



Ai-WB2-12F Specification

Version V1.1.0

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Document resume

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1. Product Overview

Ai-WB2-12F is a Wi-Fi& Bluetooth module developed by Shenzhen Ai-Thinker Technology Co., LTD. The module is equipped with BL602 chip as the core processor and supports Wi-Fi 802.11b/ G/N protocol and BLE 5.0 protocol. The BL602 chip has a low-power 32-bit RISC CPU, 276KB RAM, and a wealth of peripheral interfaces, including SDIO, SPI, UART, I2C, IR Remote, PWM, ADC, DAC, PIR and GPIO. It can be widely used in Internet of Things (IoT), mobile devices, wearable electronic devices, smart home and other fields.

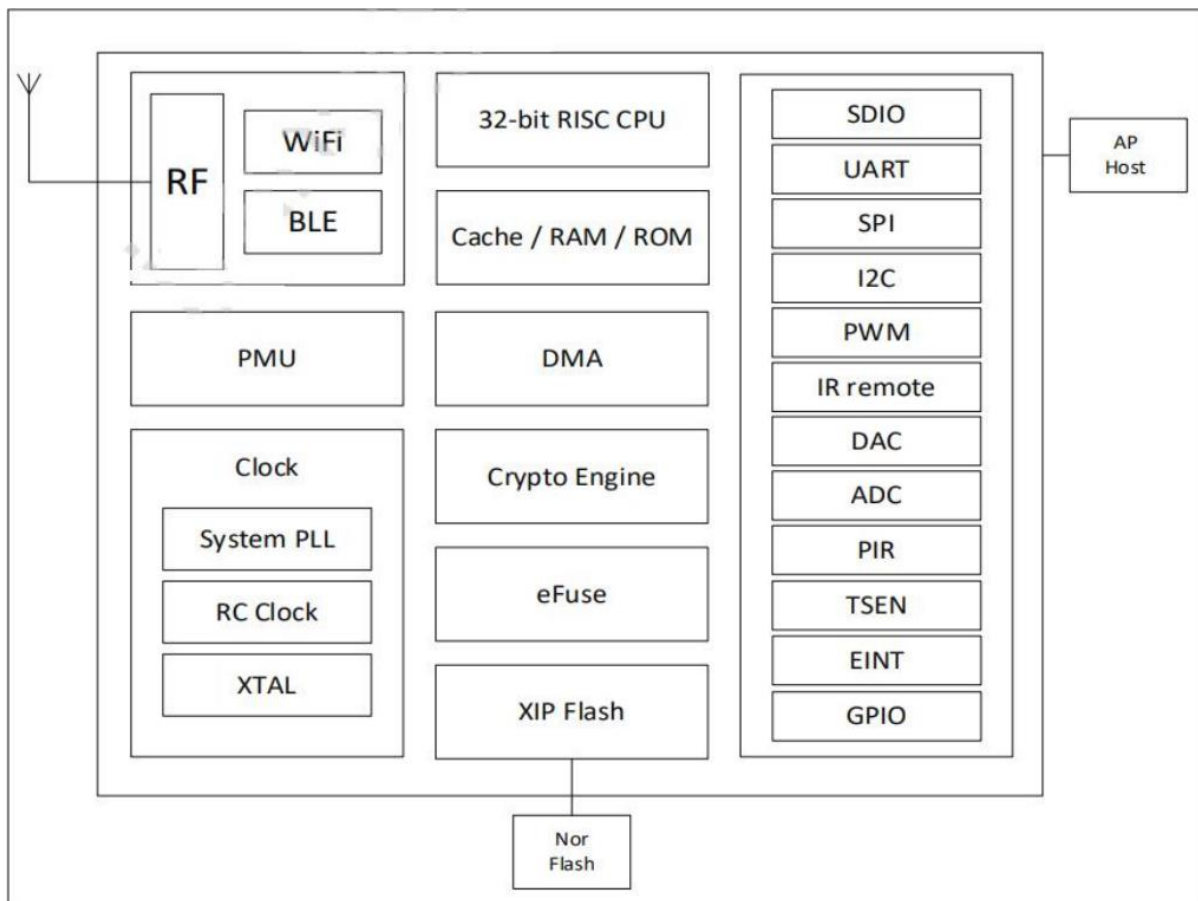


Figure 1 Main chip architecture diagram

1.1. Characteristic

- The package is SMD-22
- Support IEEE 802.11 b/g/n
- Wi-Fi Security Support WPS/WEP/WPA/WPA2 Personal/WPA2 Enterprise/WPA3
- Support 20MHz bandwidth and Max rate is 72.2 Mbps
- Bluetooth BLE 5.0,Bluetooth Mesh
- Support Station + BLE、 Station + SoftAP + BLE
- Support 32-bit RISC CPU, 276KB RAM
- Secure startup, supports mirroring with EC-256 signature
- Support QSPI/SPI Flash Instant AES Decryption (OTFAD),Support AES 128 CTR
- Support Aes128/192/256-bit encryption engine
- Support SHA-1/224/256
- Support true Random number generator (TRNG)
- Public key Accelerator (PKA), support large number basic operations, software provides signature, verification and other application program interface
- Support SDIO, SPI, UART, I2C, IR remote, PWM, ADC, DAC, PIR, GPIO etc
- Integrated Wi-Fi MAC/BB/RF/PA/LNA/Bluetooth
- Support A variety of sleep modes, deep sleep current 12 μ A
- Universal AT instruction for quick start
- Support secondary development, integrated Windows, Linux development environment

2. Main parameters

Table 1 Description of the main parameters

Model	Ai-WB2-12F
Package	SMD-22
Size	24*16*3.1(± 0.2)mm
Antenna	on-board antenna
Frequency	2400 ~ 2483.5MHz
Operating temperature	-40°C ~ 85°C
Storage temperature	-40°C ~ 125°C, < 90%RH
Power supply	Support voltage 2.7V ~ 3.6V, supply current ≥ 500 mA
Interface	UART/GPIO/ADC/PWM/I2C/SPI
IO	15
UART rate	Default 115200 bps
Security	WPS/WEP/WPA/WPA2 Personal/WPA2 Enterprise/WPA3
Flash	Default 4MByte

2.1. Static electricity requirement

Ai-WB2-12F is an electrostatic sensitive device. Therefore, you need to take special precautions when carrying it.



Figure 2 ESD preventive measures

2.2. Electrical characteristics

Table 2 Electrical characteristics table

Parameters		Conditio	Min.	Typical value	Max.	Unit
Power Supply		VDD	2.7	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 Rf Performance

Table 3 Wi-Fi RF performance table

Description	Typical value			Unit
spectral range	2400 ~ 2483.5MHz			MHz
Output Power				
Model	Min.	Typical	Max.	Unit
11n Model HT20, PA output power	-	16	-	dBm
11g Model, PA output power	-	17	-	dBm
11b Model, PA output power	-	19	-	dBm
Receive Sensitivity				
Model	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

2.4. BLE Rf Performance

Table 4 BLE RF performance table

Description	Typical value			Unit
spectral range	2400 ~ 2483.5MHz			MHz
Output Power				
Rate Mode	Min.	Typical	Max.	Unit
1Mbps	-	9	15	dBm
Receive Sensitivity				
Rate Mode	Min.	Typical	Max.	Unit
1Mbps sensitivity@30.8%PER	-	-96	-	dBm

2.5. Power

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

- All measurements are made at the antenna interface with a filter.
- All launch data are measured in a sustained launch mode based on a 100% duty cycle.

Table 5 Power consumption table

Model	Min.	AVG	Max.	Unit
Transmission 802.11b, 11Mbps, POUT=+21dBm	-	260	-	mA
Transmission 802.11g, 54Mbps, POUT	-	245	-	mA
Transmission 802.11n, MCS7, POUT	-	230	-	mA
Receive 802.11b, packet Length 1024 byte	-	65	-	mA
Receive 802.11g, packet Length 1024 byte	-	65	-	mA
Receive 802.11n, Packet Length 1024 byte	-	65	-	mA
Deep-Sleep	-	12	-	μA

3. Appearance Dimensions

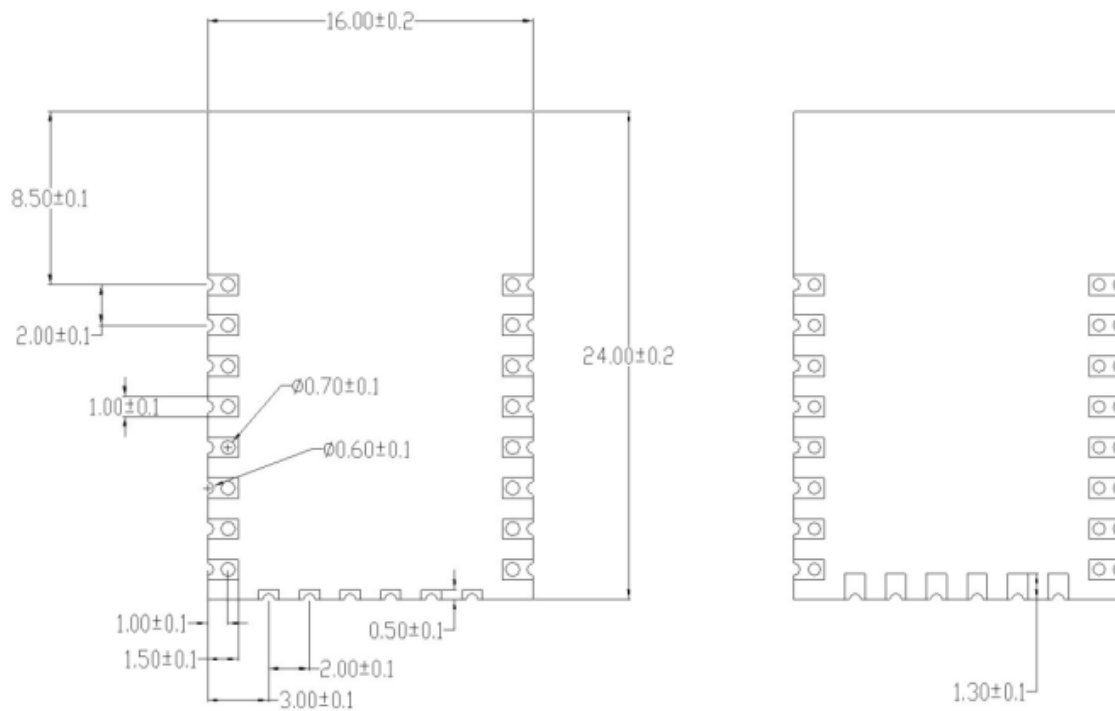
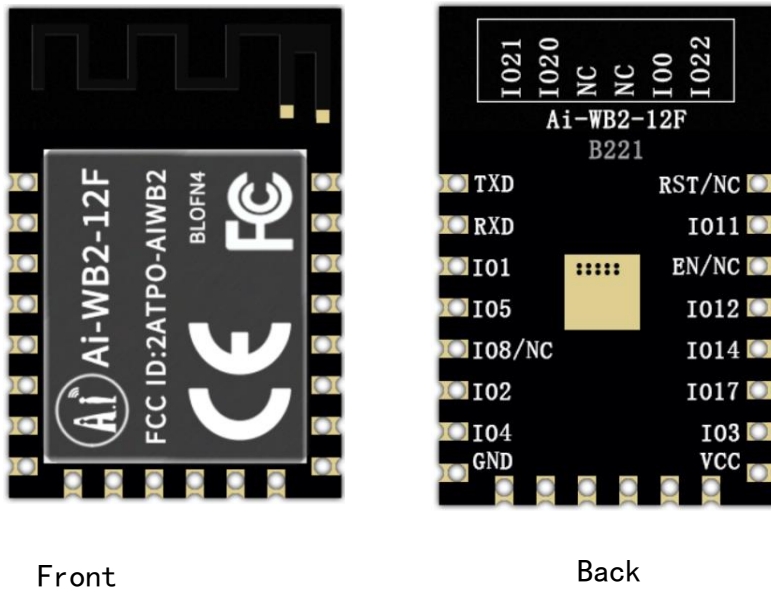


Figure 3 Appearance diagram pictures is for reference only,subject to physical objects)

Front

Back

Figure 4 Dimension diagram

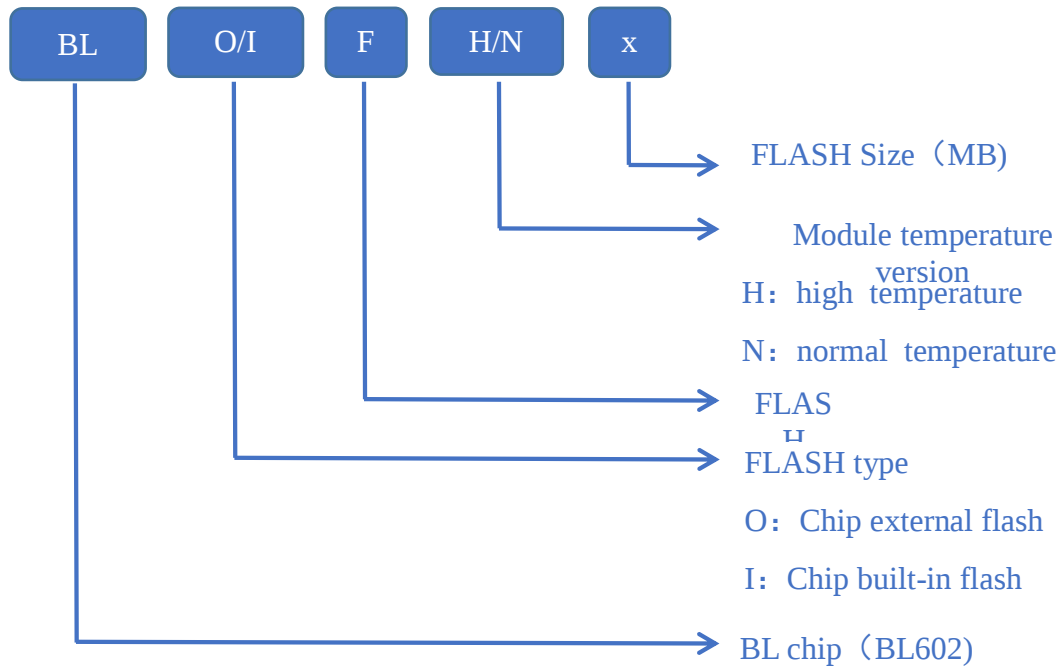


Figure 5. Naming of module screen cover

4. Pin Definition

Ai-WB2-12F module is connected with a total of 22 pins, as shown in the pin schematic diagram, pin function definition table is the interface definition.

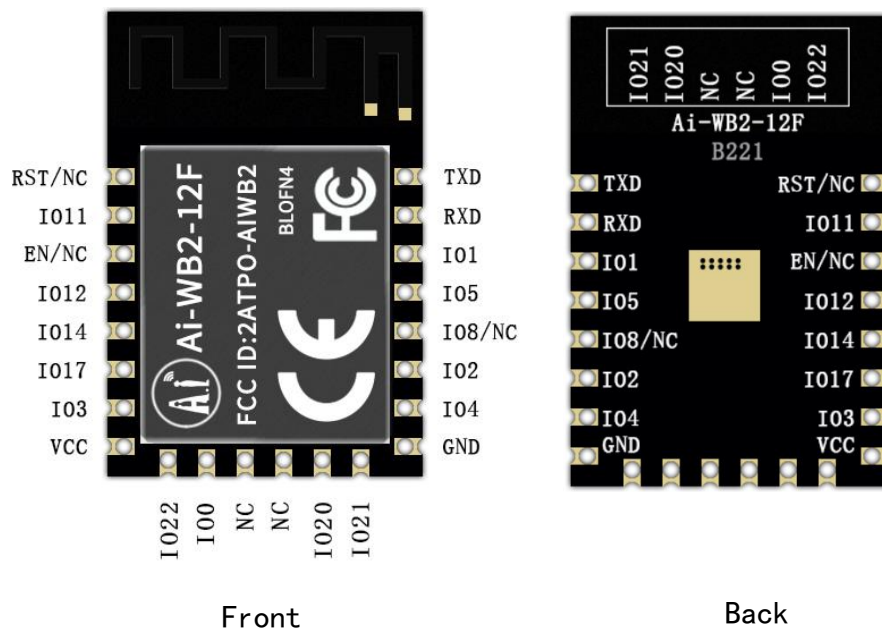


Figure 6 Schematic diagram of module pins

Table 6 Pin function definition table

No.	Name	Function
1	RST/NC	Default hanging, can be customized to reset pin, low level is effective, if you need to
2	IO11	GPIO11/SPI_SC LK/IIC_SDA/ADC_CH10
3	EN/NC	This function is enabled by default as a chip, active at high level, and cannot be used at
4	IO12	GPIO12/SPI_MOSI/MISO/IIC_SCL/PWM_CH2/ADC_CH0
5	IO14	GPIO14/SPI_SS/IIC_SCL/PWM_CH4/ADC_CH2
6	IO17	GPIO17/SPI_MOSI/MISO/IIC_SDA/PWM_CH2
7	IO3	GPIO3/SPI_SCLK/IIC_SDA/PWM_CH3
8	VCC	3.3V power supply; It is recommended that the output current of the external power
9	IO22	It is not recommended to use. It is shared with the Flash in the module. If you need to use it, please contact Ai-Thinker.
10	IO0	It is not recommended to use. It is shared with the Flash in the module. If you need to use it, please contact Ai-Thinker. GPIO0/SDIO_CLK//SPI_MOSI/MISO/IIC_SCL/PWM_CH0/JTAG_TMS/TCK
11	NC	NC
12	NC	NC
13	IO20	It is not recommended to use. It is shared with the Flash in the module. If you need to use it, please contact Ai-Thinker.
14	IO21	It is not recommended to use. It is shared with the Flash in the module. If you need to use it, please contact Ai-Thinker. GPIO21/SPI_MOSI/MISO/IIC_SDA/PWM_CH1/JTAG_TDI/TDO
15	GND	Ground
16	IO4	GPIO4/SPI_MOSI/MISO/IIC_SCL/PWM_CH4/ADC_CH4
17	IO2	It is not recommended to use. It is shared with the Flash in the module. If you need to use it, please contact Ai-Thinker. GPIO2/SPI_SS/IIC_SCL/PWM_CH2
18	IO8/NC	Default NC, unavailable
19	IO5	GPIO5/SPI_MOSI/MISO/IIC_SDA/PWM_CH0/ADC_CH4
20	IO1	It is not recommended to use. It is shared with the Flash in the module. If you need to use it, please contact Ai-Thinker. GPIO1/SPI_MOSI/MISO/IIC_SDA/PWM_CH1
21	RXD	RXD/GPIO7/SPI_SCLK/IIC_SDA/PWM_CH2
22	TXD	TXD/GPIO16/SPI_MOSI/MISO/IIC_SCL/PWM_CH1

5. Schematic

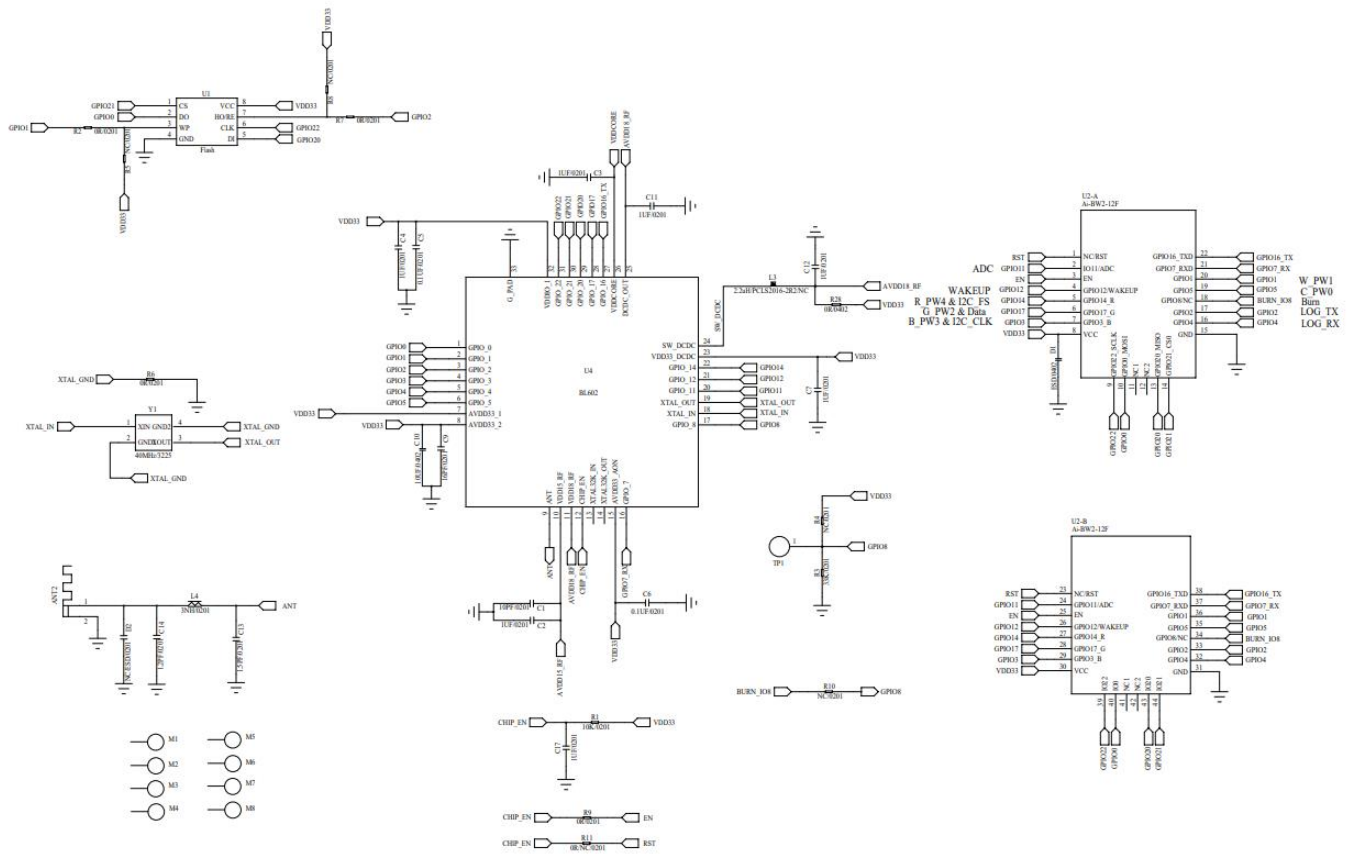


Figure 7 Module schematic

6.2. Antenna S parameter

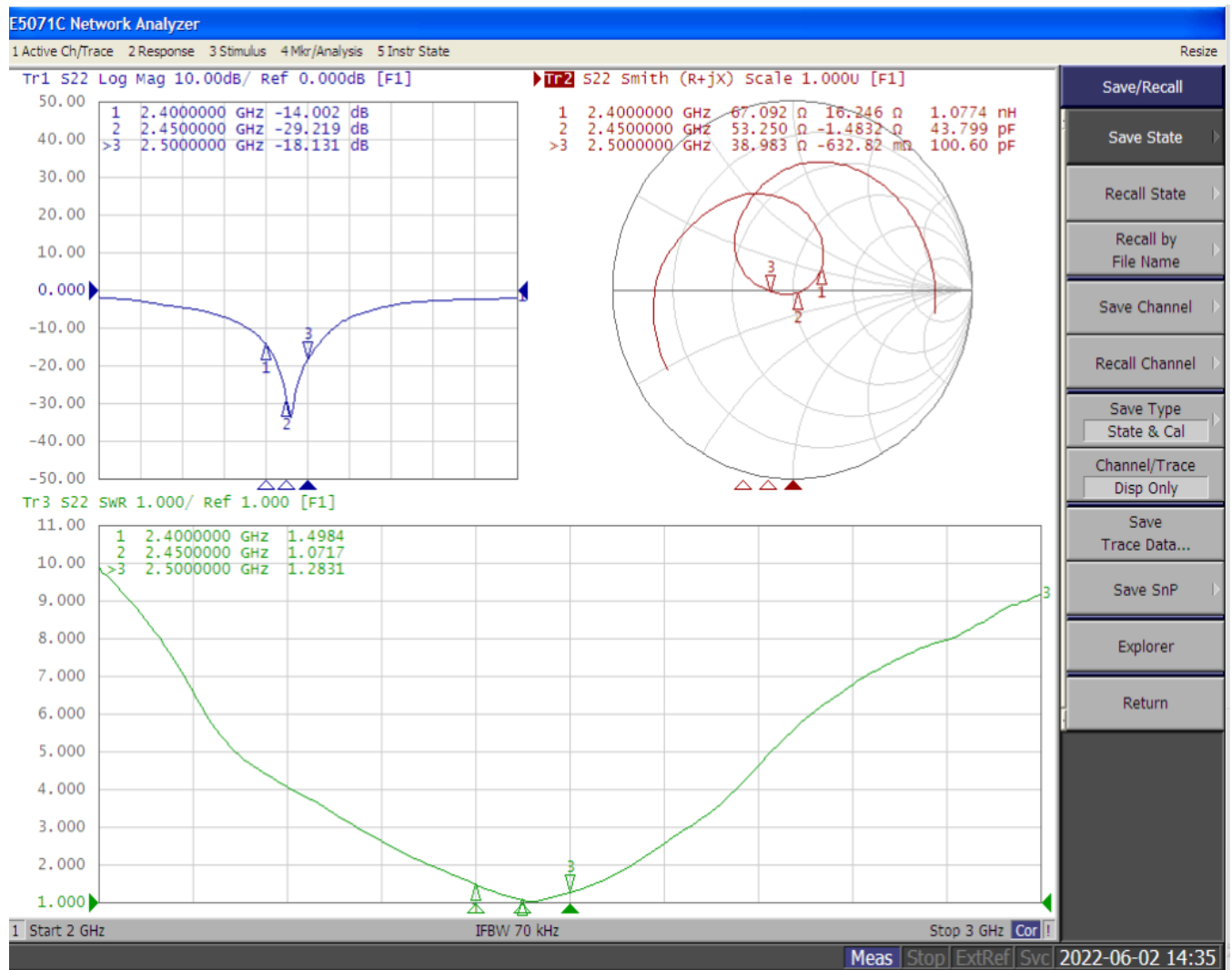


Figure 9 Antenna S parameters

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)	2.46	2.41	2.03	1.88	1.46	1.73	1.79	1.76	1.66	1.22	1.07
Efficiency (%)	61.00	62.04	60.03	62.22	58.96	64.17	63.83	62.07	60.04	54.27	52.93

6.4. Antenna Field Type Diagram

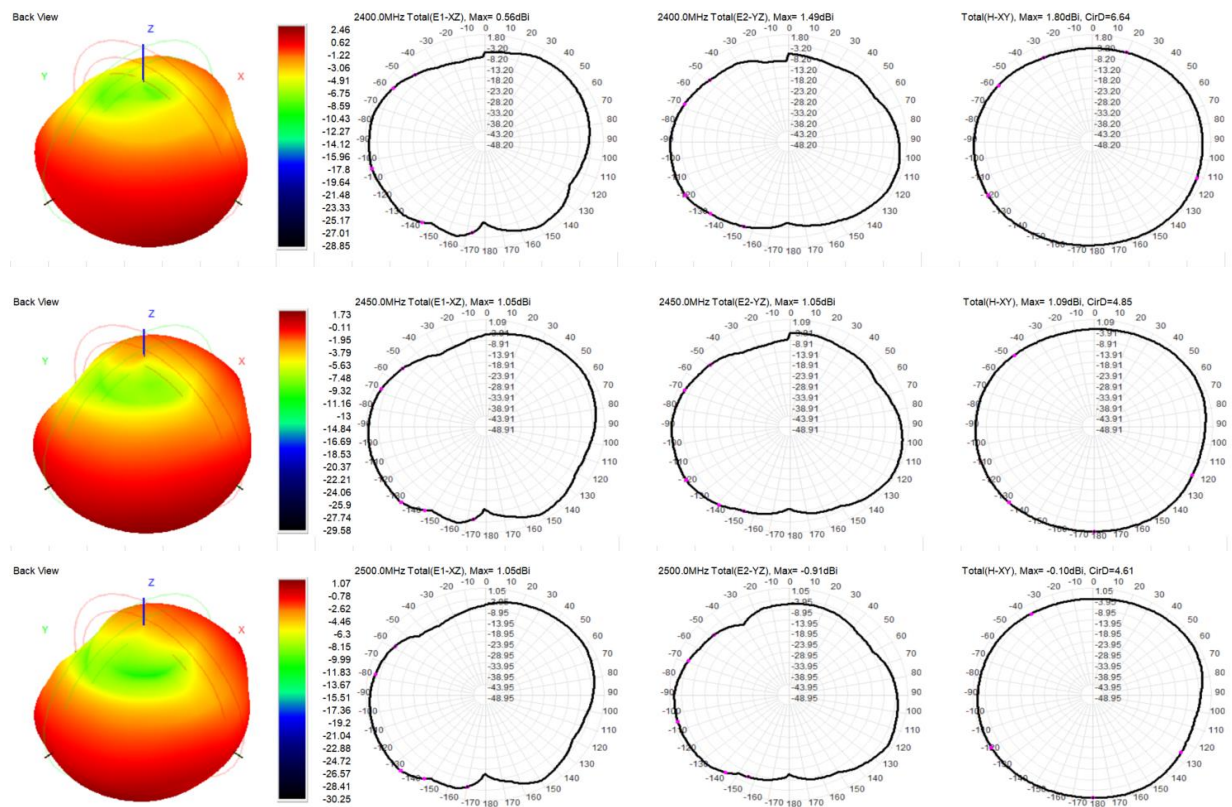


Figure 10 Antenna field type diagram

7. Design Guidance

7.1. Module application circuit

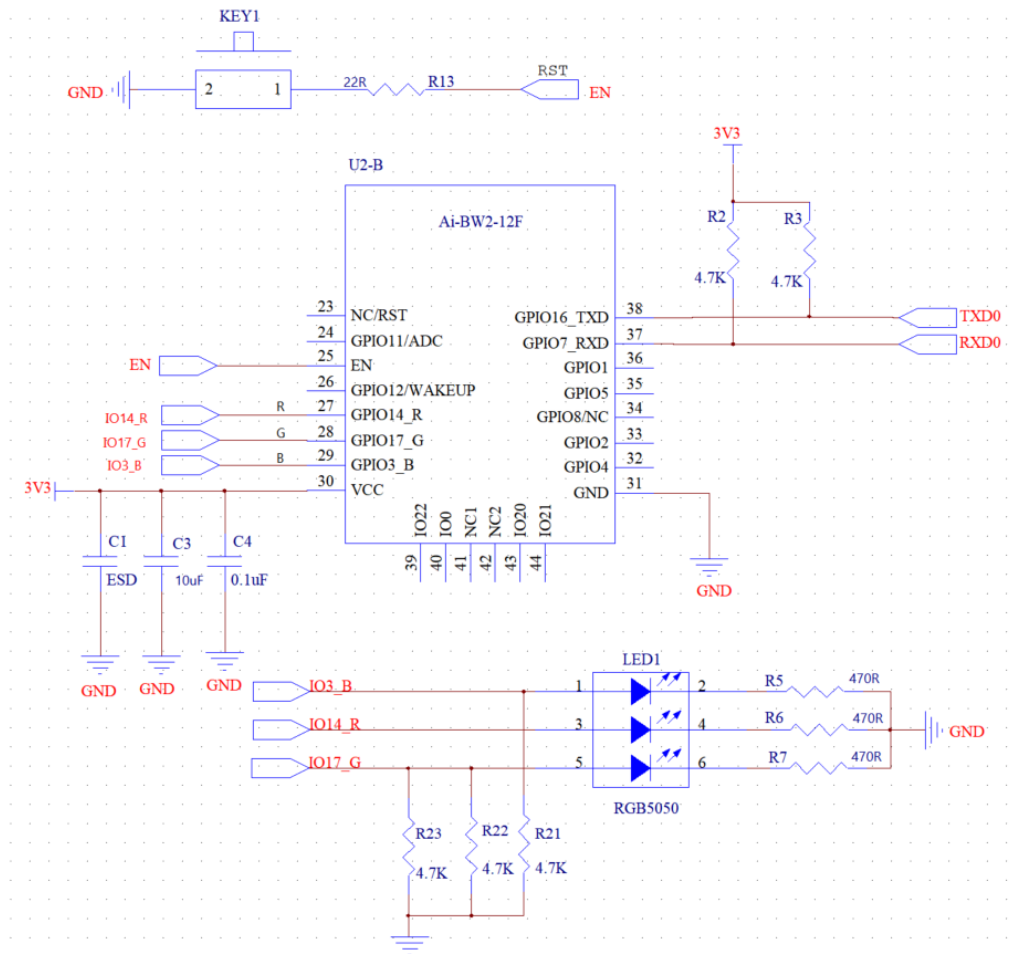


Figure 11 Application circuit diagram

- If the IO port is used as PWM, it is recommended to reserve a 4.7K pull-down resistor around the module. In particular, the application of the light control side can prevent the flash phenomenon when the power on starts.

7.2. Antenna layout requirements

- The following two methods are recommended for the installation position on the mainboard:
 - Plan one: put the module on the edge of the motherboard, and the antenna area extends out of the edge of the motherboard.
 - Plan two: put the module on the edge of the motherboard, the edge of the motherboard at the antenna position hollowed out an area.

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

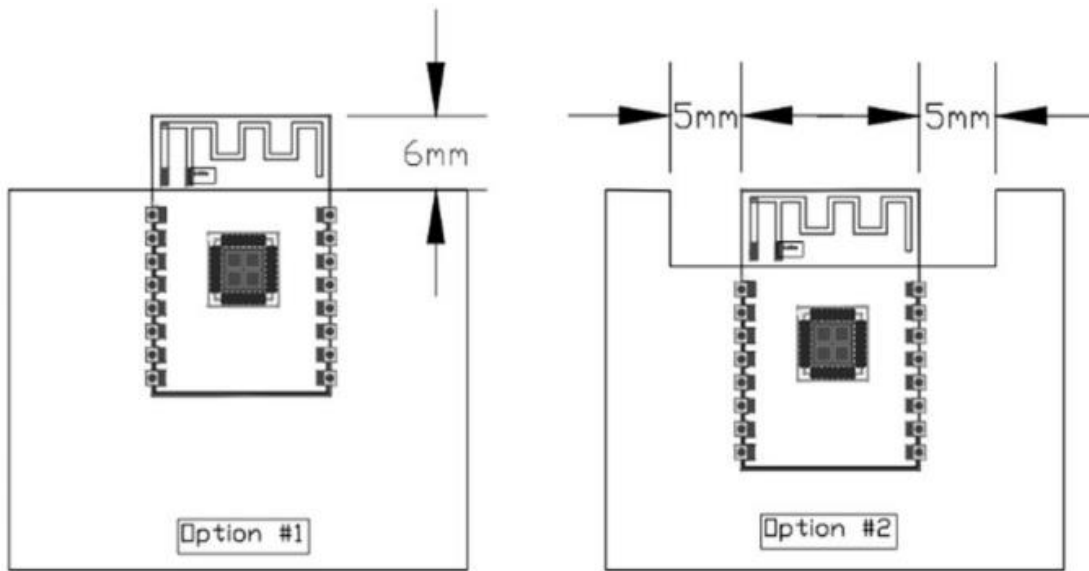


Figure 12 Antenna layout diagram

7.3. Power supply

- Recommended 3.3V voltage, peak current over 500mA.
- Power supply is recommend to use LDO; If the DC-DC is used, the ripple is recommended to be controlled within 30mV
- DC-DC power supply circuit proposes to reserve the dynamic response capacitance to optimize the output ripple with large load changes.
- 3.3V power interface it is recommended to add ESD devices.

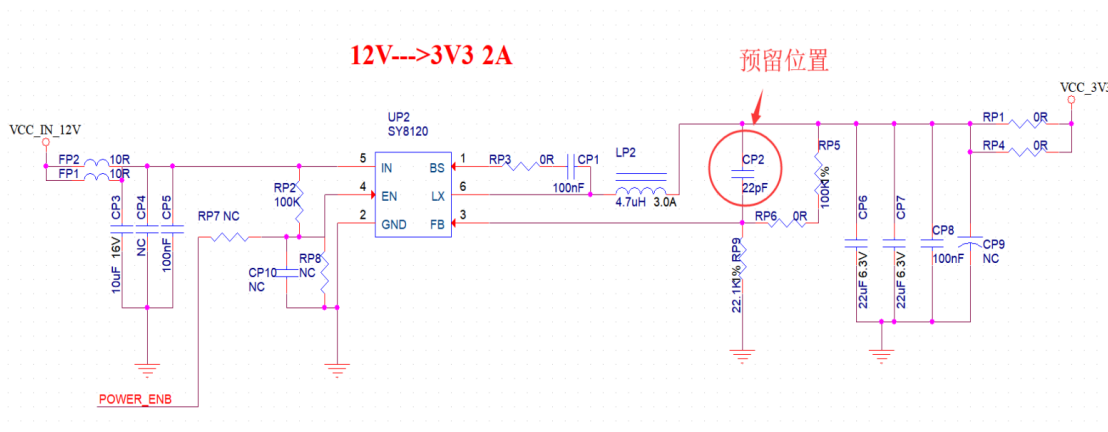


Figure 13 Dc-dc step-down circuit diagram

7.4. GPIO

- Some I/O ports are introduced outside the module. If necessary, it is recommended to use a resistor of 10–100 ohms in series on the I/O ports. This inhibits overshoot and makes both sides level more stable. It is helpful for EMI and ESD.
- For special I/O ports to be pulled up and down, refer to the usage instructions in the specifications, which may affect the module startup configuration.
- The I/O port of the module is 3.3V. If the I/O level of the main control and the module do not match, a level conversion circuit needs to be added.
- If the I/O port is directly connected to a peripheral port or terminals, for example, a pin row, reserve an ESD device near the terminal of the I/O cable.

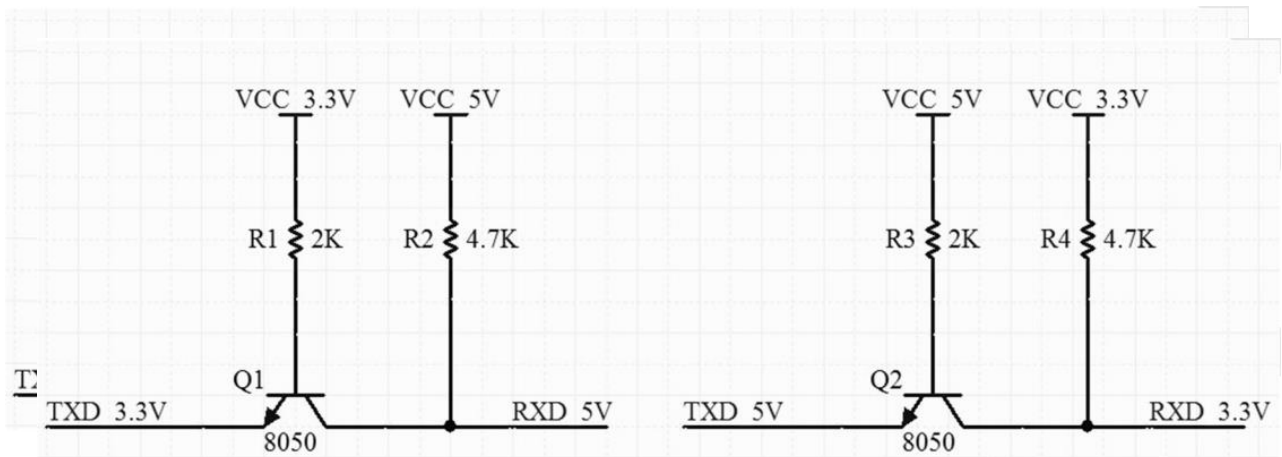


Figure 14 Level convert circuit

8. Storage conditions

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

The module has a moisture sensitivity rating of MSL 3.

After the vacuum bag is opened, 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. Flow welding curve diagram

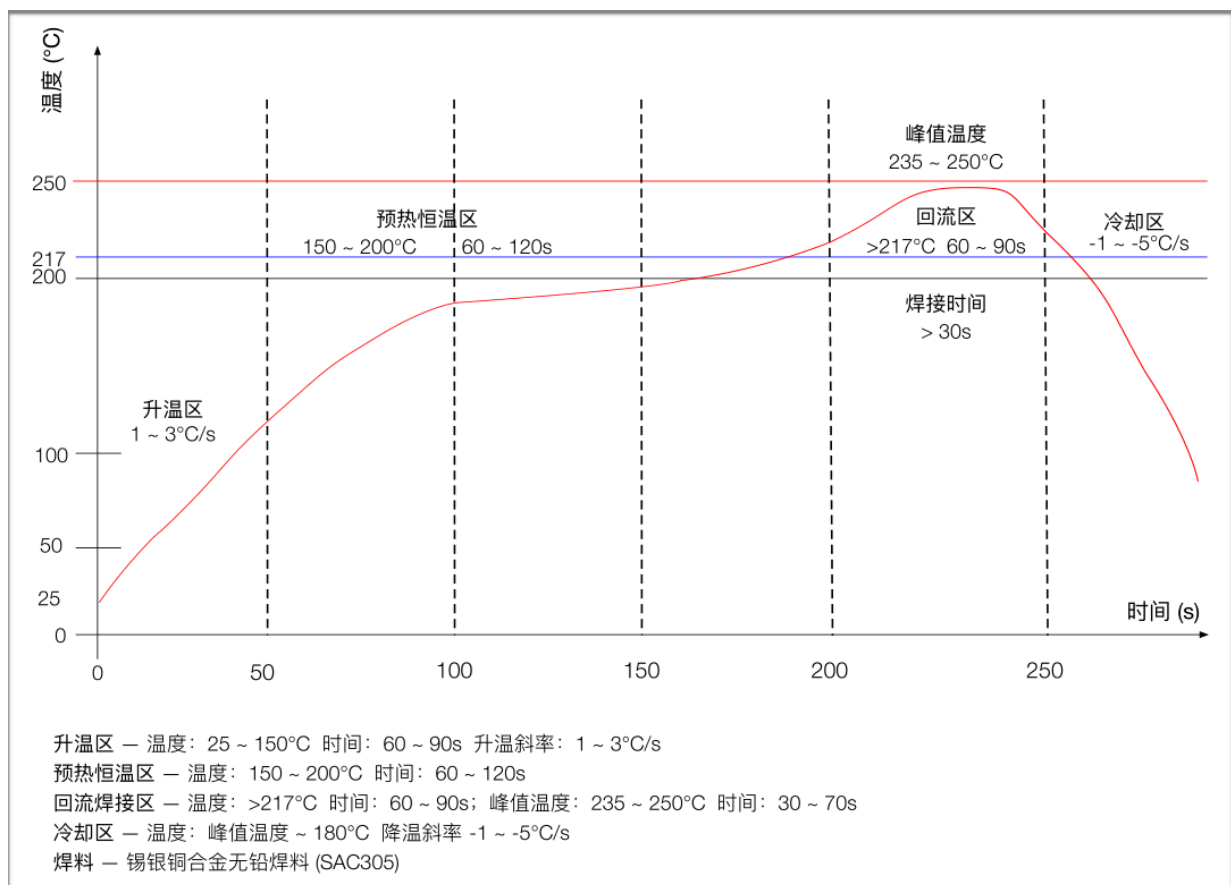


Figure 15 Flow welding diagram

10. Product related models

Table 8 Product related model list

Model	Power Supply	Package	Size	Antenna
Ai-WB2-12S	2.7V ~ 3.6V, $I \geq 500\text{mA}$	SMD-16	24.0*16.0*3.1 $\pm$ 0.2)mm	on-board PCB antenna
Ai-WB2-12F	2.7V ~ 3.6V, $I \geq 500\text{mA}$	SMD-22	24.0*16.0*3.1 $\pm$ 0.2)mm	on-board PCB antenna
Ai-WB2-07S	2.7V ~ 3.6V, $I \geq 500\text{mA}$	SMD-22	17.0*16.0*3.1 $\pm$ 0.2)mm	IPEX interface
Ai-WB2-12F	2.7V ~ 3.6V, $I \geq 500\text{mA}$	SMD-18	20.0*18.0*3.1 $\pm$ 0.2)mm	on-board PCB antenna
Ai-WB2-12FU	2.7V ~ 3.6V, $I \geq 500\text{mA}$	SMD-18	14.0*18.0*3.1 $\pm$ 0.2)mm	IPEX interface
Ai-WB2-32S	2.7V ~ 3.6V, $I \geq 500\text{mA}$	SMD-38	25.5*18.0*3.1 $\pm$ 0.2)mm	Default onboard PCB antenna/compatible IPEX interface
Ai-WB2-01M	2.7V ~ 3.6V, $I \geq 500\text{mA}$	DIP-18	18.0*18.0*2.8 $\pm$ 0.2)mm	on-board PCB antenna
Ai-WB2-12F-Kit	3.3V 或 5V, $I > 500\text{mA}$	DIP-30	49.66*25.4($\pm$ 0.2)mm	on-board PCB antenna
Ai-WB2-12F-Kit	3.3V 或 5V, $I > 500\text{mA}$	DIP-30	49.66*25.4($\pm$ 0.2)mm	on-board PCB antenna
Ai-WB2-32S-Kit	3.3V 或 5V, $I > 500\text{mA}$	DIP-38	55.05*25.4($\pm$ 0.2)mm	on-board PCB antenna
Product related information : https://docs.ai-thinker.com				

11.Product Packaging Information

Ai-WB2-12F module was packaged in a tape, 800pcs/reel.As shown in the below image:



Figure 15 Package and packing diagram

12.Contact us

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Due to product version upgrades or other reasons, the contents of this manual may be changed.

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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 “2ATPO-AIWB2”

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.³

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 1dBi

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-AIWB2

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 1dBi

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-AIWB2

2.9 Information on test modes and additional testing requirements⁵

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: Ningde lingyang Electronic 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.