Ra-09H Specification

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Document Resume

Version	Date	Develop/revise content	Edition	Approve
V1.0.0	2024.01.11	First Edition	Shengzin Zou	Ning Guan

Content

1. Product Overview

Ra-09H is a LoRa module designed and developed by Shenzhen Ai-Thinker Technology Co., Ltd. This module is used for ultra-long distance spread spectrum communication. Its chip STM32WLE5CCU6 is a general-purpose LPWAN wireless communication SoC that integrates RF transceivers, modems and 32 -bit Arm® Cortex®-M4 MCU. The MCU uses an ARM core and operates at a frequency of up to 48MHz. The Ra-09H module supports LoRa modulation and traditional (G)FSK modulation under LPWAN use cases; at the same time, the transmitter also supports BPSK modulation and (G)MSK modulation, and the receiver supports (G)MSK modulation.

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

Figure 1 Main chip architecture diagram

1.1. **Characteristic**

■ SMD- 48 package

■ Supported frequency bands: 903MHz-927MHz

■ Working voltage is 3.3V, theoretical maximum transmit power +20dBm

■ High sensitivity: -140dBm @125K H z SF12

■ Support spreading factor SF5/SF6/SF7/SF8/SF9/SF10/SF11/SF12

■ Embedded memory, 256KB FLASH, 64KB RAM

■ The antenna interface is a half-hole pad and IPEX connector, which supports a variety of external antenna connection methods and supports more solution selections.

■ Supports multiple sleep modes: deep sleep current 0.1μ A

2. Main Parameters

Table 1 Description of Main Parameters

Module Model	Ra-09H
Package	SMD-48
Size	18.0*18.0* 2.6 (±0.2)mm
Antenna Form	Compatible with half-hole pad/IPEX connector
Frequency Range	903-927MHz
Operating Temperature	-40℃~85℃
Storage Environment	-40 ℃ ~ 125 ℃ , < 90%RH
Power supply range	Supply voltage 1.8 V ~ 3.6V, supply current >500mA
Support interface	UART/GPIO/ADC/DAC/I2C/I2S/SPI/PWM
IO	24
Serial port speed	Support 110 ~ 4608000 bps, default 9600bps
Crystal frequency	32MHz
Flash	256 KB
Transfer Protocol	LoRaWAN
Transmission distance	Open space with suction cup antenna can reach 4.8km

2.1. Static Electricity Requirements

Ra-09H module is an electrostatic sensitive device and requires special precautions when handling.

Figure 2 ESD preventive measures

2.2. Electrical Characteristics

Table 2 Electrical Characteristics Table

Parameter	Name		Min.	Typ.	Max.	Unit	Remark
Operating	TOPR		-40	25	85	℃	
Supply voltage	VDD		1.8	3.3	3.6	V	≥3.3V guarantees output power
Power consumption	Sleep mode	Power consumption1	-	0.113	-	μA	Deep Sleep (LDO and SMPS regulator off, MCU regulator off)
		Power consumption 2	-	0.2	-	μA	STANDBY (without RTC)
	Operating mode		-	3.83	-	mA	Power on
	Full load mode（TX:22dBm）		-	11 9	-	mA	DC-DC mode
	receive mode (RX:SF9)		-	5.15	-	mA	DC-DC mode

2.3. Digital Port Characteristics

Table 3 Digital Ports

Type	Name	Minimum value	Typical value	Maximum value	unit
IO level (VDD)	VIO	1.8	3.3	3.6	V
Input logic level is low	VIL	-	-	VDD*0.3	V
Input logic level is high	VIH	0.7*VDD	-	-	V
Output logic level is low	VOL	-	-	0.4 (| IO| = 8 mA, VDD ≥ 2.7 V)	V
Output logic level is low	VOL	-	-	1.3 (|IO | = 20 mA, VDD ≥ 2.7 V)	V
Output logic level is high	VOH	VDD-0.45	-	-	V

2.4. RF Parameters

Table 4 RF parameters

Output Power					
PA parameters	**Frequency band**	**Minimum value**	**Typical value**	**Maximum value**	**Unit**
Transmit power	870MHz	-	2 0.5	twenty two	dBm
Transmit power	890MHz	-	2 0.5	twenty two	dBm
Transmit power	91 0MHz	-	2 0.5	twenty two	dBm
Transmit power	925MHz	-	2 0.5	twenty two	dBm
Receive Sensitivity Modulation bandwidth 125kHz					
Model		**Minimum value**	**Typical value**	**Maximum value**	**Unit**
SF7		-	-123	-	dBm
SF8		-	-126	-	dBm
SF9		-	-128	-	dBm
SF10		-	-131	-	dBm
SF11		-	-135	-	dBm
SF12		-	-1 40	-	dBm

3. Dimension

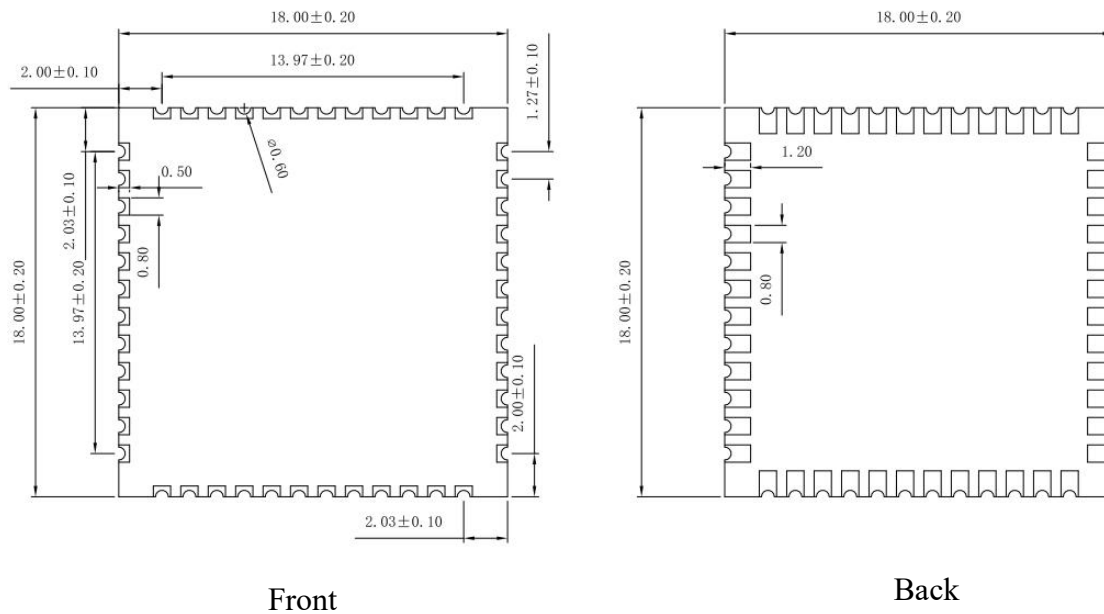Front   Back

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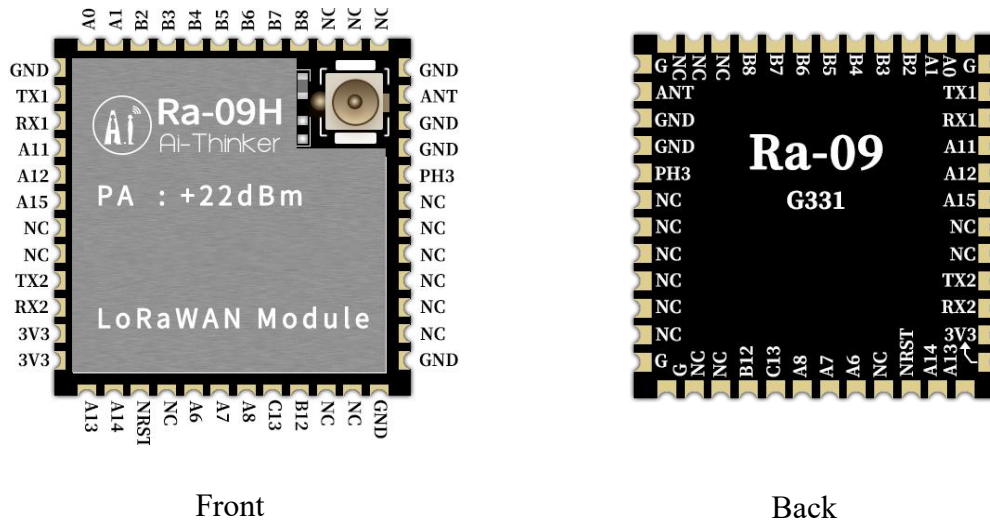

Front   Back

Figure 4 Module size diagram

4. Pin Definition

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

Front   Back

Figure 5 Module pin diagram

Table 5 Module startup mode description

System startup mode			
Pin	**Default**	**SPI boot mode**	**Download boot mode**
PH3	drop down	0	1

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

Table 6 Pin function definition table

Pin	Name	Function Description
1, 2, 3, 19, 20, 28 , 34, 35, 38-43	NC	Not connected
4	PB8	PB8/I2C1_SCL/PWM
5	PB7	PB7/I2C1_SDA
6	PB6	PB6/I2C1_SCL
7	PB5	PB5/SPI1_MOSI
8	PB4	PB4/SPI1_MISO/ADC_IN3
9	PB3	PB3/ADC_IN2/SPI1_SCK
10	PB2	PB2/SPI1_NSS/ADC_IN4
11	PA1	PA1/SPI1_SCK
12	PA0	PA0
13，36-37，45-46，48	GND	Ground
14	TX1	PA9/UART1_TX/I2C1_SCL/SPI2_SCK/I2S2_CK
15	RX1	PA10/UART1_RX/DAC_OUT1/ADC_IN6/I2C1_SDA
16	PA11	PA11/I2C2_SDA/SPI1_MISO/PWM/ADC_IN7
17	PA12	PA12/I2C2_SCL/SPI1_MOSI/ADC_IN8
18	PA15	PA15/I2C2_SDA/SPI1_NSS/ADC_IN11
21	TX2	PA2/UART2_TX
22	RX2	PA3/ UA RT2_RX/I2S2_MCK
23-24	3V3	3.3V power supply, recommended power supply current
25	PA13	PA13/ADC_IN9
26	PA14	PA14/ADC_IN10
27	NRST	NRST external reset, active low
29	PA6	PA6/SPI1_MISO
30	PA7	PA7/I2C3_SCL/SPI1_MOSI/PWM
31	PA8	PA8/SPI2_SCK/I2S2_CK
32	PC13	PC13
33	PB12	PB 12/SPI2_NSS/I2S2_WS
4 4	PH3	PH3/BOOT0
47	ANT	Antenna interface

6. Design Guidance

6.1. Module Application Circuit Guidance

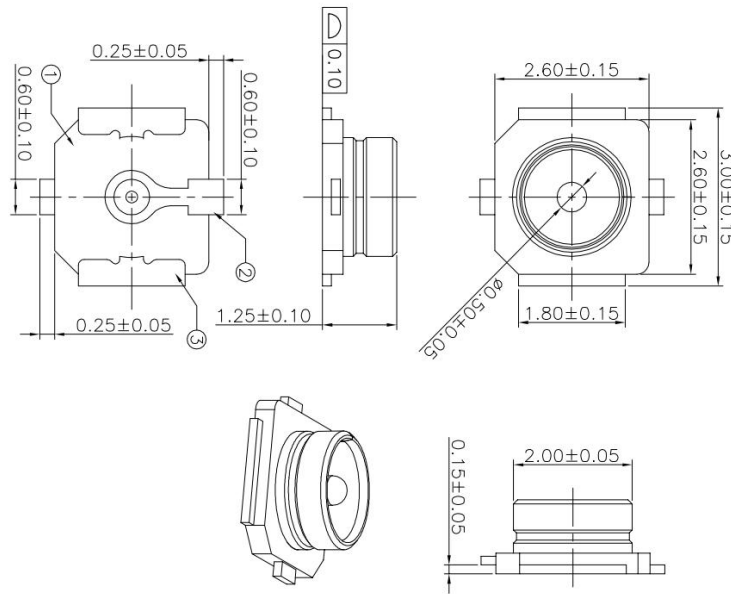(It is recommended to use DC-DC or LDO for independent power supply, with a current greater than 500mA)

Figure 7 Application circuit diagram

Notice:

■ PH3 is the startup control pin. It is in the normal working mode when the level is low, and it is in the firmware burning mode when the level is high. The chip internal default is low level.

6.2. Antenna Interface

■ The Ra-09H module requires an external antenna. The antenna has two wiring methods, which are compatible with half-hole pads and IPEX sockets. The module has a standard IPEX socket interface. The dimensions of the IPEX seat are as follows:

Figure 8 Dimensional drawing of the IPEX seat at the board end

6.3. Power Supply

■ Recommended voltage is 3.3V, peak current is 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 dynamic response capacitor in 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 9 DC-DC step-down circuit diagram

6.4. Use of GPIO port

■ 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 to the IO port. This can suppress overshoot and make the levels on both sides more stable. Helps with both EMI and ESD.

■ For the up and down pull-down of the special IO port, please refer to the instructions in the specification sheet, which will affect the startup configuration of the module.

■ The IO port of the module is 3.3V. If the level of the main control and the IO port of the module do not match, a level conversion circuit needs to be added.

■ If the IO port is directly connected to a peripheral interface or a terminal such as a pin header, it is recommended to reserve ESD devices near the terminals in the IO port wiring.

Figure 10 Level conversion circuit

7. FAQ

7.1. Factors Affecting Transmission Distance

(1) When there are straight-line communication obstacles, the communication distance will be correspondingly attenuated;

(2) Temperature, humidity, and co-channel interference will cause the communication packet loss rate to increase;

(3) The ground absorbs and reflects radio waves, and the test effect is poor when close to the ground;

(4) Seawater has a strong ability to absorb radio waves, so the seaside test results are poor;

(5) If there are metal objects near the antenna, or if it is placed in a metal case, the signal attenuation will be very serious;

(6) The power register setting is wrong and the air rate is set too high . The higher the air rate, the closer the distance;

(7) The low voltage of the power supply at room temperature is lower than the recommended value. The lower the voltage, the smaller the transmit power;

(8) There is a poor match between the antenna and the module or there is a quality problem with the antenna itself .

7.2. Precautions for using the module

(1) Check the power supply to ensure that it is within the recommended power supply voltage. If it exceeds the maximum value, it will cause permanent damage to the module;

(2) Check the stability of the power supply. The voltage cannot fluctuate greatly and frequently;

(3) Ensure anti-static operation during installation and use, and high-frequency devices are electrostatically sensitive;

(4) Ensure that the humidity during installation and use should not be too high, as some components are humidity-sensitive devices;

(5) If there are no special needs, it is not recommended to use it at too high or too low temperature .

7.3. Factors causing interference to the module

(1) If there is co-channel signal interference nearby, stay away from the interference source or modify the frequency or channel to avoid interference;

(2) The clock waveform on SPI is not standard. Check whether there is interference on the SPI line. The SPI bus line should not be too long;

(3) Unsatisfactory power supply may also cause garbled code, so be sure to ensure the reliability of the power supply;

(4) Poor quality or too long extension cords and feeders can also cause a high bit error rate .

8. Storage Conditions

Products sealed in moisture-proof bags should be stored in a non-condensing atmospheric environment <40℃/90%RH.

The module's moisture sensitivity level MSL is level 3.

After the vacuum bag is unsealed, it must be used within 168 hours at 25±5℃/60%RH, otherwise it will need to be baked before it can be put online again.

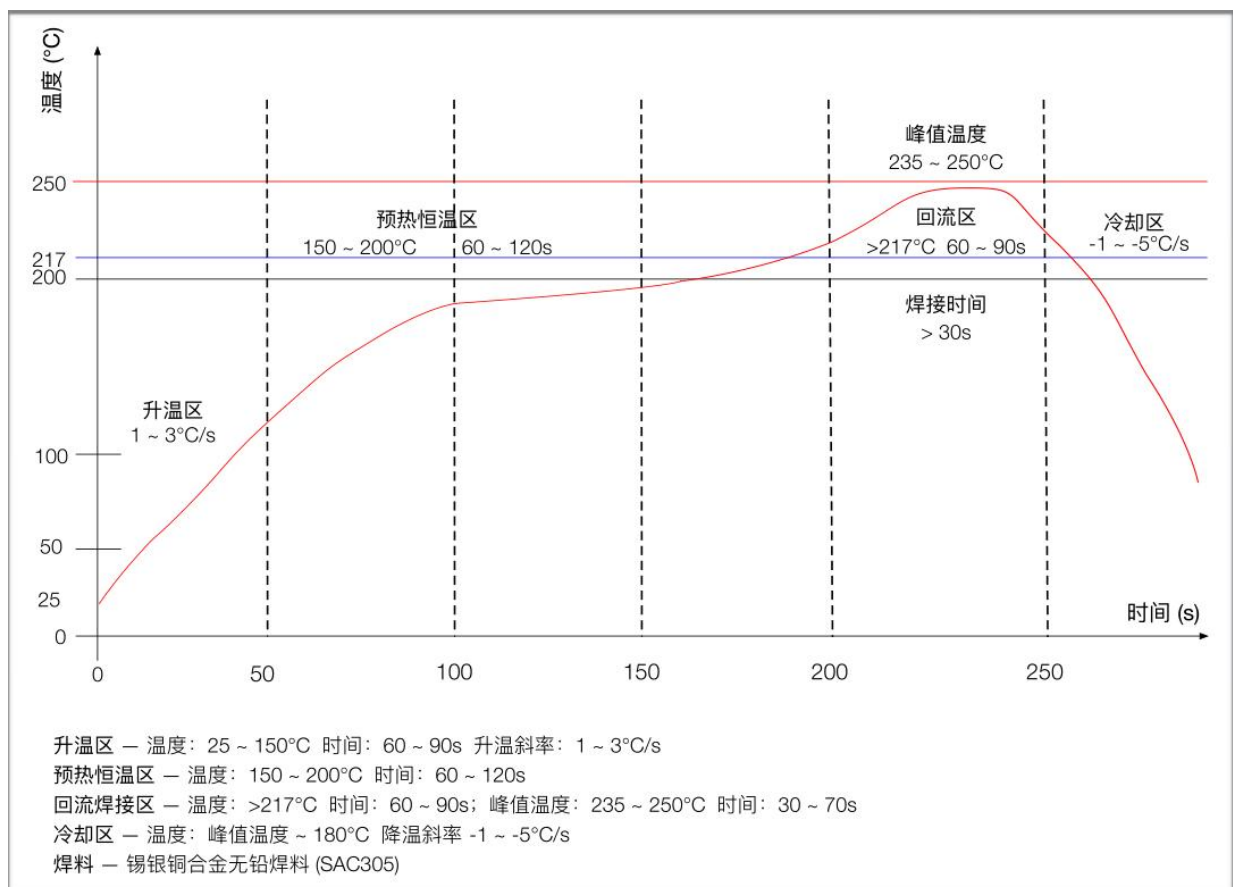# 9. Reflow Soldering Curve

Figure 11 Reflow soldering curve

10.Product Packaging Information

Ra-09H module is packed in tape, 900pcs/tray. As shown below:

Figure 12 Packaging and taping diagram

11.Contact Us

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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 uncon-
trolled environment. This equipment should be installed and operated with minimum
distance 20cm 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-RA09H"

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 alsoSection 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.

Explanation: The product antenna uses an Glue stick antenna with a gain of 0.94dBi

2.4 Single Modular

If a modular transmitter is approved as a "Single Modular," then the module manufacturer isresponsible 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-RA09H

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 0.94dBi

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-RA09H

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: 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 circuity), 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 circuity, so the module does not require an evaluation by FCC Part 15 Subpart B. The host shoule be evaluated by the FCC Subpart B.