



Ra-05U Specification

Version V1.0.0

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Document resume

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1. Product Overview

Ra-05U is a 2.4GHz RF transceiver module developed by Shenzhen Ai-Thinker Technology Co., Ltd. The module is equipped with Semtech's SX1281 RF chip as the core processor, supports modulation methods such as GFSK and is compatible with Bluetooth protocol. This module is a pure RF transceiver module and needs to be driven by MCU or a dedicated SPI debugging tool.

LoRa direct sequence spread spectrum technology will bring a longer communication distance, and has the advantages of a wider power spectrum and strong anti-interference ability. The module has a hardware FEC forward error correction algorithm, which has high coding efficiency and strong error correction ability. In the case of sudden interference, it can actively correct the interfered data packets, greatly improving reliability and transmission distance.

The module has high transmit power and receiving sensitivity, and has good performance in spectrum characteristics, harmonic spurious, channel crosstalk, etc. In addition, the module is small in size and has strong packaging compatibility.

1.1. Characteristic

- Supports unlicensed ISM 2.4GHz frequency band;
- Supports 1kbps~2Mbps data air transmission rate;
- Maximum transmit power 12.5dBm, software adjustable in multiple levels;
- Receiver sensitivity (chip manual) LoRa mode can reach -132dBm;
- Supports 1.8~3.6VDC power supply, and power supply greater than 3.3V can guarantee the best performance;
- Industrial standard design, supports long-term use at -40~85℃;
- Supports modulation modes (GFSK);
- Excellent anti-blocking characteristics;
- The antenna interface uses IPEX connector, which can enrich the selection of antennas

2. Main parameters

Table 1 Description of the main parameters

Model	Ra-05U
Package	SMD-14
Size	15.0*17.8*3.1(± 0.2)mm
Antenna	IPEX connector for external antenna
Frequency	2401-2482MHz
Operating temperature	-40℃ ~ 85℃
Storage temperature	-40℃ ~ 125℃, < 90%RH
Power supply	Supply voltage 1.8V ~ 3.6V
Interface	SPI or UART
IO	3

2.1. Static electricity requirement

Ra-05U 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

Main Parameters		Condition	Min.	Typical value	Max.	Uni
Power supply voltage		VDD	1.8	3.3	3.6	V
I/O	VIL	-	-	-	0.2*VDDIO	V
	VIH	-	0.8*VDDIO	-	-	V
	VOL	-	-	0.1*VDDIO	-	V
	VOH	-	-	0.12*VDDIO	-	V
	Ileak	-	-1	-	1	uA

Table 3 SPI interface characteristics

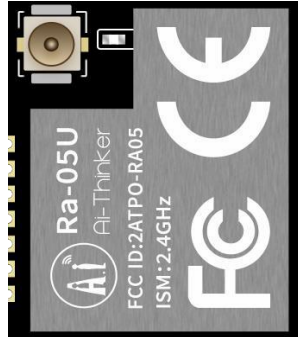
Symbol	Description	Min.	Typical value	Max.	Unit
T1	NSS falling edge to SCK setup time	25	-	-	ns
T2	SCK cycle time	55	-	-	ns
T3	SCK high level time	25	-	-	ns
T4	MOSI to SCK hold time	5	-	-	ns
T5	MOSI to SCK setup time	5	-	-	ns
T6	NSS falling edge to MISO setup time	0	-	15	ns
T7	SCK falling edge to MISO falling edge time	0	-	15	ns
T8	SCK falling edge to NSS rising edge hold time	25	-	-	ns
T9	NSS high level hold time	100	-	-	ns
T10	NSS falling edge to SCK setup time when switching from sleep mode to STDBY_RC mode	125	-	-	ns

2.3. Working Parameters

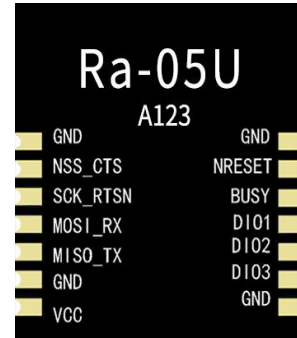
Table 4 Working parameters

Main Parameters		Min.	Typical value	Max.	Unit
Operating frequency band		2401	-	2582	MHz
Maximum transmit power		-	12.5	-	dBm
Receive sensitivity (chip manual)		-	-132	-	dBm
Power consumption	Transmitting current (mA)	-	50	-	mA
	Receiving current (mA)	-	10	-	mA
	Sleeping current (uA)	-	1.0	-	uA
Air speed LoRa (bps)		1K	1K	2M	bps
Operating temperature		-40	-	+85	℃

3. Appearance dimensions

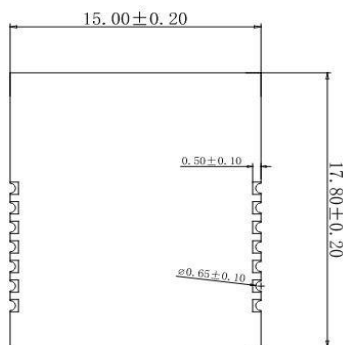


Front

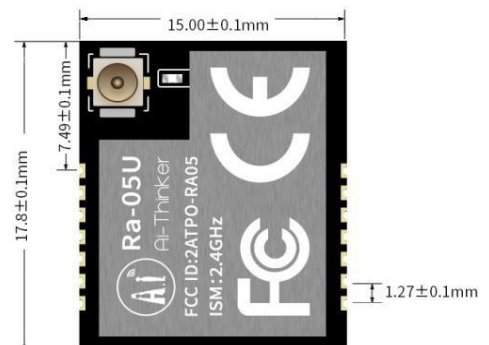


Back

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



Front



Back

Figure 4 Dimensions (unit: mm)

4. Pin definition

The Ra-05U module has 14 pins in total, as shown in the pin diagram. The pin function definition table is the interface definition.

Figure 5 Pin diagram

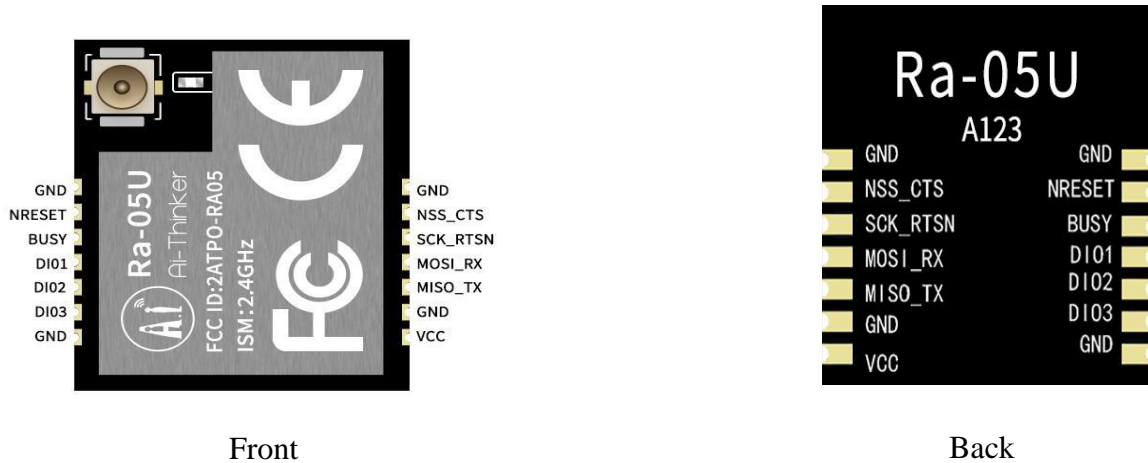


Table 5 Pin function definition table

No.	Name	Function
1	VCC	Power supply, range 1.8~3.6V (it is recommended to add ceramic filter)
2	GND	Ground wire, connected to power reference ground
3	MISO_TX	SPI data output pin; can also be used for UART transmit pin
4	MOSI_RX	SPI data input pin; can also be used for UART receive pin
5	SCK_RTSN	SPI clock input pin; can also be used for UART request transmit pin
6	NSS_CTS	Module chip select pin
7	GND	Ground wire, connected to power reference ground
8	GND	Ground wire, connected to power reference ground
9	NRESET	Chip reset
10	BUSY	For status indication
11	DIO1	General IO port
12	DIO2	General IO port
13	DIO3	General IO port
14	GND	Ground wire, connected to power reference ground

5. Design guidance

5.1. Recommended PCB package size

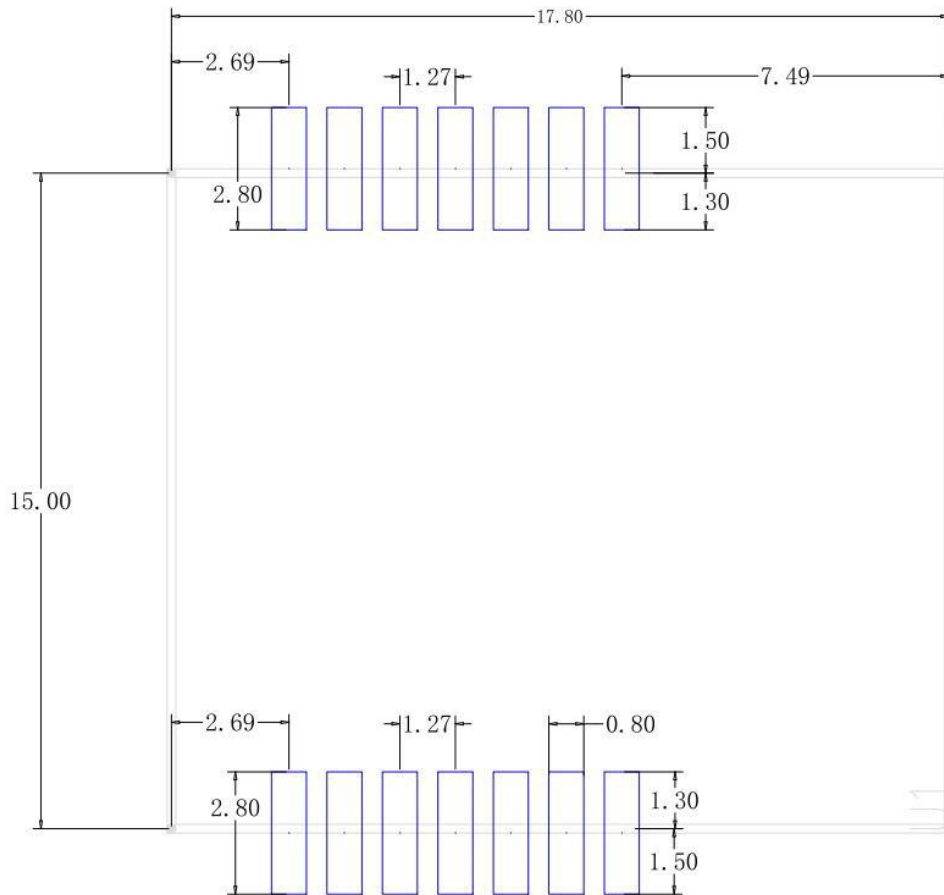


Figure 8 Recommended PCB package dimensions (unit: mm)

5.2. Power supply

- 3.3V voltage and peak current of more than 500mA are recommended.
- It is recommended to use LDO for power supply; if DC-DC is used, it is recommended to control the ripple within 100mV.
- It is recommended to reserve a position for dynamic response capacitors in the DC-DC power supply circuit, which can optimize the output ripple when the load changes greatly.
- It is recommended to add ESD devices to the 3.3V power supply interface.

5.3. GPIO

- Some IO ports are led out from the periphery of the module. If you need to use them, it is recommended to connect a 10-100 ohm resistor in series on the IO port. This can suppress overshoot and make the levels on both sides more stable. It is helpful for EMI and ESD.
- For the pull-up and pull-down of special IO ports, please refer to the instructions in the specification, which will affect the startup configuration of the module.
- Some IO ports of the module are 3.3V. If the IO port levels of the main control and 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 ESD devices near the terminals of the IO port routing.

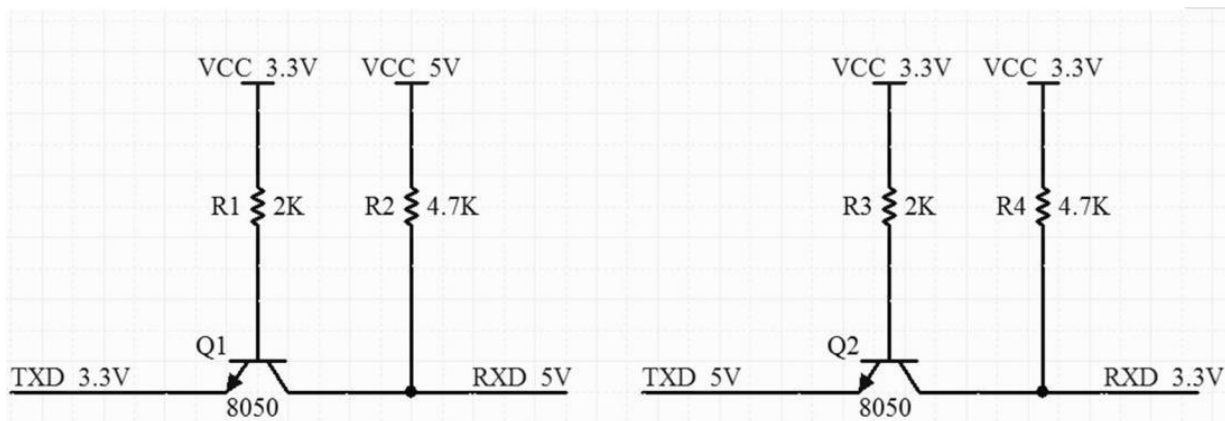


Figure 10 Level conversion circuit

6. Storage conditions

Products sealed in moisture-proof bags should be stored in a non-condensing atmosphere of <40°C/90%RH.

The module's moisture sensitivity level MSL 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 online again.

7. Reflow soldering curve

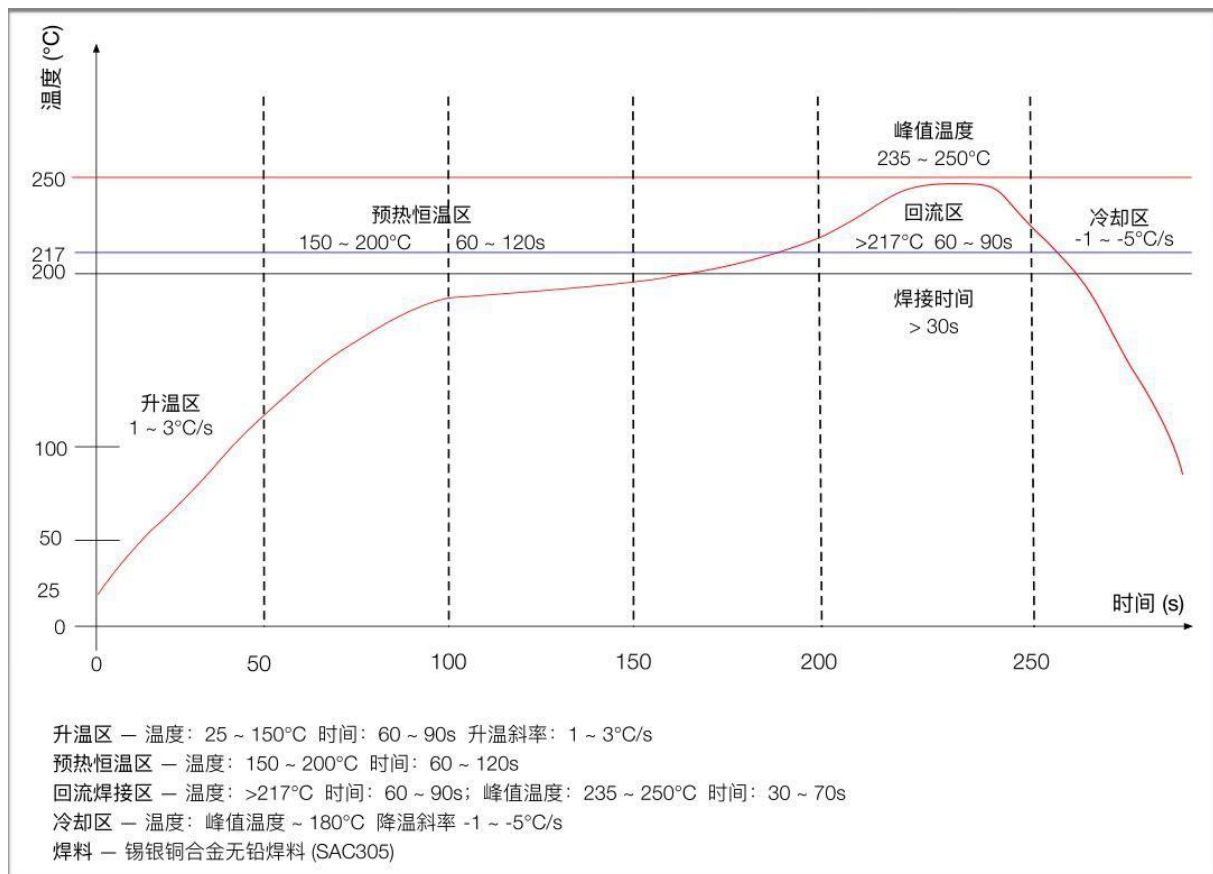


Figure 11 Reflow soldering curve

8. Product packaging information

Ra-05U module is packed in tape. As shown in the following figure:



Figure 12 Packaging and taping diagram

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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 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-RA05U”

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 2.43dBi

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-RA05U

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 2.43dBi

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-RA05U

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.