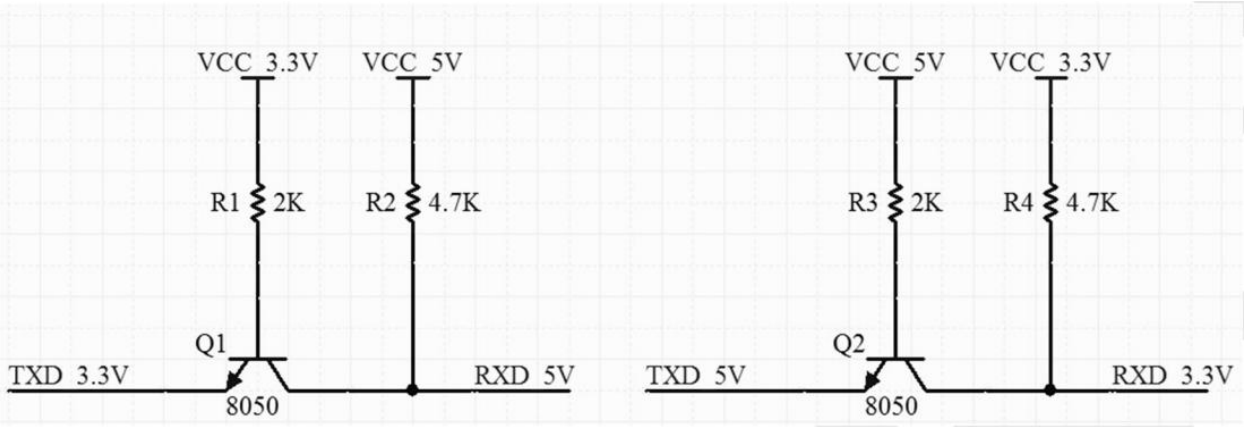

Figure 14 Level conversion circuit

9. Reflow soldering curve

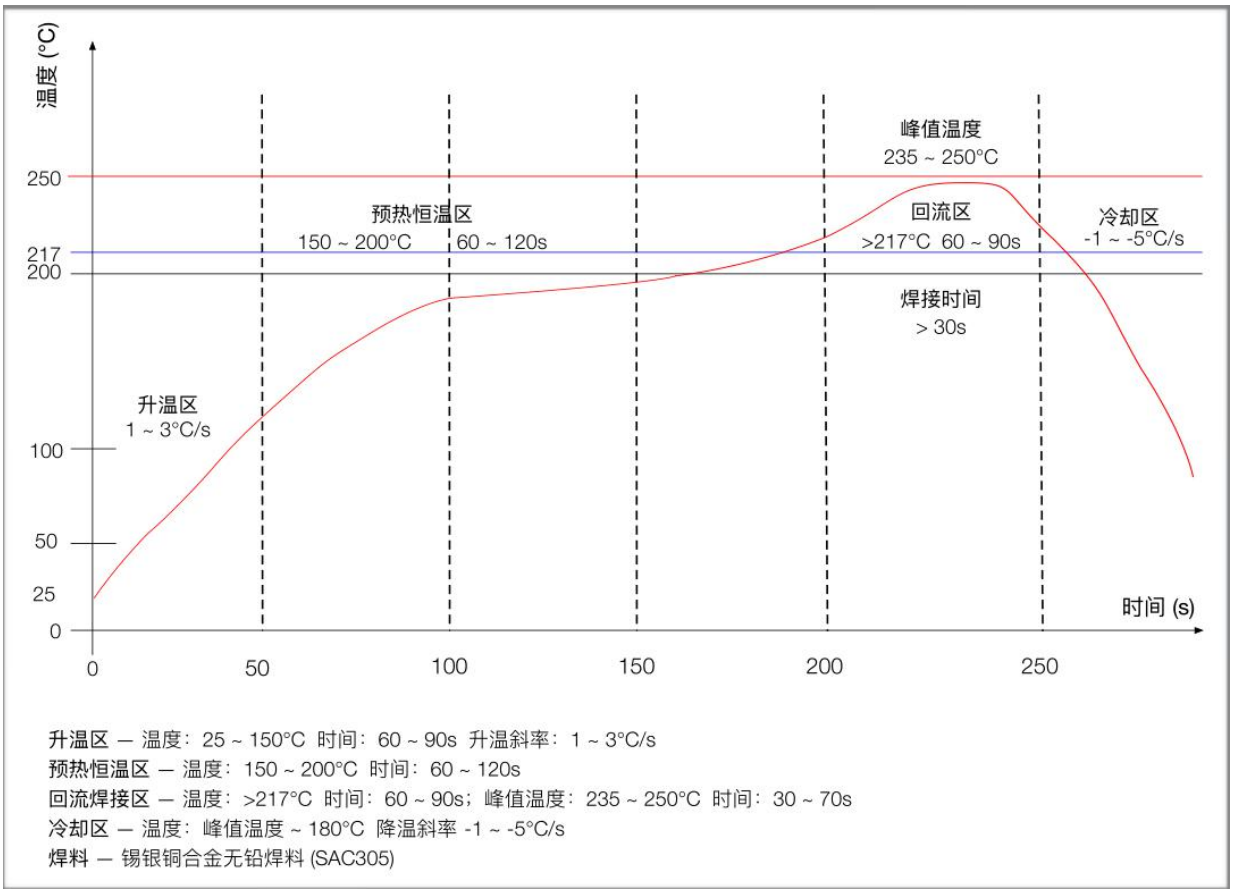

Figure 15 Reflow Soldering Curve

10. Product related models

Table 10 Product related model list

Model	Power Supply	Package	Size	Antenna
ESP-S3-12K	3.0V ~ 3.6V，I>500mA	SMD-42	31.0*18.0*3.2(±0.2)mm	The on-board PCB antenna or external antenna connector is compatible
ESP-S3-32S	3.0V ~ 3.6V，I>500mA	SMD-40	25.5*18.0*3.2(±0.2)mm	The on-board PCB antenna or external antenna connector is compatible
NodeMCU-ESP-S3-32S	5V, I>500mA	DIP42	61.0*25.5*12.9 (±0.2)mm	The on-board PCB antenna
NodeMCU-ESP-S3-12K	5V, I>500mA	DIP42	58.5*25.5*12.9 (±0.2)mm	The on-board PCB antenna
Product related information：https://docs.ai-thinker.com				

11.Product packaging information

The ESP-S3-32S module is packaged with tape, 800pcs/reel. As shown below:

Figure 16 Packaging Taping Diagram

12.Contact us

Ai-Thinker official website　Office forum　Develop DOCS

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