



Ra-01S-P Specification

Version V1.0.0

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Document resume

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1. Product overview

Ra-01S-P is a LoRa series module designed and developed by Shenzhen Ai-Thinker Technology Co., Ltd. This module is used for ultra-long distance spread spectrum communication. Its RF chip SX1268 mainly uses LoRa™ long-range modem for ultra-long distance spread spectrum communication, with strong anti-interference and the ability to minimize current consumption. With the help of SEMTECH's LoRa™ patented modulation technology, the module has built-in power amplifier (PA) and low noise amplifier (LNA) on this basis, with a high sensitivity of more than -137dBm, long transmission distance and high reliability. At the same time, compared with traditional modulation technology, LoRa™ modulation technology also has obvious advantages in anti-blocking and selection, solving the problem that traditional design solutions cannot take into account distance, anti-interference and power consumption at the same time.

It can be widely used in automatic meter reading, home building automation, security systems, remote irrigation systems, etc.

Figure 1 Main chip architecture diagram

1.1. Characteristic

- Support FSK、GFSK、LoRa® modulation
- ☐ Support frequency band: 410MHz~525MHz
- ☐ Maximum transmit power +29dBm, operating current 700mA
- ☐ High sensitivity: as low as -137dBm@SF10 125KHz
- Extremely small size 17*16*3.2(± 0.2)MM, double row stamp hole patch package
- ☐ Support spreading factors SF5/SF6/SF7/SF8/SF9/SF10/SF11/SF12
- ☐ It has low power consumption in receiving state, and the minimum receiving current is 11mA
- ☐ The module uses SPI interface, half-duplex communication, CRC, and up to 256 bytes of data packet engine
- ☐ Support a variety of antenna installation methods, compatible with half-hole pads/through-hole pads/IPEX connector

2. Main parameters

Table 1 Description of the main parameters

| | |
|------------------------------|---|
| Model | Ra-01S-P |
| Package | SMD-16 |
| Size | 17*16*3.2(±0.2)mm |
| Antenna | Compatible with half-hole pad/through-hole pad/IPEX connector |
| Frequency | 410MHz~525MHz |
| Operating temperature | -40℃~ 85℃ |
| Storage temperature | -40℃~ 125℃, < 90%RH |
| Power supply | Supply voltage 3.0~3.6V, typical value 3.3V, current>1A |
| Interface | SPI |
| Programmable bit rate | Up to 300kbps |

2.1. Static electricity requirement

Ra-01S-P is an electrostatic sensitive device. Therefore, you need to take special precautions when carrying it.



Figure 2 ESD preventive measures

Notice:

The Ra-01S-P module is an electrostatic sensitive device (ESD) and requires special ESD precautions that should normally be applied to ESD sensitive groups. Proper ESD handling and packaging procedures must be used throughout the handling, transportation, and operation of any application incorporating the Ra-01S-P module. Do not touch the module with your hands or use a non-antistatic soldering iron for soldering to avoid damaging the module.

2.2. Electrical characteristics

Table 2 Electrical characteristics table

| Parameters | Min. | Typical value | Max. | Unit |
|--------------------------------|-----------|---------------|-----------|------|
| Power supply voltage 3V3 | 3.0 | 3.3 | 3.6 | V |
| IO Output High Level (VOH) | 0.9*VDDIO | - | VDDIO | V |
| IO Output Low Level (VOL) | 0 | - | 0.1*VDDIO | V |
| IO Input High Level (VIH) | 0.7*VDDIO | - | VDDIO+0.3 | V |
| IO Input Low Level (VIL) | -0.3 | - | 0.3*VDDIO | V |
| (RF_EN/CPS)IO Input High Level | 1.2 | - | 3.6 | V |
| (RF_EN/CPS)IO Input Low Level | 0 | - | 0.3 | V |

Table 3 SPI interface characteristics

| Symbol | Description | Condition | Min. | Typical value | Max. | Unit |
|---------|--------------------------------------|---|------|---------------|------|------|
| Fsck | SCK frequency | - | - | - | 10 | MHz |
| tch | SCK high level time | - | 50 | - | - | ns |
| tcl | SCK low level time | - | 50 | - | - | ns |
| trise | SCK rise time | - | - | 5 | - | ns |
| tfall | SCK fall time | - | - | 5 | - | ns |
| tsetup | MOSI setup time | From MOSI change to SCK rising edge | 30 | - | - | ns |
| thold | MOSI hold time | From SCK rising edge to MOSI change | 20 | - | - | ns |
| tnsetup | NSS setup time | From NSS falling edge to SCK rising edge | 30 | - | - | ns |
| tnhold | NSS hold time | From SCK falling edge to NSS rising edge, normal mode | 100 | - | - | ns |
| tnhigh | NSS high time of SPI access interval | - | 20 | - | - | ns |
| T_DATA | DATA hold and setup time | - | 250 | - | - | ns |
| Fsck | SCK frequency | - | - | - | - | ns |

3. Pin definition

The Ra-01S-P module has a total of 16 pins, as shown in the pin diagram. The pin function definition table is the interface definition.

Table 4 Pin function definition table

| No. | Name | Function |
|------|-------|--|
| 1 | ANT | Connect antenna |
| 2 | GND | Ground |
| 3 | 3V3 | Typical value 3.3V power supply |
| 4 | RESET | Reset pin |
| 5 | CPS | FEM chip TX pass-through enable pin, in transmit mode, this pin is low level R F and is directly output without PA amplification, and is internally pulled up by default |
| 6 | DIO1 | Digital IO1 software configuration |
| 7 | DIO2 | Digital IO2 software configuration |
| 8 | DIO3 | Digital IO3 software configuration |
| 9 | GND | Ground |
| 10 | BUSY | Status indication pin |
| 11 | RF_EN | FEM chip enable pin, high level is effective, the module is pulled up by default; High level is in working state, low level is in sleep state |
| 12 | SCK | SPI clock input |
| 13 | MISO | SPI data output |
| 14 | MOSI | SPI data input |
| 15 | NSS | SPI chip select input |
| 16 | GND | Ground |
| EPAD | GND | Ground, reliable grounding is required to facilitate heat dissipation |

The general IO pins of SX1262 are available in LoRa™ mode. Their mapping relationship depends on the configuration of the two registers RegDioMapping1 and RegDioMapping2.

Table 5 IO port function mapping table

| Operation Mode | DIOx Mapping | DIO3 | DIO2 | DIO1 |
|----------------|--------------|------------------|---------------------|---------------------|
| All | 00 | CadDone | Fhss Change Channel | RxRimeout |
| | 01 | Valid Header | Fhss Change Channel | Fhss Change Channel |
| | 10 | PayloadCrc Error | Fhss Change Channel | CadDetected |
| | 11 | - | - | - |

4. Design guidance

4.1. Application Guide Circuit

(1) Special pin description

☐ About CPS pin

CPS is the TX pass-through control pin of the built-in PA chip of the module, with an internal pull-up resistor of 10K (that is, R F is in PA amplification output mode in the default transmission mode). When the module is in transmission mode:

- ✓ This pin is high level, and the module's R F is amplified and output by PA;
- ✓ When this pin is low level, the module's R F is directly output without being amplified by PA;
- ✓ The logic of this pin is invalid in the receiving state and needs to be set to a low level when low power consumption;

☐ About RF_EN pin

RF_EN is the enable pin of the module's built-in PA chip. When the pin is high, the module's RF is in normal transceiver state; when the pin is low, the module's RF function is turned off, which can reduce the module's power consumption.

Table 6 RF switch truth table

| Mode | RF_EN |
|---------------|-------|
| FEM power off | 0 |
| FEM working | 1 |

The module defaults to BOM, with an internal pull-up resistor of 10K (i.e., it is in normal amplification and transceiver state by default). If a low-power working scenario is required, please use an external MCU to control this pin to a low level state. When the level is low, the default pull-up resistor of this pin may have leakage current. If the built-in pull-up resistor is not required, please contact Ai-Thinker to modify the BOM.

In summary, the module has two BOM configurations.

Configuration 1. CPS and RF_EN have built-in pull-up resistors of 10K (default BOM configuration)

Configuration 2. CPS and RF_EN have built-in pull-up resistors without mounting, and require IO port control of the peripheral MCU

(2) Typical application circuit

- ☐ It is recommended that the IO port of the external MCU control the RF_EN of the module to achieve low power consumption application scenarios

(3) Other instruction

- ☐ The communication interface with the master MCU, in addition to the SPI interface, also needs to connect BUSY/DIO1 to the IO port of the master MCU.
- ☐ The antenna is soldered on the main control board. It is recommended to reserve a pie-shaped matching circuit at the antenna interface.

4.2. Recommended PCB package size

4.3. Antenna Installation

- ☐ Ra-01S-P requires an external antenna. There is a half-hole pad on the module that can be connected to the mainboard.
- ☐ In order for the antenna to achieve the best effect, the antenna should be installed away from metal parts.
- ☐ The antenna installation structure has a great impact on the performance of the module. Make sure that the antenna is exposed, preferably vertically upward. When the module is installed inside the casing, a high-quality antenna extension cable can be used to extend the antenna to the outside of the casing.
- ☐ The antenna must not be installed inside the metal casing, which will greatly reduce the transmission distance.

4.4. Power supply

- ☐ Recommend 3.3V voltage, peak current above 1A.
- ☐ If using DC-DC, 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.
- ☐ When designing the power supply circuit for the module, it is recommended to retain more than 30% of the power supply current margin, which is conducive to long-term stable operation of the whole machine.
- ☐ Please pay attention to the correct connection of the positive and negative poles of the power supply. Reverse connection may cause permanent damage to the module.

4.5. GPIO level conversion

- ☐ 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.
- ☐ The IO port of the module is 3.3V. If the IO port level 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 pin headers, it is recommended to reserve ESD devices near the terminals of the IO port routing.

4.6. Software Writing

- ☐ The maximum input power of the FEM chip cannot exceed +5dBm, otherwise the FEM chip will be burned. Users need to strictly configure the output power of SX1268, 3dBm-5dBm is recommended.
- ☐ This module is SX1268+peripheral circuit, users can operate it completely according to the SX1268 chip manual.
- ☐ DIO1/DIO2 is a general IO port that can be configured for multiple functions.
- ☐ The control of the RF switch TX/RX can be controlled by an external MCU; it can also be jointly controlled by an external MCU and DIO2 of SX1262.
- ☐ Differences between LLCC68 and SX1262/SX1268:

(1) SX1262/SX1268 supports spreading factors SF5, SF6, SF7, SF8, SF9, SF10, SF11, SF12;

SX1262/SX1268 can set the spreading factor and receiving bandwidth

LoRa@ Rx/Tx, BW = 7.8 - 500 kHz,

SF5 TO SF12, BR = 0.018 - 62.5 Kb/S

(2) LLCC68 supports spreading factors SF5, SF6, SF7, SF8, SF9, SF10, SF11;

LLCC68 can set the spreading factor and receiving bandwidth

LoRa@ Rx/Tx, BW = 125 - 250 - 500 kHz,

LoRa@, SF=5-6-7-8-9 for BW=125kHz,

LoRa@, SF=5-6-7-8-9-10 for BW =250 kHz,

LoRa@, SF=5-6-7-8-9-10-11 for BW=500 kHz.

5. FAQ

5.1. Factors affecting transmission distance

- ☐ When there is a straight-line communication obstacle, the communication distance will be attenuated accordingly.
- ☐ Temperature, humidity, and co-frequency interference will lead to an increase in the communication packet loss rate.
- ☐ The ground absorbs and reflects radio waves, so the test effect is poor near the ground.
- ☐ Seawater has a strong ability to absorb radio waves, so the test effect is poor at the seaside.
- ☐ If there are metal objects near the antenna, or it is placed in a metal shell, the signal attenuation will be very serious.
- ☐ The power register is set incorrectly, and the air rate is set too high (the higher the air rate, the closer the distance).
- ☐ The power supply low voltage at room temperature is lower than the recommended value. The lower the voltage, the lower the power.
- ☐ The antenna used is poorly matched with the module or the antenna itself has quality problems.

5.2. Module usage precautions

- ☐ Check the power supply to ensure that it is within the recommended power supply voltage. If it exceeds the maximum value, the module will be permanently damaged.
- ☐ Check the stability of the power supply. The voltage cannot fluctuate frequently and significantly.
- ☐ Ensure anti-static operation during installation and use, and high-frequency components are electrostatically sensitive.
- ☐ Ensure that the humidity during installation and use is not too high. Some components are humidity-sensitive devices.
- ☐ If there is no special requirement, it is not recommended to use it at too high or too low temperature.

5.3. Factors that interfere with the module

- ☐ There is interference from the same frequency signal nearby, stay away from the interference source or change the frequency or channel to avoid interference.
- ☐ 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.
- ☐ Unsatisfactory power supply may also cause garbled code, so the reliability of the power supply must be ensured.
- ☐ Poor or too long extension line or feeder line will also cause a high bit error rate.

6. 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's moisture sensitivity level MSL is level 3.

After the vacuum bag is unsealed, 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

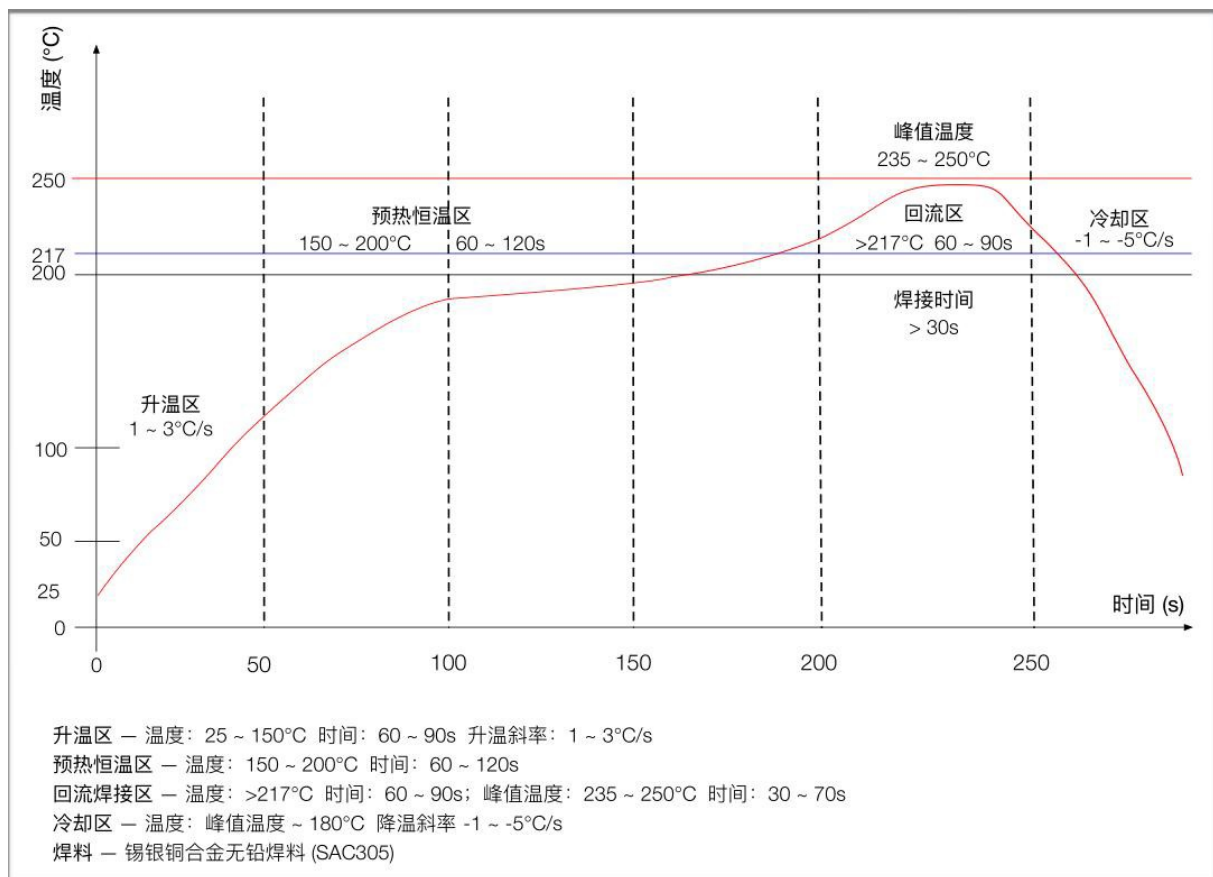
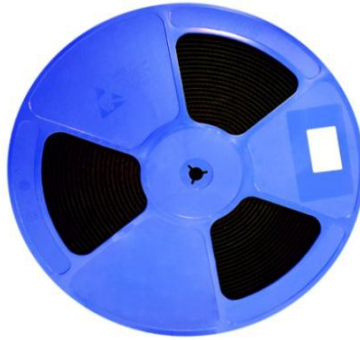


Figure 12 Reflow soldering curve

8. Product packaging information

As shown in the figure below, the packaging of Ra-01S-P is braided tape, 800pcs/reel. As shown in the figure below:



13 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-RA01SP"

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-RA01SP
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-RA01SP

2.9 Information on test modes and additional testing

requirements 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.