



# Ai-M62-12F Specification

Version V1.0.0

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## Document resume

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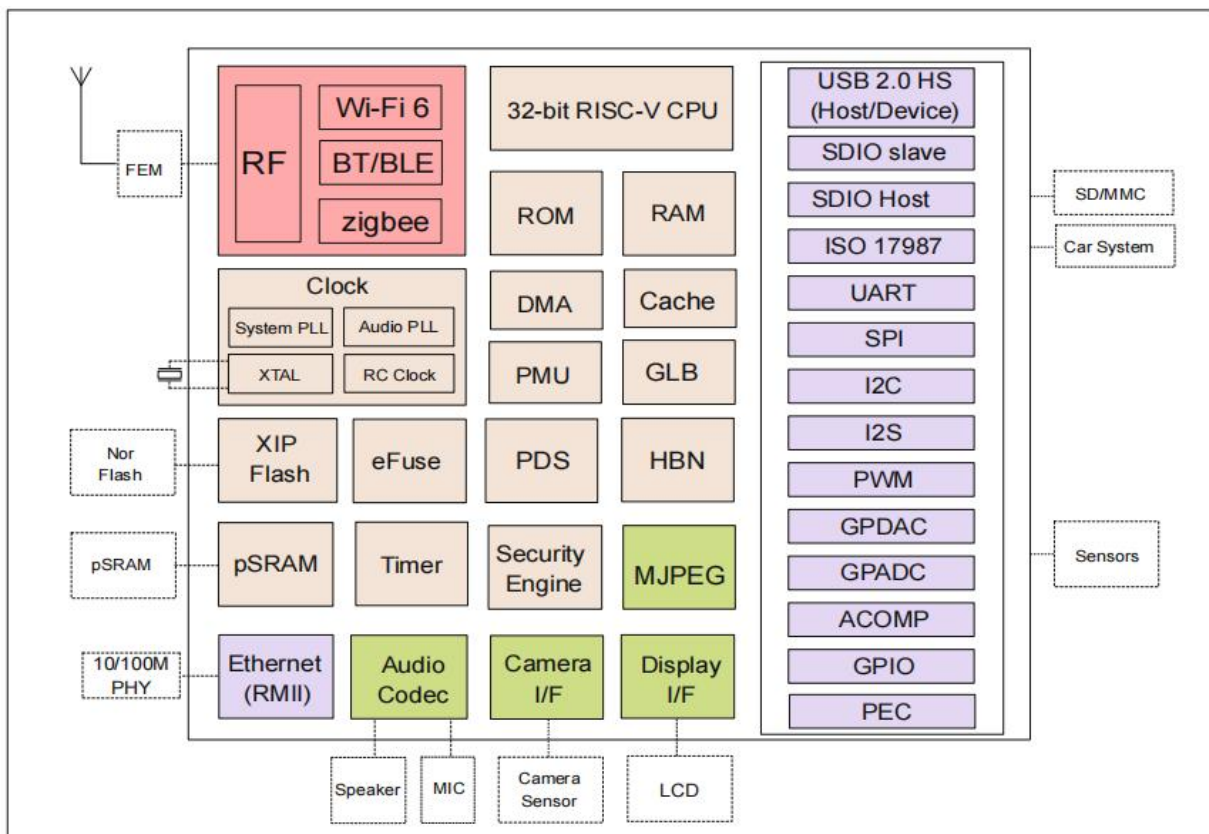
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## 1. Product overview

Ai-M62-12F is a Wi-Fi 6 + BLE5.3 module developed by Shenzhen Ai-Thinker Technology Co., Ltd. The module is equipped with BL616 chip as the core processor, supports Wi-Fi 802.11b/g/n/ax protocol and BLE protocol, and supports Thread protocol. The BL616 system includes a low-power 32-bit RISC-V CPU with floating-point unit, DSP unit, cache and memory, with a maximum dominant frequency of 320M.

The Ai-M62-12F module has rich peripheral interfaces, including Audio Codec, USB2.0, SDU, SD/MMC(SDH), SPI, UART, I2C, I2S, PWM, GPDAC, GPDC, ACOMP, GPIO, etc. It can be widely used in audio and video multimedia, Internet of Things (IoT), mobile devices, wearable electronic devices, smart homes and other fields.

The Ai-M62-12F module Sec Eng module supports AES/SHA/PKA/TRNG and other functions, supports image encryption and signature startup, and meets various security application requirements in the Internet of Things field.



**Figure 1 Main chip architecture diagram**

## 1.1. Characteristics

- SMD-22 package
- Supports 2.4GHz operating frequency band
- Support IEEE 802.11 B/g/n/ax
- Support BLE5.3
- Support Thread
- Support Wi-Fi/BLE/Thread coexistence
- Wi-Fi security support WPS/WEP/WPA/WPA2/WPA3
- Supports 20/40MHz bandwidth, 1T1R, maximum rate 229.4 Mbps
- Support STA, SoftAP, STA + SoftAP and sniffer modes
- 32-bit RISC-V CPU with FPU and DSP, with a maximum dominant frequency of 320M
- 532KB SRAM, 128KB ROM, 4Kb eFuse
- Support Audio Codec, USB2.0, SDU, SD/MMC(SDH), SPI, UART, I2C, I2S, PWM, GPDAC, GPDC, ACOMP, GPIO, etc.
- Integrated RF Balun, PA/LNA
- Support for safe startup and safe debugging
- Support XIP QSPI On-The-Fly AES decryption (OTFAD)
- Support TrustZone
- Support AES-CBC/CCM/GCM/XTS mode
- Support MD5, SHA-1/224/256/384/512
- TRNG (True Random Number Generator) is supported
- Support PKA (Public Key Accelerator) for RSA/ECC
- BLE-enabled Wi-Fi fast connection
- Universal AT command can be used quickly.
- Supports secondary development and integrates Windows and Linux development environments

## 2. Main parameters

**Table 1 Description of Main Parameters**

<b>Model</b>	Ai-M62-12F
<b>Package</b>	SMD-22
<b>Size</b>	24.0*16.0*3.1( $\pm 0.2$ )mm
<b>Antenna</b>	onboard antenna
<b>Frequency</b>	2400~2483.5MHz
<b>Operating temperature</b>	-40 °C ~ 85 °C
<b>Storage temperature</b>	-40°C ~ 125°C, < 90%RH
<b>Power supply</b>	The power supply voltage is 2.97V ~ 3.6V, and the power supply current is $\geq 500\text{mA}$ .
<b>Interface</b>	Audio Codec, USB2.0, SDU, SD/MMC(SDH), SPI, UART, I2C, I2S, PWM, GPDAC, GPDC, ACOMP, GPIO, etc.
<b>IO</b>	15
<b>UART rate</b>	Default 115200 bps
<b>Security</b>	WPS/WEP/WPA/WPA2/WPA3
<b>Flash</b>	Default 4MByte, Support expansion

### 2.1. Electrostatic requirements

Ai-M62-12F are electrostatic sensitive equipment, special precautions need to be taken when handling.



**Figure 2 ESD preventive measures**

## 2.2. Electrical characteristics

Table 2 Table of Electrical Characteristics

Parameters	Conditio	Min.	Typical value	Max.	Unit
Supply voltage	VDD	2.97	3.3	3.6	V
I/O	VIL	-	-	0.3*VDDIO	V
	VIH	-	0.7*VDDIO	-	V
	VOL	-	0.1*VDDIO	-	V
	VOH	-	0.9*VDDIO	-	V
	IMAX	-	-	15	mA

## 2.3. Wi-Fi radio frequency performance

Table 3 Wi-Fi RF Performance Table

Description	Typical value			Unit
Spectrum range	2400~2483.5MHz			MHz
Output power				
Mode	Min.	Typical	Max.	Unit
11ax mode HE40,PA output power	-	16	-	dBm
11ax mode HE20,PA output power	-	17	-	dBm
11n mode HT40,PA output power	-	19	-	dBm
11n mode HT20,PA output power	-	19	-	dBm
In 11g mode, PA output power	-	19	-	dBm
In 11b mode, PA output power	-	22	-	dBm
Receiving sensitivity				
Mode	Min.	Typical	Max.	Unit
11b,1 Mbps	-	-98	-	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 RF Performance Table**

Description	Typical value			Unit
Spectrum range	2400~2483.5MHz			MHz
Output power				
Mode	Min.	Typical value	Max.	Unit
1Mbps	-	10	15	dBm
2Mbps	-	10	15	dBm
Receiving sensitivity				
Mode	Min.	Typical value	Max.	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 based on a 3.3V power supply and measured at an ambient temperature of 25°C.

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

**Table 5 Power consumption table**

Mode	Min.	Average	Max.	Unit
Transmit 802.11B, 11Mbps, POUT = + 22dBm	-	442	-	mA
Transmit 802.11g, 54Mbps, POUT = + 19dBm	-	296	-	mA
Emission 802.11n, MCS7, POUT = + 19dBm	-	301	-	mA
Launch 802.11ax, MCS9, POUT = + 17dBm	-	269	-	mA
Receive 802.11B, packet length 1024 bytes	-	59	-	mA
Receive 802.11g, packet length 1024 bytes	-	59	-	mA
Receive 802.11n, packet length 1024 bytes	-	59	-	mA
Receive 802.11ax, packet length 1024 bytes	-	59	-	mA



### 3. Appearance size

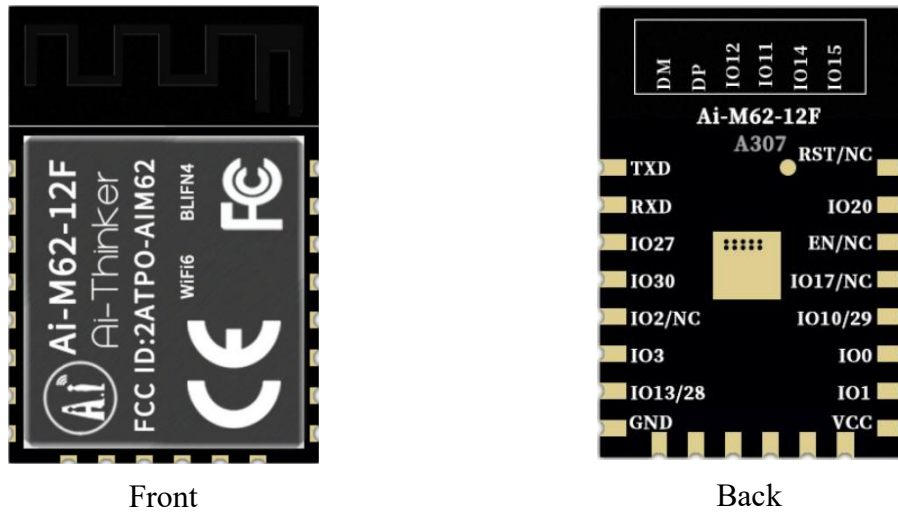


Figure 3 appearance diagram (Rendering diagram is for reference only, subject to actual objects)

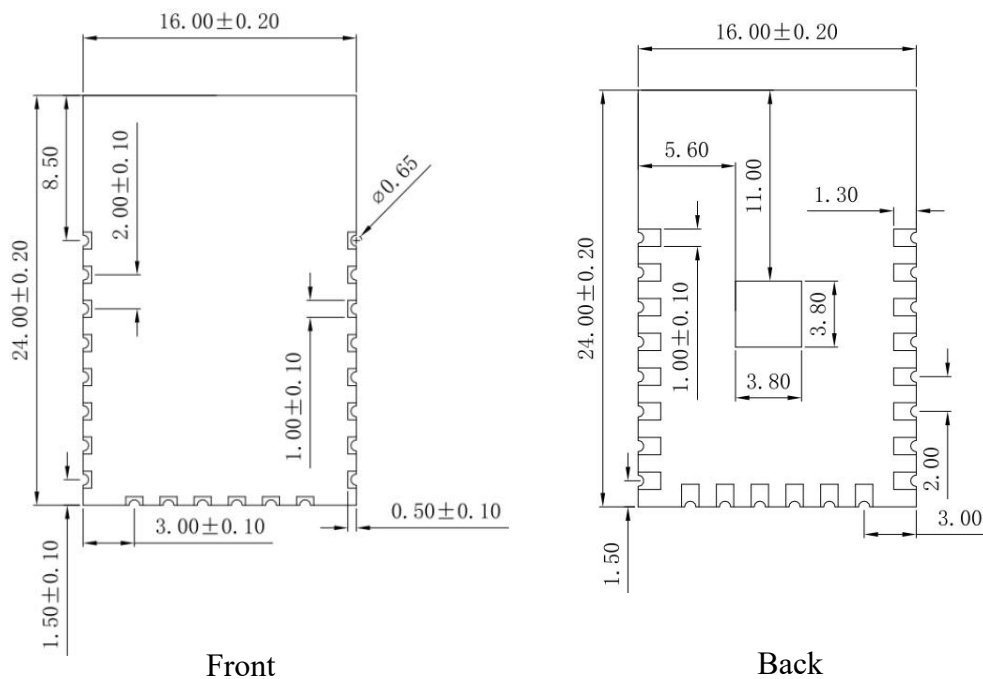


Figure 4 dimension diagram

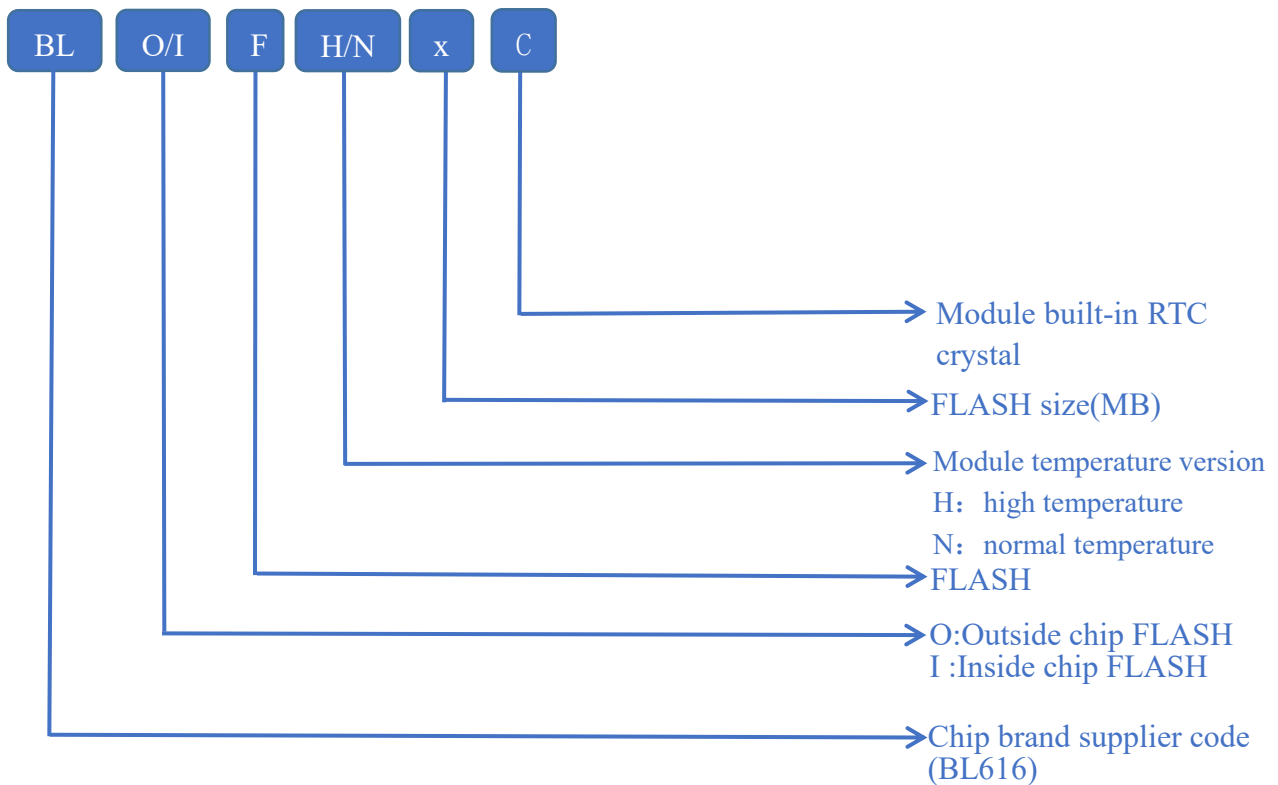


Figure 5 Screen Screen Representative Information of Shields

## 4. Pin definition

A total of 22 pins are connected to the Ai-M62-12F module, as shown in the pin diagram, the pin function definition table is an interface definition.

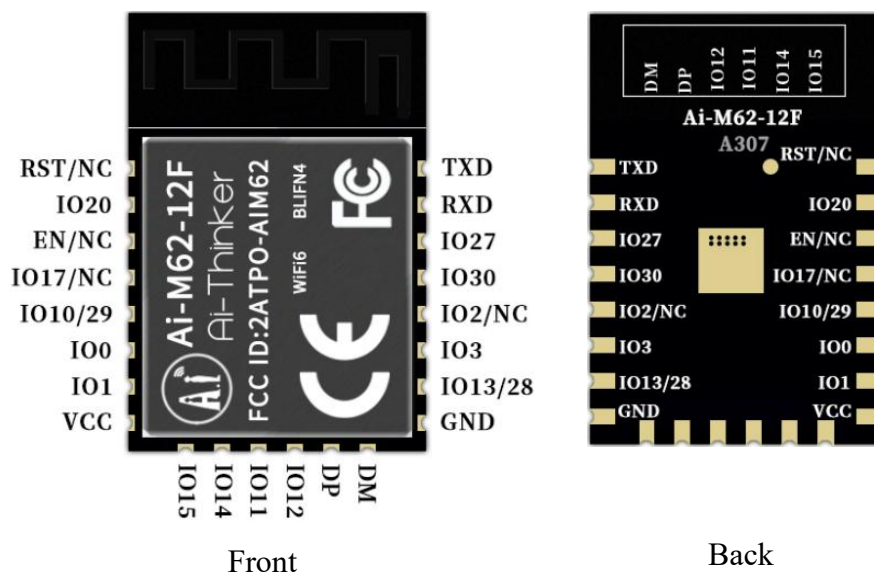


Figure 6 pin diagram

**Table 6 Pin Function Definition Table**

Foot	Name	Functional description
1	RST/NC	The default is floating, and it can be customized as a reset pin, which is active at low level. If you need to use it, please contact Ai-Thinker
2	IO20	GPIO20/SPI_SS/I2S_BCLK/I2C_SCL/ADC_CH0/PWM0
3	EN/NC	By default, it is enabled as a chip, active at high level, and cannot be used at the same time as RST
4	IO17/NC	Available by default, the IO port is shared with the 32.768KHz crystal output PIN pin inside the module. If the module of the internal patch 32.768KHz crystal oscillator is customized, the IO is in NC state. GPIO17/SPI_SCLK/I2S_FS/I2C_SDA/XTAL_32K_OUT/PWM0
5	IO10/29	The default is IO29,GPIO29/SPI_SCLK/I2S_FS/I2C_SDA/PWM0
6	IO0	GPIO0/SPI_SS/I2S_BCLK/I2C_SCL/ADC_CH9/PWM0
7	IO1	GPIO1/SPI_SCLK/I2S_FS/I2C_SDA/ADC_CH8/PWM0
8	VCC	3.3V power supply; The output current of external power supply is recommended to be above 500mA.
9	IO15	Available by default, this IO port is shared with Flash in the module. If a module with external Flash is customized, the IO is not available. For use, please contact Ai-Thinker. GPIO15/SPI_MOSI/I2S_DO/I2S_RCLK_O/I2C_SDA/PWM0
10	IO14	Available by default, this IO port is shared with Flash in the module. If a module with external Flash is customized, the IO is not available. For use, please contact Ai-Thinker. GPIO14/SPI_MISO/I2S_DI/I2S_RCLK_O/I2C_SCL/ADC_CH4/PWM0
11	IO11	Available by default, this IO port is shared with Flash in the module. If a module with external Flash is customized, the IO is not available. For use, please contact Ai-Thinker. GPIO11/SPI_MOSI/I2S_DO/I2S_RCLK_O/I2C_SDA/PWM0
12	IO12	Available by default, this IO port is shared with Flash in the module. If a module with external Flash is customized, the IO is not available. For use, please contact Ai-Thinker. GPIO12/SPI_SS/I2S_BCLK/I2C_SCL/ADC_CH6/PWM0
13	DP	USB_DP
14	DM	USB_DM
15	GND	Grounding
16	IO13/28	The default is IO28,GPIO28/SPI_SS/I2S_BCLK/I2C_SCL/ADC_CH11/PWM0

17	IO3	GPIO3/SPI_MOSI/I2S_DO/I2S_RCLK_O/I2C_SDA/ADC_CH3/PWM0
18	IO2/NC	The default NC is not available. If you need to use it, please contact Ai-Thinker. If elicited, support Bootstrap/GPIO2/SPI_MISO/I2S_DI/I2S_RCLK_O/I2C_SCL/ADC_CH2/PWM0
19	IO30	GPIO30/SPI_MISO/I2S_DI/I2S_RCLK_O/I2C_SCL/PWM0
20	IO27	GPIO27/SPI_MOSI/I2S_DO/I2S_RCLK_O/I2C_SDA/ADC_CH10/PWM0
21	RXD	RXD/GPIO22/SPI_MISO/I2S_DI/I2S_RCLK_O/I2C_SCL/PWM0
22	TXD	TXD/GPIO21/SPI_SCLK/I2S_FS/I2C_SDA/ADC_RCAL_VOUT/PWM0

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

## 5. Schematic diagram

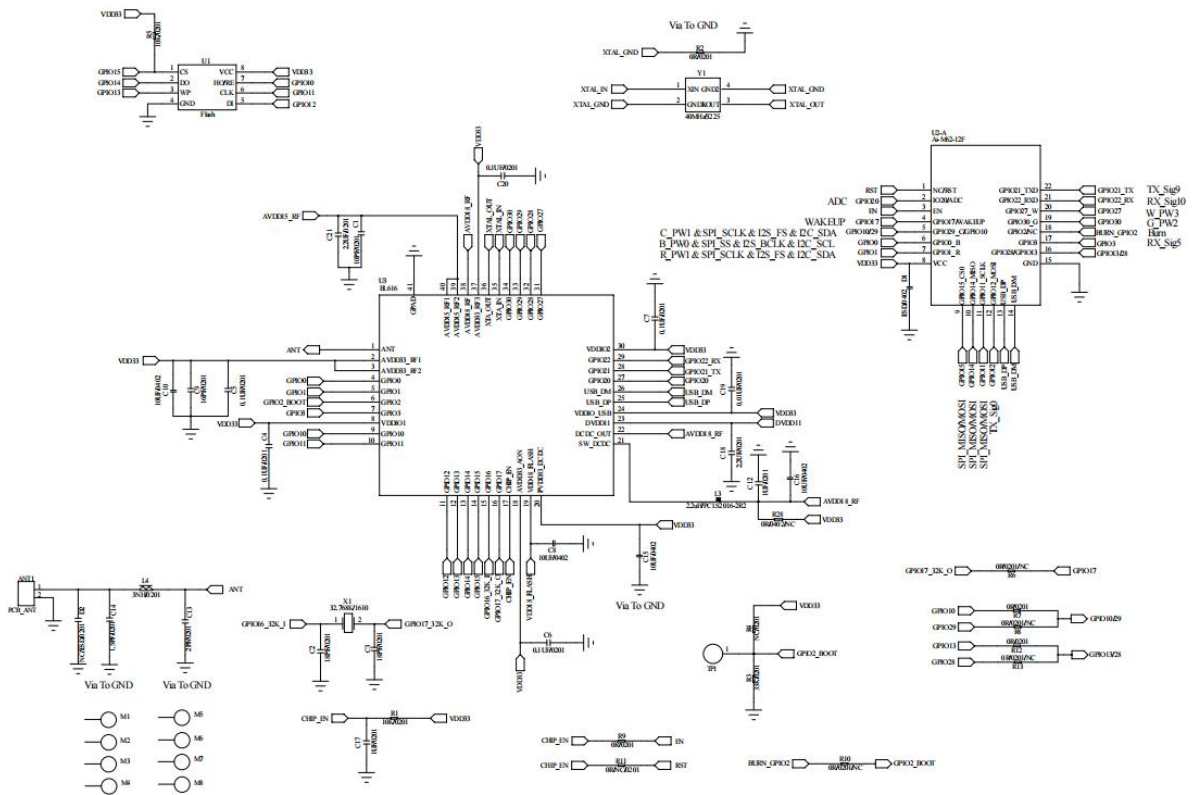


Figure 7 Schematic Diagram

## 6. Antenna parameters

### 6.1. Schematic of Antenna Test Prototype

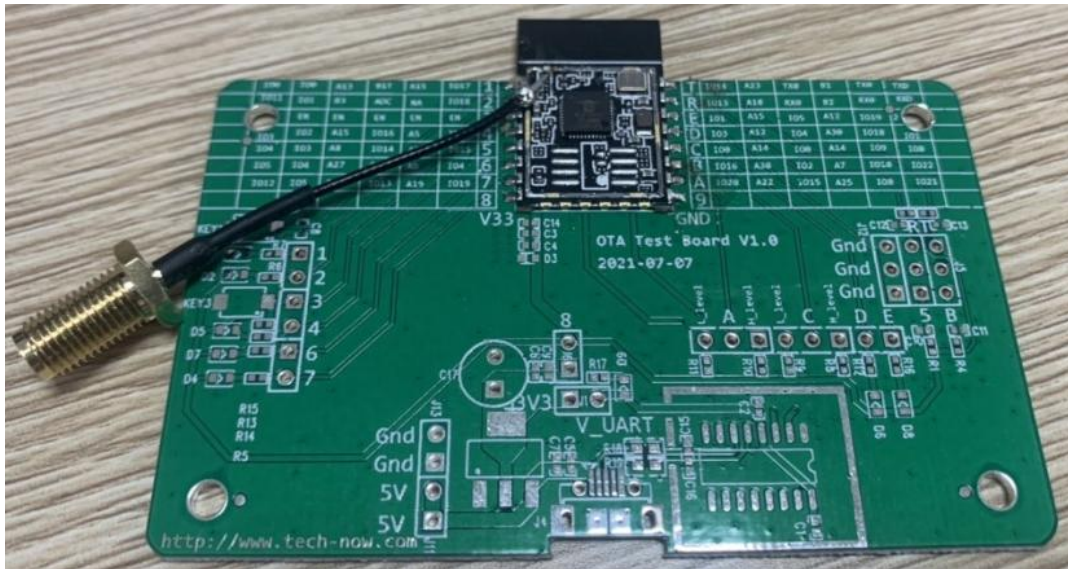


Figure 8 schematic diagram of antenna test prototype

## 6.2. Antenna s parameter

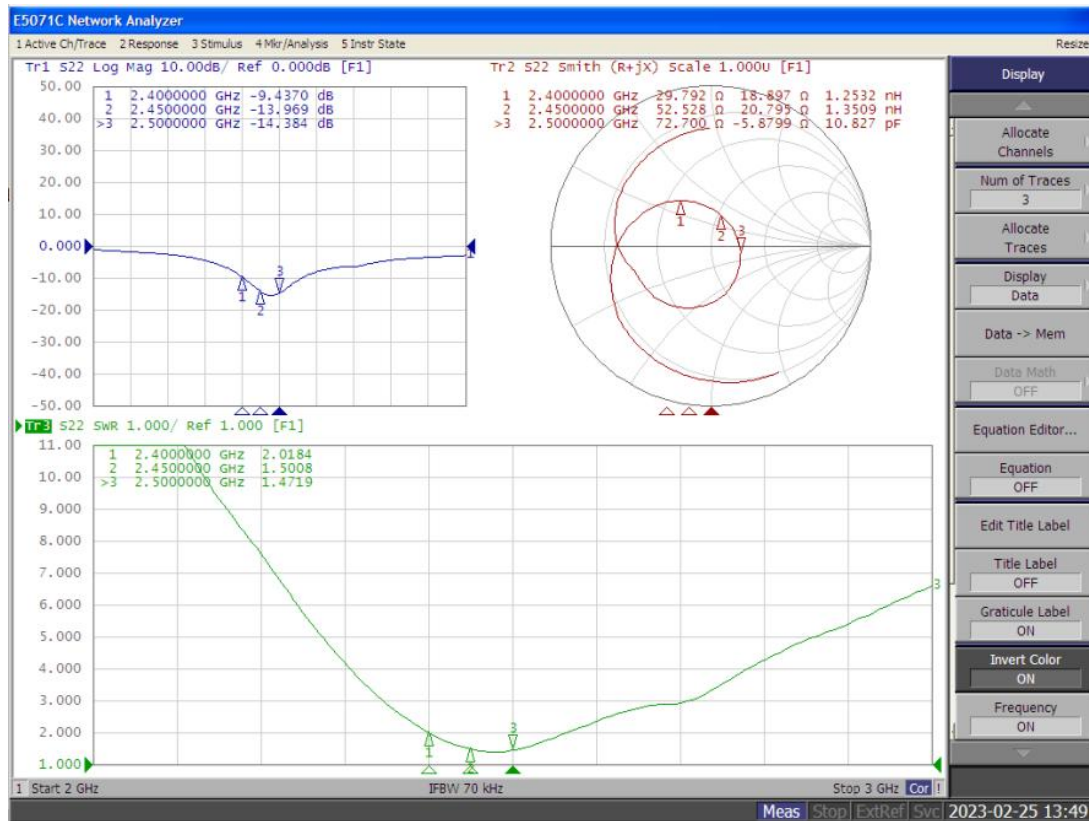


Figure 9 antenna s parameters

## 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	2410	2420	2430	2440	2450	2460	2470	2480	2490	2500
Gain (dBi)	0.15	0.35	0.33	0.54	0.93	1.00	1.21	1.32	1.18	1.14	1.23
Efficiency (%)	46.44	48.21	46.87	48.02	51.00	51.53	54.15	55.61	54.13	53.62	54.38



## 6.4. Antenna field pattern

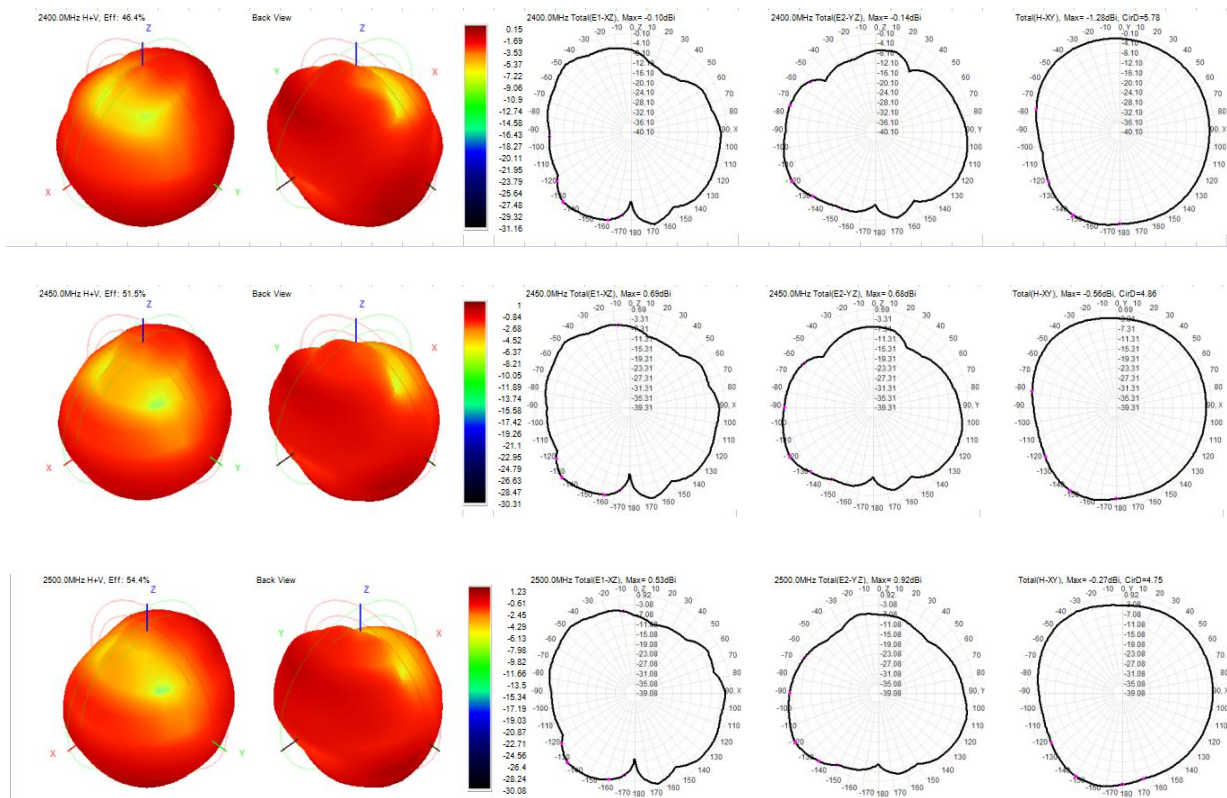
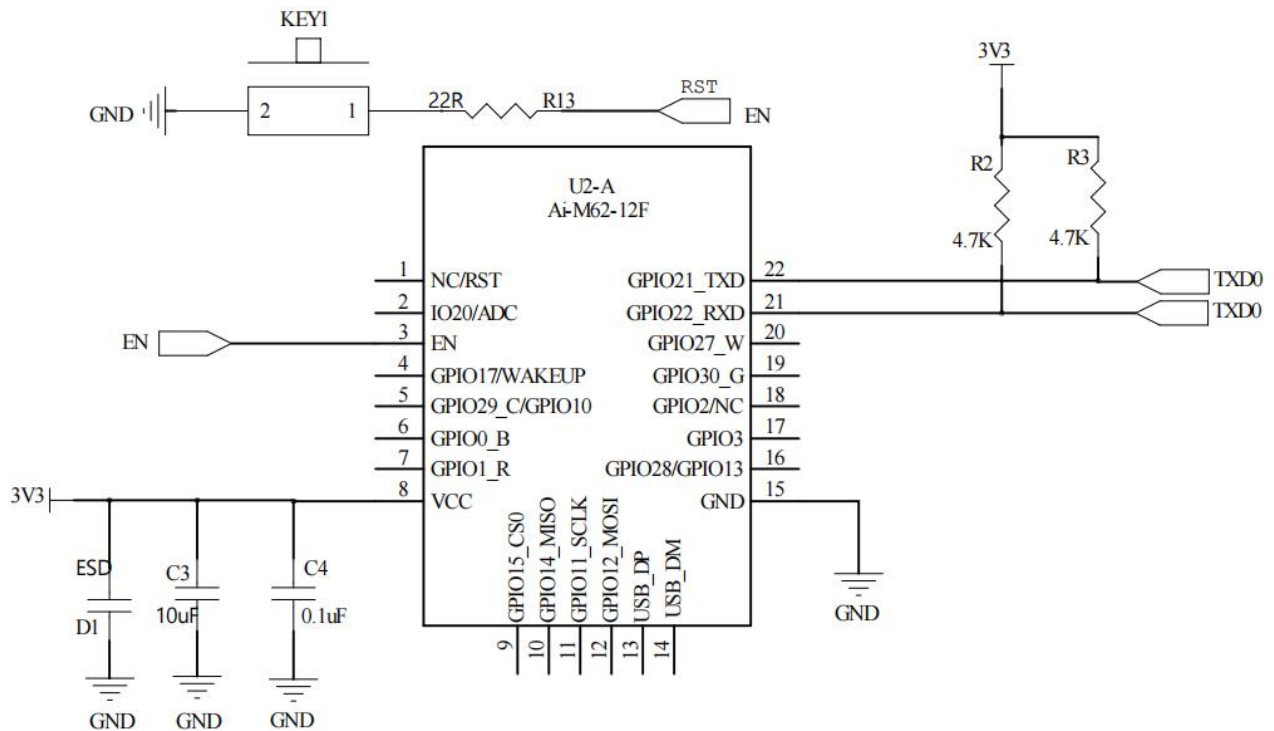


Figure 10 antenna field diagram



## 7. Design guidance

### 7.1. Application guidance circuit



**Figure 11 Application Guidance Circuit**

- IO2 is the module start control pin, which is in normal working mode at low level and in firmware burning mode at high level. The default low level inside the chip.
- IO2/NC, not available by default
- IO11/IO12/IO14/IO15, available by default. These IO ports are shared with the internal Flash of the module. If the module with external Flash is customized, it cannot be used. For use, please contact Ai-Thinker.
- IO17/NC, available by default. The IO port is shared with the 32.768KHz crystal output PIN pin inside the module. If the module of the internal patch 32.768KHz crystal oscillator is customized, the IO is in NC state.

## 7.2. Recommended PCB package size

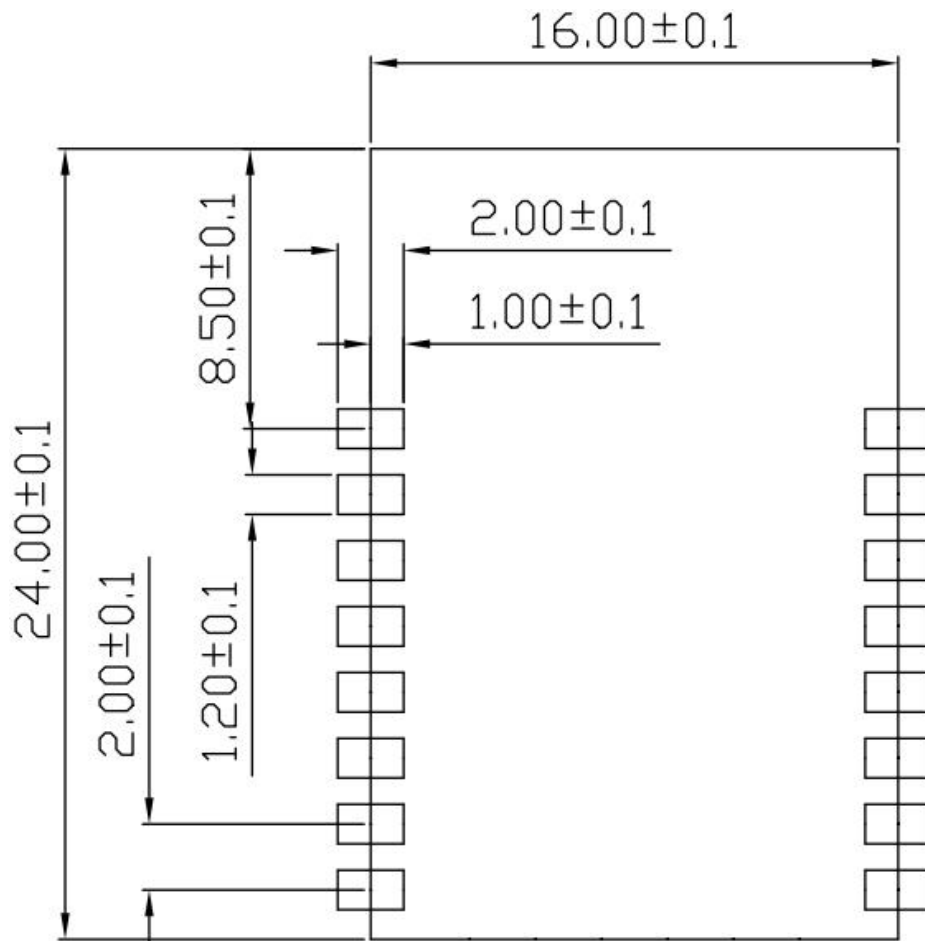


Figure 12 Recommended PCB Package Size

## 7.3. Antenna layout requirements

- In the installation position on the motherboard, the following 2 methods are recommended:

Scheme 1: Place the module on the edge of the main board, and the antenna area extends out of the edge of the main board.

Scheme 2: Place the module on the edge of the motherboard, and the edge of the motherboard hollowed out an area 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, away from high-frequency devices.

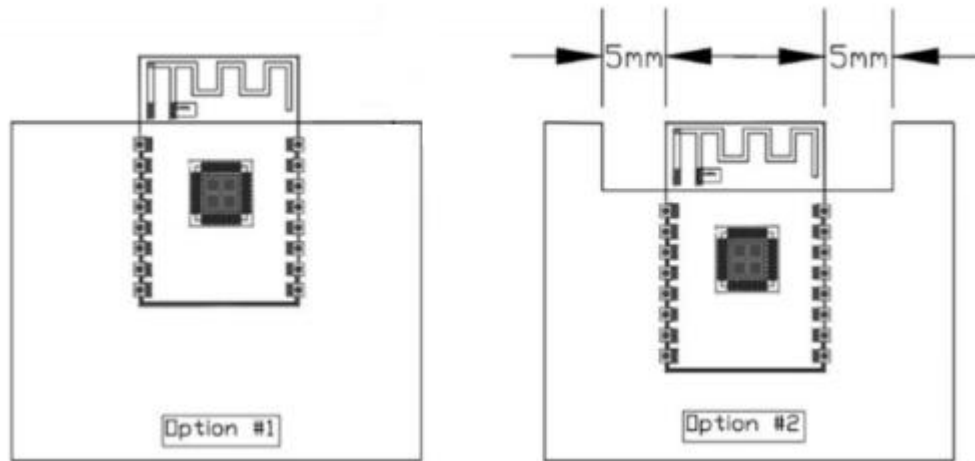


Figure 13 schematic diagram of antenna layout

## 7.4. Power supply

- Recommended 3.3V voltage, peak current above 500mA.
- LDO is recommended for power supply; If DC-DC is used, it is recommended that the ripple be controlled within 30mV.
- The DC-DC power supply circuit suggests to reserve the position of the dynamic response capacitor, which can optimize the output ripple when the load changes greatly.
- It is recommended to add ESD devices to the 3.3V power interface.

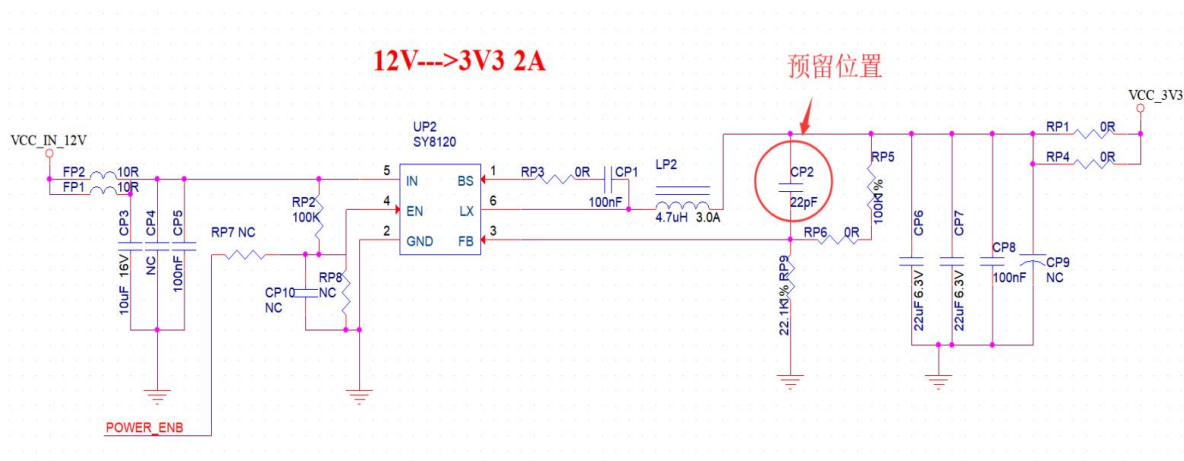
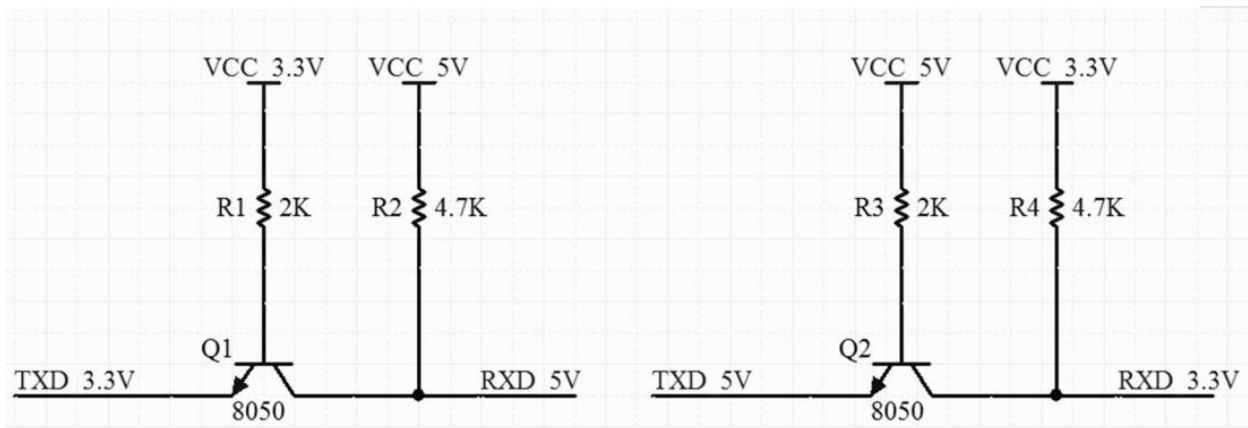


Figure 14 DC-DC step-down circuit diagram

## 7.5. GPIO

- Some IO ports are led out from the periphery of the module. If you need to use a resistor of 10-100 ohms in series on the IO port. This can suppress overshoot and make the level on both sides more stable. It is helpful for both EMI and ESD.
- For the up and 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 IO port of the main control and the module does 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 pins, it is recommended to reserve ESD devices at the IO port wiring close to the terminals.



**Figure 15 Level Shift Circuit**

## 8. Storage conditions

The product sealed in the moisture-proof bag should be stored in a non-condensing atmospheric environment of  $<40^{\circ}\text{C}/90\%\text{RH}$ .

The moisture sensitivity level MSL of the module is level 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 on line again.

## 9. Reflow Soldering Curve

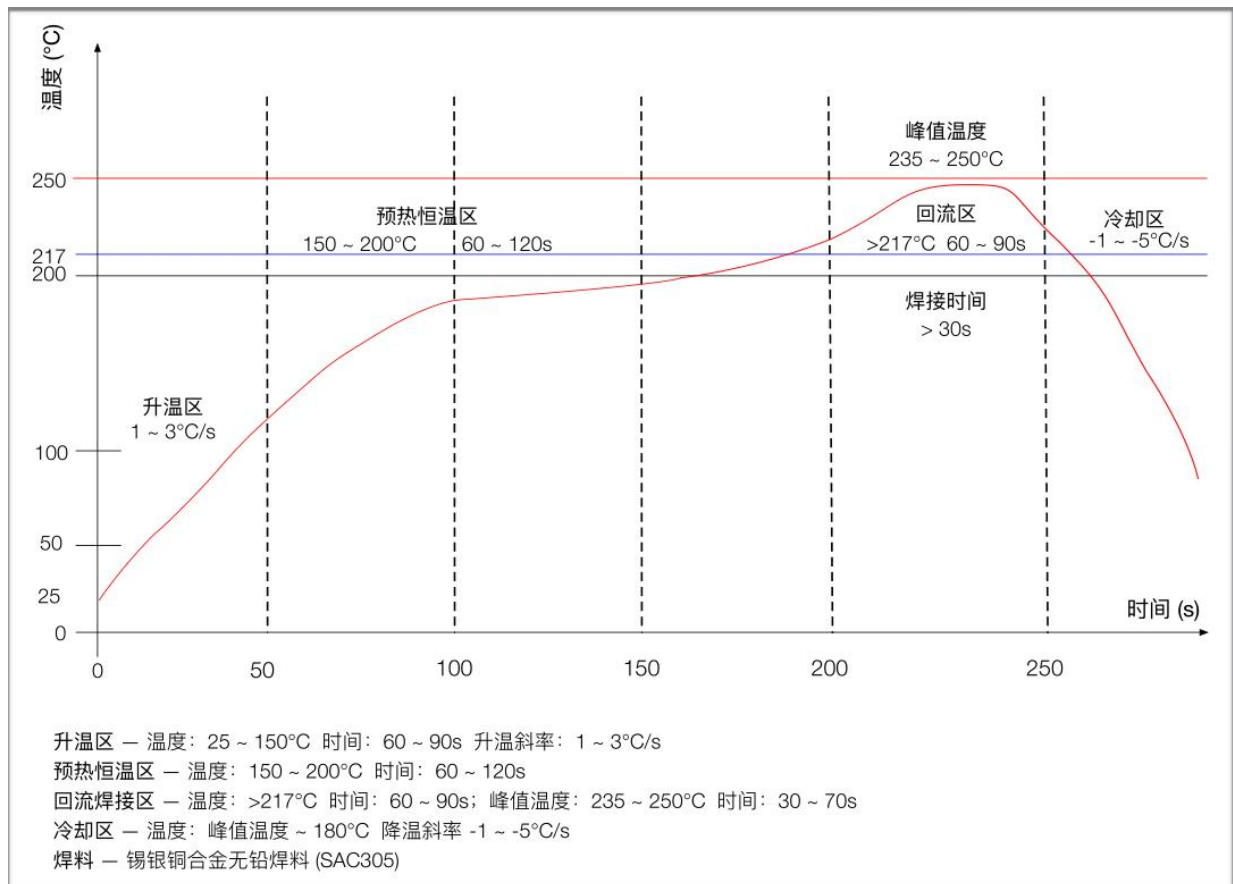


Figure 16 reflow soldering graph

## 10. Product packaging information

The Ai-M62-12F module adopts braided packaging, 800 pcs/disk. As shown in the following figure:



Figure 17 packing tape drawing

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[Tmall shop](#)

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[Alibaba shop](#)

[Technical support email: support@aithinker.com](#)

[Domestic business cooperation: sales@aithinker.com](#)

[Overseas business cooperation: overseas@aithinker.com](#)

Company Address: Room 403,408-410, Block C, Huafeng Smart Innovation Port, Gushu 2nd Road, Xixiang, Baoan District, Shenzhen.

Tel: +86-0755-29162996



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## 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 20

cm 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-AIM62”

## **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 also Section 2.10 below concerning the need to notify host manufacturers that further testing is required.<sup>3</sup>

**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 1.32dBi

### **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.

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-AIM62

## **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 "omni-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 1.32dBi

## **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-AIM62

## **2.9 Information on test modes and additional testing requirements<sup>5</sup>**

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.