



# Ra-01SC Specification

Version V1.1

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## 1. Product Overview

LoRa series module Ra-01Sc is designed and developed by Shenzhen Ai-Thinker Technology Co., Ltd. This module is used for ultra-long distance spread spectrum communication. Its RF chip LLCC68 mainly uses LoRa™ remote modem for ultra-long distance spread spectrum communication, with strong anti-interference and low power consumption. LLCC68 chip has a high sensitivity of over-129 dBm, a 20 dBm power output, a long transmission distance and a high reliability with SEMTECH's LoRa™ patent modulation technique. Meanwhile, comparing with the traditional modulation technology, LoRa™ provides significant advantages in both blocking and selectivity over conventional modulation techniques. It solves the problem of simultaneously balance the distance, the anti-interference and the power consumption which the traditional design scheme can't achieve.

### Application areas

automatic meter reading, supply chain and logistics, home building automation, security system, remote irrigation system.

### 1. 1. Characteristics

- LoRa™ modem
- Support FSK
- Frequency supports 410MHz~525MHz
- Operating voltage is 3.3V, Max current:140m
- Low power consumption in a received state, the min received current is 4.2mA, stand-by current is 0.6mA
- High sensitivity: As low as -129dBm
- Support spreading factor:SF5/SF6/SF7/SF8/SF9/SF10/SF11
- Small volume double row stamp hole patch for SMD package
- Adopts SPI interface, half-duplex communication, with CRC, up to 256-b yte packet engine

## 1.2 Main parameters

**Table 1 main parameters instruction**

|                              |                                                                                                                                                                                |
|------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Model</b>                 | Ra-01SC                                                                                                                                                                        |
| <b>Package</b>               | SMD16                                                                                                                                                                          |
| <b>Size</b>                  | 17*16*3.2(±0.2)mm                                                                                                                                                              |
| <b>Antenna</b>               | Spring antenna                                                                                                                                                                 |
| <b>Frequency range</b>       | 410MHz~525MHz                                                                                                                                                                  |
| <b>Operating Temperature</b> | -40 °C ~ 85 °C                                                                                                                                                                 |
| <b>Storage environment</b>   | -40 °C ~ 125 °C , < 90%RH                                                                                                                                                      |
| <b>Power supply</b>          | 2.7~3.6V, typical value 3.3V, recommended current > 200mA                                                                                                                      |
| <b>Support Interface</b>     | SPI                                                                                                                                                                            |
| <b>Programmable bit rate</b> | Max up to 300Kbps                                                                                                                                                              |
| <b>Crystal frequency</b>     | 32MHz                                                                                                                                                                          |
| <b>Transmission distance</b> | In an open environment, this module match with spring antenna the transmitting range can reach 2.8km or match with suction cup antenna the transmitting range can reach 4.6km. |

## 2. Electrical parameters

*Ra-01SC series modules are electrostatic sensitive devices, special precautions need to be taken when handling.*



Note:

*Ra-01SC module is electrostatic sensitive devices (ESD) , It requires special ESD precautions and should generally be classified as an ESD sensitive component. During the entire handling, transportation and operation of the Ra-01SC module, proper ESD handling and packaging procedures should be used. Please do not touch the module with hands or use a non-antistatic soldering iron for soldering, so as not to damage the module.*

### 2.1. Electrical character

| Parameter             | Name | Min | Typ | Max | Unit | Remarks                        |
|-----------------------|------|-----|-----|-----|------|--------------------------------|
| Operating temperature | TOPR | -40 | 25  | 85  | °C   | Industrial design              |
| Supply voltage        | VDD  | 2.7 | 3.3 | 3.6 | V    | ≥3.3V(Guaranteed output power) |

### 2.2. Digital port characteristics

| Description            |      | Typ     |     | Unit |      |
|------------------------|------|---------|-----|------|------|
| Operating frequency    |      | 410~525 |     | MHz  |      |
| IO                     | Name | Min     | Typ | Max  | Unit |
| IO level               | VIO  | 2.7     | 3.3 | 3.6  | V    |
| Low input logic level  | VIL  | -       | -   | 0.2  | V    |
| High input logic level | VIH  | 0.8     | -   | -    | V    |

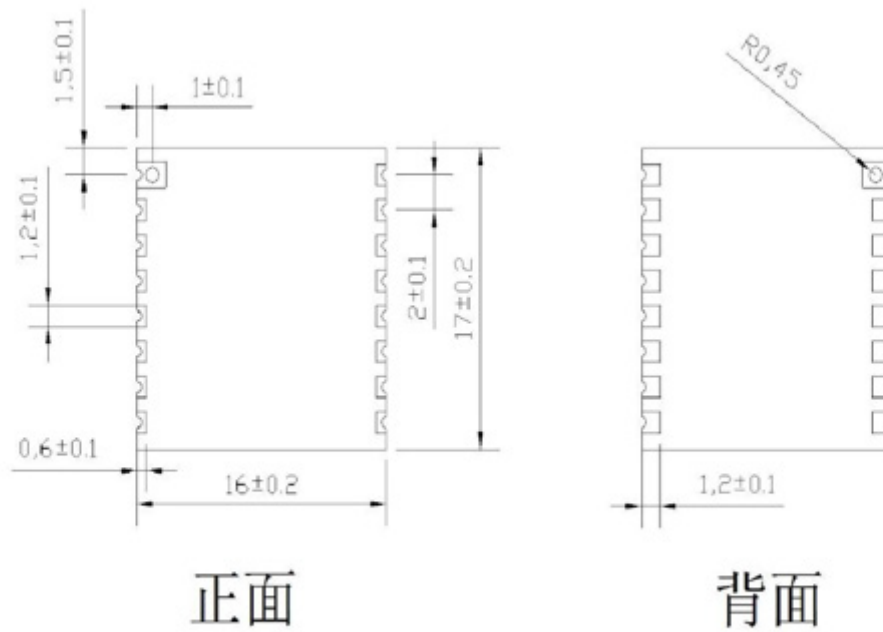
|                         |     |     |   |     |   |
|-------------------------|-----|-----|---|-----|---|
| Low output logic level  | VOL | -   | - | 0.1 | V |
| High output logic level | VOH | 0.9 | - | -   | V |

## 2.3. SPI Interface features

| Name    | Description                                | Condition                                             | Min | Typ | 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 Time setting                          | From MOSI change to SCK rising edge                   | 30  | -   | -   | ns   |
| Thold   | MOSI Duration                              | Change from rising edge of SCK to MOSI                | 20  | -   | -   | ns   |
| Tnsetup | NSS Set up time                            | From NSS falling edge to SCK rising edge              | 30  | -   | -   | ns   |
| Tnhold  | NSS Time maintain                          | From SCK falling edge to NSS rising edge, normal mode | 100 | -   | -   | ns   |
| Tnhigh  | SPI Access interval<br>NSS High level time | -                                                     | 20  | -   | -   | ns   |
| T_DATA  | DATA maintenance and set up time           | -                                                     | 250 | -   | -   | ns   |

## 3. Appearance size

Ra-01SC has one antenna interface : Spring antenna



## 4. Pin function

Ra-01SC module is connected to 16 interfaces, refer to pin diagram, pin function definition table is interface definition.

Ra-01SC Pin diagram



Table Pin function definition

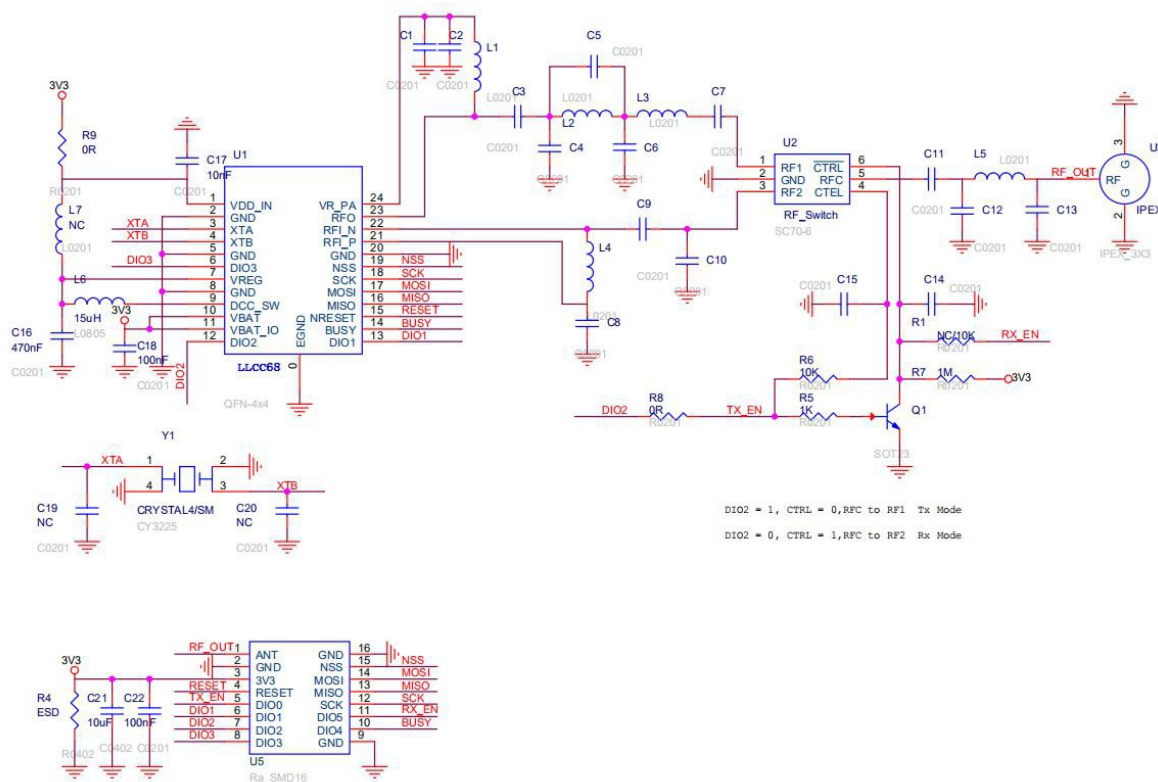
| No. | Name  | Function instruction                                                       |
|-----|-------|----------------------------------------------------------------------------|
| 1   | ANT   | Ground                                                                     |
| 2   | GND   | Ground, Connect to the power reference ground                              |
| 3   | 3.3V  | Typical value 3.3V, recommended current > 200mA                            |
| 4   | RESET | Reset                                                                      |
| 5   | TXEN  | RF control port                                                            |
| 6   | DIO1  | Digital IO1 software configuration                                         |
| 7   | DIO2  | Digital IO2 software configuration                                         |
| 8   | DIO3  | Digital IO3 software configuration                                         |
| 9   | GND   | Ground                                                                     |
| 10  | BUSY  | Status indicator pin (Be sure to connect to the IO port of the master MCU) |
| 11  | RXEN  | RF control port                                                            |
| 12  | SCK   | SPI clock input                                                            |
| 13  | MISO  | SPI data output                                                            |
| 14  | MOSI  | SPI data input                                                             |
| 15  | NSS   | SPI chip select input                                                      |
| 16  | GND   | Ground, Connect to the power reference ground                              |

The three general IO pin of LLCC68 can be available in LoRa™ mode.

Their mapping depends on the configuration of the two registers RegDioMapping1 and RegDioMapping2.

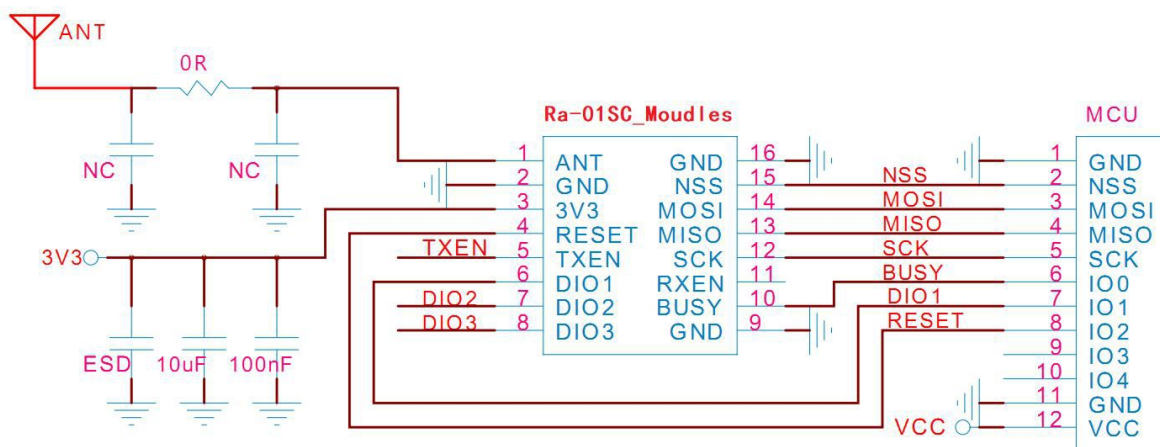
| Operating Mode | DIOx Mapping | DIO3             | DIO2                | DIO1                |
|----------------|--------------|------------------|---------------------|---------------------|
| All            | 00           | CadDone          | Fhss Change Channel | RxRimeout           |
|        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

## 5. Schematics



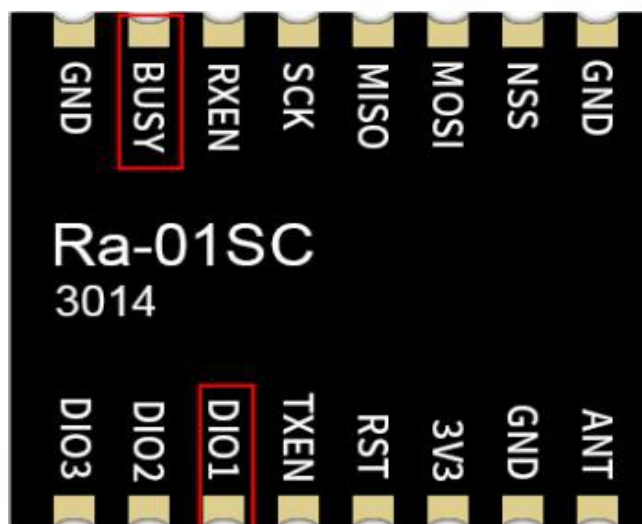
## 6. Design guidance

### 6.1 Application Circuit



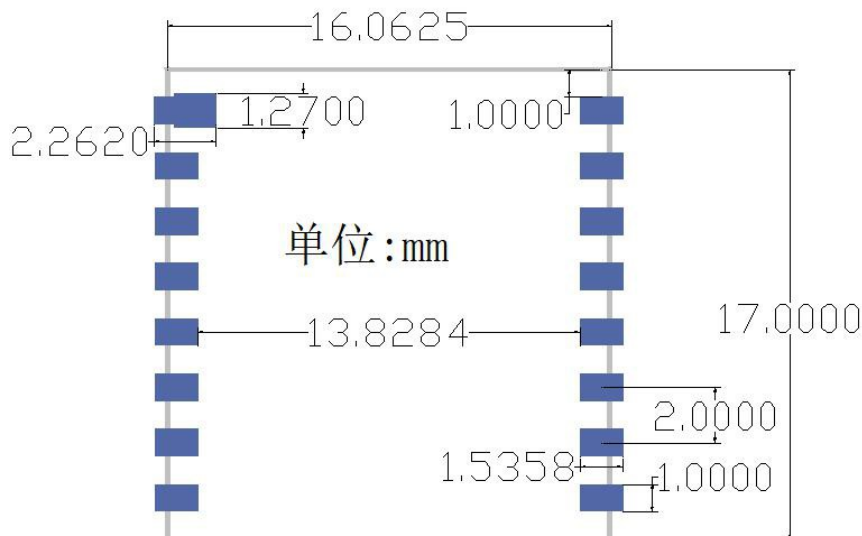
(1) In addition to the SPI interface, the communication interface with the master MCU must also connect BUSY/DIO1 to the IO port of the master MCU

(2) If the antenna is soldered on the main control board, it is recommended to reserve a  $\Pi$  matching circuit at the antenna interface.



### 6.2 Recommended module package design size

*Note: This is the package drawing of the Ra-01SC module. It is recommended to design the PCB board according to this drawing so that the module can work normally on the PCB board; and when designing the pads, pay attention to the design of the pads on the PCB. The pad is retracted and offset, and the PCB pad is expanded relative to the module pad without affecting the use of the module.*

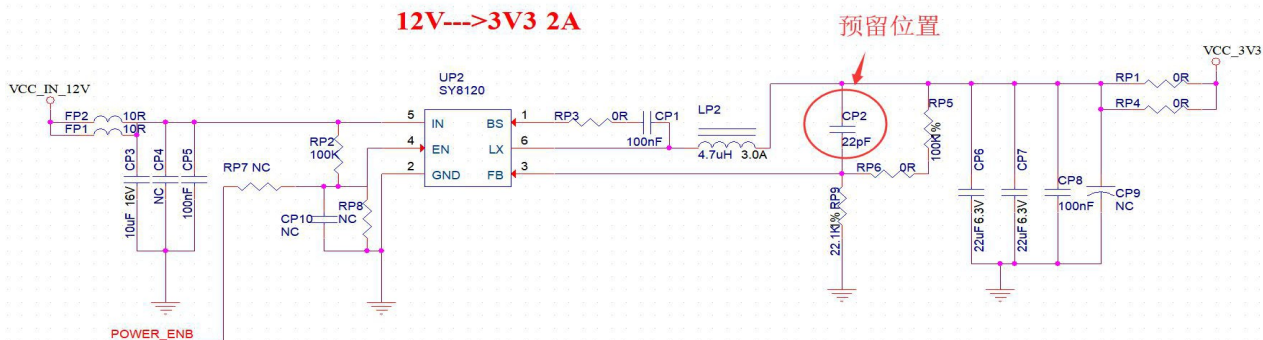


### 6.3 Antenna installation

- (1) Ra-01SC has one spring antenna, the antenna can not be replaced by other authorized antennas;
- (2) In order to meet the best antenna effect, the location of the antenna assembly should be far away from the metal parts;
- (3) The antenna installation structure has a great influence on the performance of the module. Make sure that the antenna is exposed, preferably vertically upward;
- (4) The antenna must not be installed inside the metal shell, which will greatly reduce the transmission distance.

### 6.4 Power Supply

- (1) Recommended voltage 3.3 V, Peak: Current over 200mA.
- (2) It is recommended to use the LDO power supply; If DC-DC is used, the ripple is controlled within 30 mV.;
- (3) DC-DC power supply circuit is recommended to reserve the position of the dynamic response capacitor, and the output ripple can be optimized when the load change is large.;
- (4) 3.3V power jack advise to add ESD components.;
- (5) When designing the power supply circuit for the module, it is recommended to reserve more than 30% of the power supply current, which is conducive to the long-term stable operation of the whole machine;
- (6) 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.



## 6.5 GPIO

- ① There are some GPIO ports on the periphery of the module. If you need to use a 10-100 ohm resistor in series with the IO port, it can suppress overshoot and make the levels on both sides more stable, which is helpful for EMI and ESD.
- ② 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;
- ③ The IO port of the module is 3.3V. If the main control and the IO level of the module do not match, a level conversion circuit needs to be added
- ④ If the IO port is directly connected to a peripheral interface, or a terminal such as a header, it is recommended to reserve an ESD device near the terminal of the IO trace.

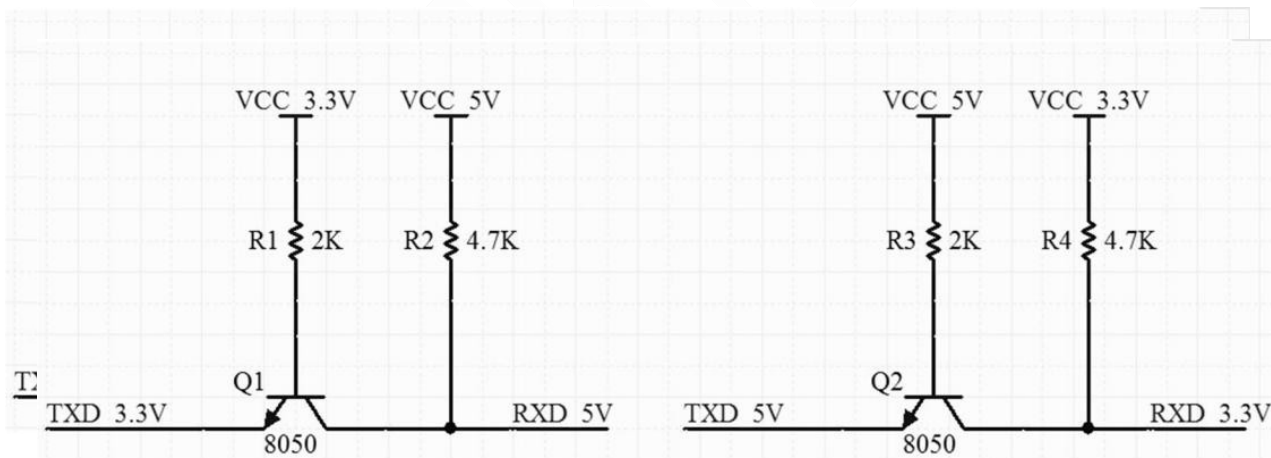


Table Level switching circuit

## 6.6 Software writing

- (1) This module is LLCC68+ peripheral circuit, users can operate according to LLCC68 chip manual;
- (2) DIO1, DIO2, DIO3 are general-purpose IO ports, which can be configured into multiple functions;
- (3) The control of the RF switch TX/RX is completed by the internal circuit of the module by default. But the interface is reserved in the design, which can realize external MCU control. If you need external MCU control, please contact Ai-Thinker technicians to replace the module BOM.

Different between LLCC68 and SX1262/SX1268:

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

SX1262/SX1268 can set 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 support spreading factor SF5,SF6,SF7,SF8,SF9,SF10,SF11.

LLCC68can set 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;

## 7. FAQ

### 7.1 Factors affecting transmission distance

- (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, the test effect is poor when it is close to the ground
- (4) Sea water has a strong ability to absorb radio waves, so the seaside test results are poor;
- (5) If there is a metal object near the antenna or placed in a metal shell, the signal attenuation will be serious;
- (6) Incorrectly set the power register, and 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 power output;;
- (8) The poor matching degree of the antenna and the module or the quality of the antenna itself

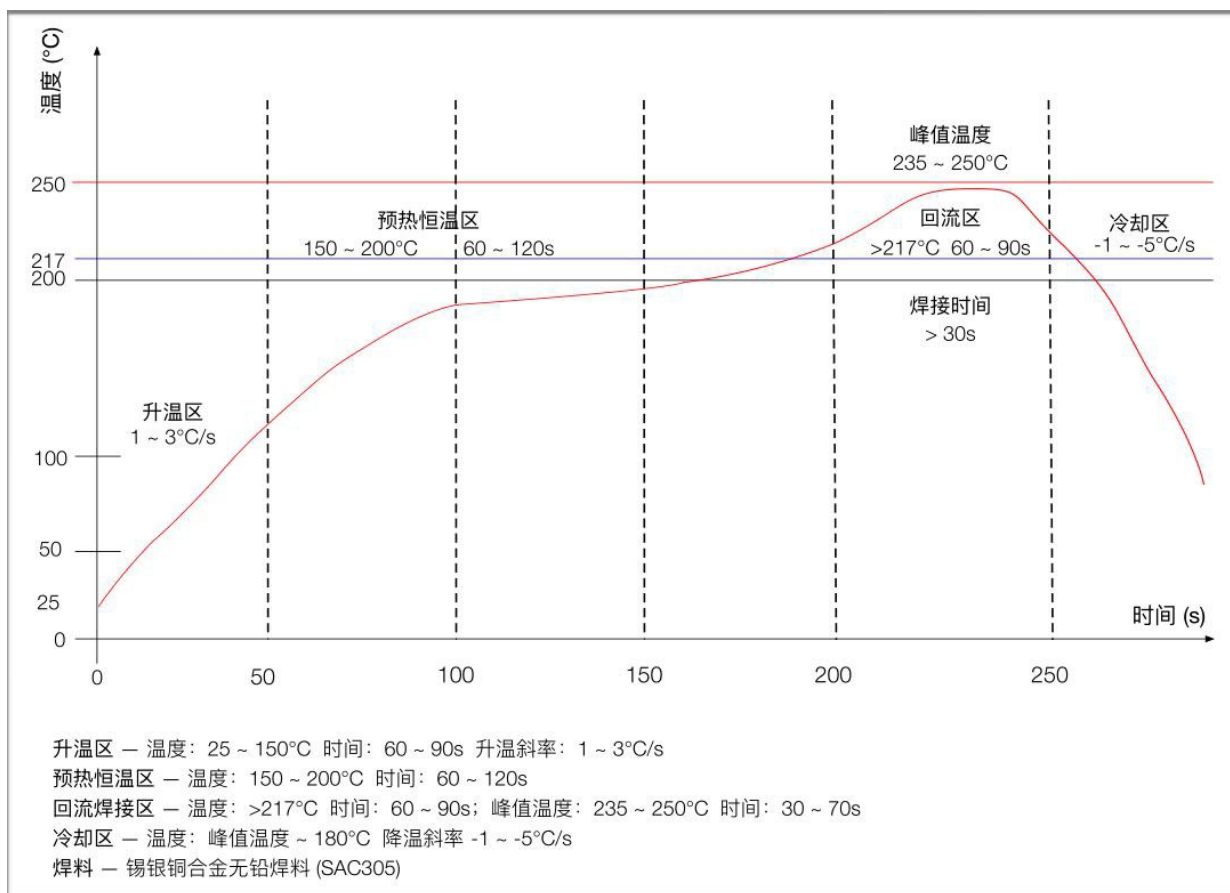
### 7.2 Module use reminder

- (1) Check the power supply to ensure that it is between the recommended supply voltages. 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 should not fluctuate significantly and frequently;
- (3) Ensure the anti-static operation during installation and use, and the electrostatic sensitivity of high-frequency devices;
- (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 Interfering factors

- (1) There is co-channel signal interference nearby, please stay away from the interference source or modify the frequency and channel to avoid interference;
- (2) The clock waveform on SPI is not standard, please 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 codes, so the reliability of the power supply must be ensured;
- (4) Extension cords and feeders are of poor quality or too long, which will also cause a high bit error rate

## 8. Reflow Welding Curve



## 9. Related models

| Model                                                                                                        | Chip    | Frequency     | Transmitting power | Package | Size    | Interface |
|--------------------------------------------------------------------------------------------------------------|---------|---------------|--------------------|---------|---------|-----------|
| Ra-01                                                                                                        | SX1278  | 410MHz~525MHz | 20dB               | SMD     | 17*16   | SPI       |
| Ra-01H                                                                                                       | SX1276  | 410MHz~525MHz | 20dB               | SMD     | 17*16   | SPI       |
| Ra-01S                                                                                                       | SX1268  | 410MHz~525MHz | 22dB               | SMD     | 17*16   | SPI       |
| Ra-02                                                                                                        | SX1278  | 410MHz~525MHz | 20dB               | SMD     | 17*16   | SPI       |
| Ra-06                                                                                                        | SX1278  | 410MHz~525MHz | 20dB               | SMD     | 22.8*16 | SPI       |
| Ra-07                                                                                                        | ASR6501 | 410MHz~525MHz | 20dB               | SMD     | 16*16   | UART/I2C  |
| Ra-07H                                                                                                       | ASR6501 | 803MHz~930MHz | 21dB               | SMD     | 16*16   | UART/I2C  |
| Product related information: <a href="https://docs.ai-thinker.com/lora">https://docs.ai-thinker.com/lora</a> |         |               |                    |         |         |           |

## 10. Packaging information

Refer to below image, Ra-01SC package is in Tape/Reel.



## 11. Contact us

Official website: <https://www.ai-thinker.com>

Development DOCS: <https://docs.ai-thinker.com>

Official Forum: <http://bbs.ai-thinker.com>

Sample purchase: <https://ai-thinker.en.alibaba.com/>

Business cooperation: [overseas@aithinker.com](mailto:overseas@aithinker.com)

Technical support: [support@aithinker.com](mailto:support@aithinker.com)

Company Address: Room 403,408-410, Block C, Huafeng Smart Innovation Port, Gushu 2nd Road, Xixiang, Baoan District, Shenzhen.

Tel : 0755-29162996



## 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.

Radiation Exposure Statement:

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment.

This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

The availability of some specific channels and/or operational frequency bands are country dependent and are firmware programmed at the factory to match the intended destination.

The firmware setting is not accessible by the end user.

The final end product must be labelled in a visible area with the following:

“Contains Transmitter Module 2ATPO-RA-01SC”

## **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.<sup>3</sup>

**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 EUT has one spring antenna, the antenna can not be replaced by other authorized antennas.

### **2.4 Limited module procedures**

If a modular transmitter is approved as a "limited module," then the module manufacturer is responsible for approving the host environment that the limited module is used with. The manufacturer of a limited module must describe, both in the filing and in the installation instructions, the alternative means that the limited module manufacturer uses to verify that the host meets the necessary requirements to satisfy the module limiting conditions.

A limited module 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 limited module 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.

## **2.6 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:** This module complies with FCC RF radiation exposure limits set forth for an uncontrolled environment." This module is designed to comply with the FCC statement, FCC ID is: 2ATPO-RA-01SC.

## **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 EUT has one spring antenna, the antenna can not be replaced by other authorized antennas.

## **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-RA-01SC."

## **2.9 Information on test modes and additional testing requirements<sup>5</sup>**

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.