



Ra-09 Specification

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Document resume

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1. Product Overview

Ra-09 is a LoRa module designed and developed by Shenzhen Ai-Thinker Technology Co., Ltd., which is used for ultra-long-distance spread spectrum communication. Its chip STM32WLE5CCU6 is a general-purpose LPWAN wireless communication SoC that integrates a radio frequency transceiver, a modem and a 32-bit Arm® Cortex®-M4 MCU. The MCU adopts ARM core, and its operating frequency can reach 48MHz. The Ra-09 module supports

The Ra-09 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

- Adopt SMD-48 package
- Support frequency: 411MHz-525MHz
- Working voltage is 3.3V, and the theoretical maximum transmit power
- High sensitivity: -140dBm @125KHz SF12
- Support spread spectrum factor SF5/SF6/SF7/SF8/SF9/SF10/SF11/SF12
- Embedded memory, 256KB FLASH, 64KB RAM
- The antenna interface is a half-hole pad and an IPEX connector, which supports a variety of external antenna connections and supports more program selection
- Support multiple sleep modes: depth sleep current is low to 0.1uA

2. Main parameters

Table 1 Description of the main parameters

Model	Ra-09
Package	SMD-48
Size	18.0*18.0*2.6(±0.2)mm
Antenna	Compatible with half-hole pad /IPEX connector
Frequency	411-525MHz
Operating temperature	-40 °C ~ 85 °C
Storage temperature	-40 °C ~ 125 °C , < 90%RH
Power supply	Voltage 1.8V ~ 3.6V, Current >500mA
Interface	UART/GPIO/ADC/DAC/I2C/I2S/SPI/PWM
IO	24
UART rate	Support 110 ~ 4608000 bps, Default 9600 bps
Crystal frequency	32MHz
SPI Flash	256KB
Transfer Protocol	LoRaWAN
Transmission Distance	The open field is equipped with a sucker antenna 4.8km

2.1. Static electricity requirements

Ra-09 is an electrostatic sensitive device, and special precautions must be taken when handling it.



Figure 2 ESD anti-static diagram

2.2. Electrical characteristics

Table 2 Electrical characteristics table

Parameter	Name		Min.	Typical value	Max.	Unit	Remark
Operating temperature	TOPR		-40	25	85	°C	
Supply voltage	VDD		1.8	3.3	3.6	V	≥3.3V can guarantee output power
Power consumption	Sleep mode	Power consumption 1	-	0.113	-	uA	Deep Sleep(LDO and SMPS regulator off, MCU regulator off)
		Power consumption 2	-	0.2	-	uA	STANDBY(without RTC)
	Operation mode		-	3.83	-	mA	Power on
	Full load mode		-	119	-	mA	DC-DC mode
	Receive mode (RX:SF9)		-	5.15	-	mA	DC-DC mode

2.3. Digital port characteristics

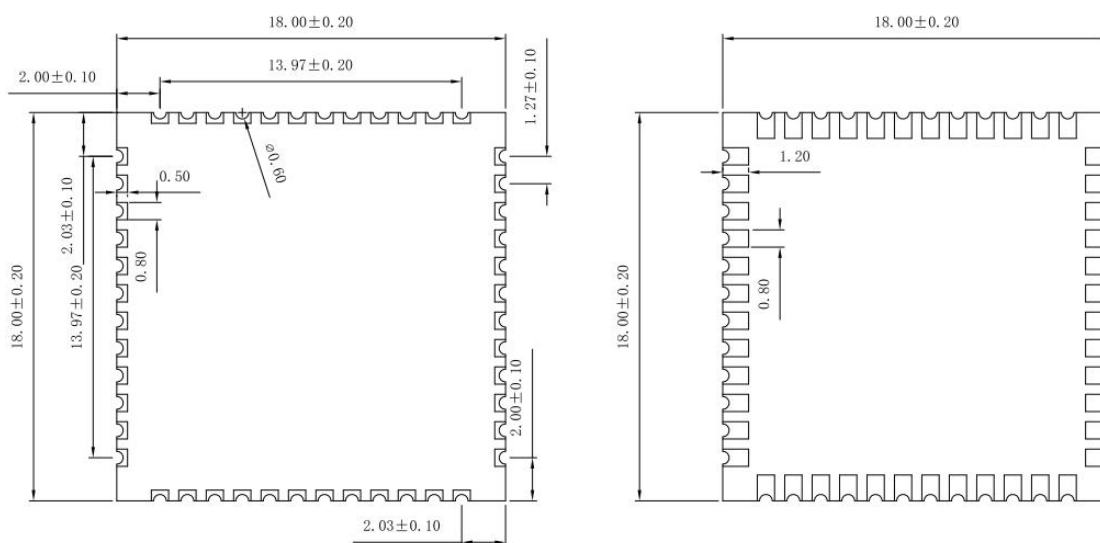
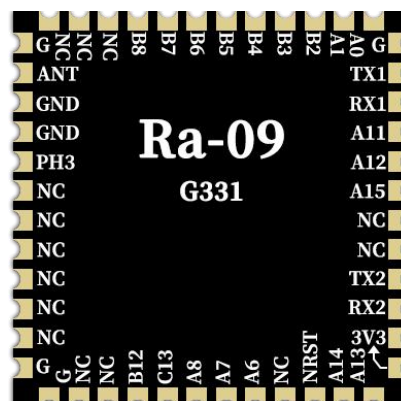
Table 3 Digital port

Type	Name	Min.	Typical value	Max.	Unit
IO level (VDD)	VIO	1.8	3.3	3.6	V
Enter logic level low	VIL	-	-	VDD*0.3	V
Enter logic level high	VIH	0.7*VDD	-	-	V
Enter logic level low	VOL	-	-	0.4 (IO = 8 mA, VDD ≥ 2.7 V)	V
Enter logic level low	VOL	-	-	1.3 (IO = 20 mA, VDD ≥ 2.7 V)	V
Enter logic level high	VOH	VDD-0.45	-	-	V

2.4. RF parameters

Table 4 RF parameters

Output Power					
PA parameter	Frequency band	Min.	Typical value	Max.	Unit
Transmit power	433MHz	-	-	-	dBm
Transmit power	470MHz	-	-	-	dBm
Transmit power	490MHz	-	-	-	dBm
Transmit power	510MHz	-	-	-	dBm
Receive sensitivity modulation bandwidth 125kHz					
Mode		Min.	Typical value	Max.	Unit
SF7		-	-123	-	dBm
SF8		-	-126	-	dBm
SF9		-	-128	-	dBm
SF10		-	-131	-	dBm
SF11		-	-135	-	dBm
SF12		-	-140	-	dBm



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/UART2_RX/I2S2_MCK
23-24	3V3	3.3V power supply, recommended supply
25	PA13	PA13/ADC_IN9
26	PA14	PA14/ADC_IN10
27	NRST	NRST external reset, low power is effective
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	PB12/SPI2_NSS/I2S2_WS
45	PH3	PH3/BOOT0
47	ANT	Antenna interface

Table 6 Module Start Mode Description

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

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

6. Design Guide

6.1. Module Application Guidance Circuit

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

Figure 7 application circuit diagram

Note:

- PH3 is the boot control pin. It is in the normal working mode when it is low level, and it is in the firmware burning mode when it is high level. The default low level inside the chip.

6.2. Antenna Interface

- The Ra-09 module requires an external antenna. There are two wiring methods for the antenna, which are compatible with half-hole pads and IPEX connectors, and the standard IPEX connector interface is left on the module. The size chart of the IPEX connector is as follows:

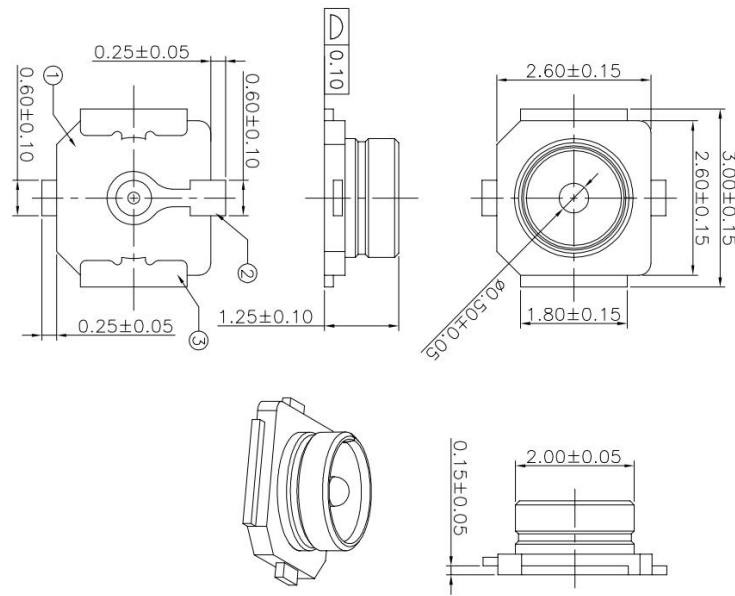


Figure 8 board end IPEX seat size diagram

6.3. Power supply

- Recommend 3.3V voltage, current peak $\geq 500\text{mA}$.
- It is recommended to use LDO power supply; if using DC-DC, it is recommended to control the ripple 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.
- 3.3V power interface suggestion increase ESD devices.

Figure 9 DC-DC step-down circuit diagram

6.4. 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 ports. This can suppress overshoot and make the levels on both sides more stable. Helpful for both EMI and ESD.
- For the pull-up and pull-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 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 the peripheral interface, or terminals such as pin headers, it is recommended to reserve an ESD device near the IO port wiring near the terminal.

Figure 10 Level conversion circuit

7. Common issues

7.1. Effect of transmission distance factors

- (1) When there is a straight-line communication obstacle, the communication distance will be attenuated accordingly;
- (2) Temperature, humidity, and co-frequency interference will increase the communication packet loss rate;
- (3) The ground absorbs and reflects radio waves, and the test effect close to the ground is poor;
- (4) Seawater has a strong ability to absorb radio waves, so the seaside test effect is poor;
- (5) There are metal objects near the antenna, or placed in a metal case, the signal attenuation will be very serious;
- (6) The power register is set incorrectly, the air speed is set too high, the higher the air speed, 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 lower the transmission power;
- (8) The matching degree between the used antenna and the module is poor or the quality of the antenna itself is problematic.

7.2. Attention item for using 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, and 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, and some components are humidity-sensitive devices;
- (5) If there is no special requirement, it is not recommended to use it at too high or too low temperature.

7.3. Factors that cause interference to the module

- (1) There is co-frequency signal interference nearby, stay away from the source of interference or modify the frequency and channel to avoid interference;
- (2) The clock waveform on the SPI is not standard, check whether there is interference on the SPI line, and the SPI bus line should not be too long;
- (3) Unsatisfactory power supply may also cause garbled characters, so be sure to ensure the reliability of the power supply;
- (4) The extension line and feeder line are of poor quality or are too long, which will also cause a high bit error rate.

8. Storage conditions

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

The moisture sensitivity level MSL of the module is 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 online again.

9. Flow welding curve diagram

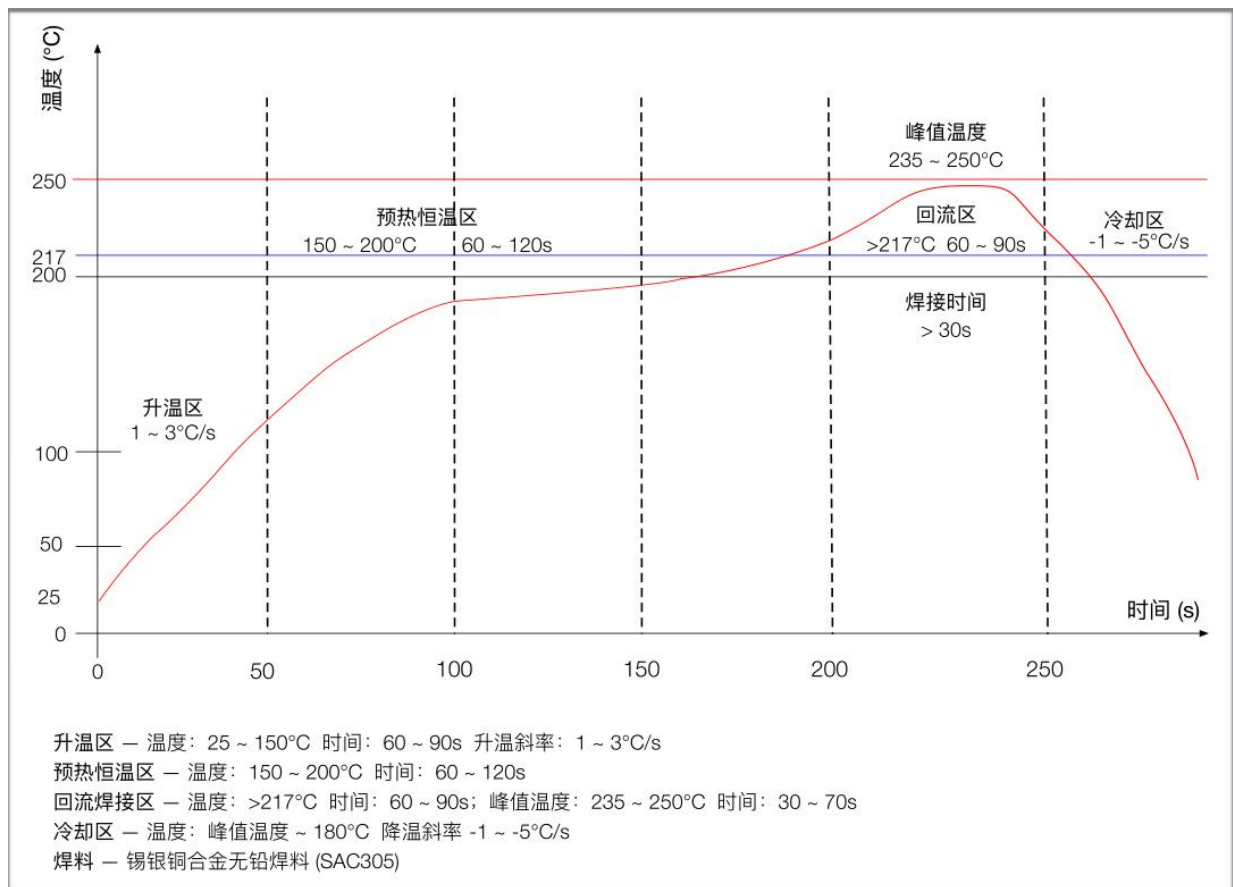


Figure 11 Flow welding diagram

10. Product packaging information

Ra-09 module was packaged in a tape, 900pcs/ reel. As shown in the below image:



Figure 12 Package and packing diagram

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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 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-RA09"

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 (15.231).it specifically establish AC Power Line Conducted Emission, Radiated Emission Dwell Time, Occupied Bandwidth

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-RA09

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: 22ATPO-RA09

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 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.