



Ra-01SH-P Specification

Version V1.0.3

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Document Revision History

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1. Product Overview

The Ra-01SH-P is a LoRa series module designed and developed by Shenzhen Ai-Thinker Technology Co., Ltd. This module is used for ultra-long-range spread-spectrum communication. Its RF chip, the SX1262, primarily employs the LoRa™ long-range modem for ultra-long-range spread-spectrum communication, offering strong interference immunity and minimizing current consumption. Leveraging Semtech's LoRa™ patented modulation technology, the module integrates a power amplifier (PA) and a low-noise amplifier (LNA), achieving a high sensitivity of over -137dBm and a transmit Power of +29dBm, ensuring long transmission distance and high reliability. Additionally, compared to traditional modulation technologies, LoRa™ modulation technology demonstrates significant advantages in blocking immunity and selectivity, solving the problem that traditional designs that cannot simultaneously balance distance, interference immunity, and power consumption.

The module can be widely used in automatic meter reading, home and building automation, security systems, remote irrigation systems, and other applications.

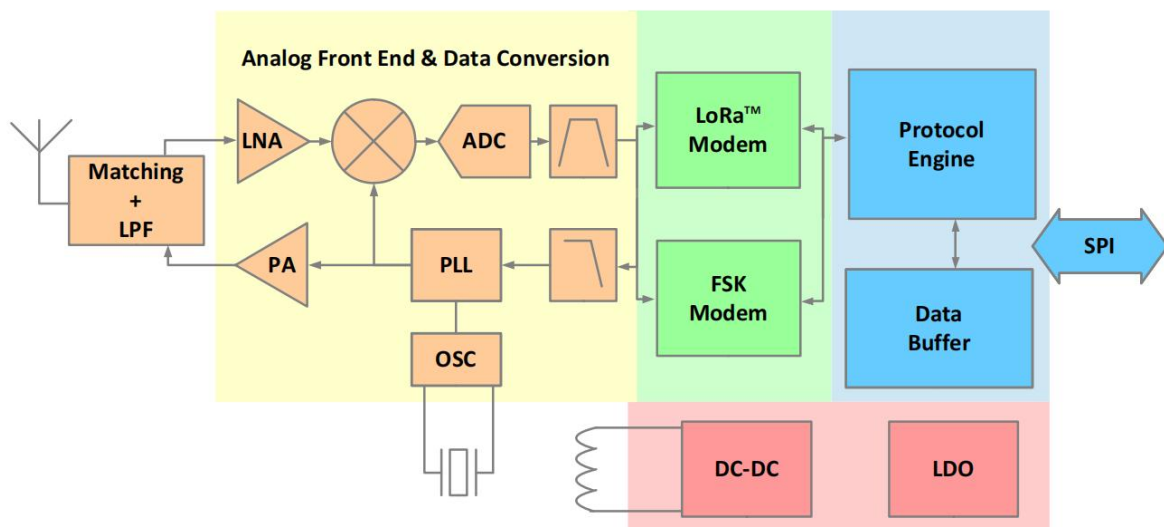


Figure 1 Main Chip Architecture Diagram

1.1. Features

- Supports FSK, GFSK, and LoRa® modulation modes
- Supports the 803 – 930MHz frequency band
- Maximum transmit power up to +29dBm
- High sensitivity: down to -137dBm @ SF10, 125kHz bandwidth
- Compact dimensions of $17 \times 16 \times 3.2 (\pm 0.2)$ mm, with a dual-line castellated-hole SMD package
- Supports spreading factors SF5/SF6/SF7/SF8/SF9/SF10/SF11/SF12
- Low power consumption in receive mode, with receive current as low as 16mA
- Uses an SPI interface and half-duplex communication, with CRC and a data-packet engine supporting up to 256 bytes
- Supports multiple antenna installation methods and is compatible with castellated pads, through-hole pads, and an IPEX connector

2. Key Specifications

Table 1 Key Specifications

Model	Ra-01SH-P
Package	SMD-16
Dimensions	17 × 16 × 3.2 (±0.2) mm
Antenna Type	Compatible with castellated pads/through-hole pads/IPEX connector
Frequency Range	803 – 930MHz
Operating Temperature	-40 – 85°C
Storage Conditions	-40 – 125°C, < 90% RH
Power Supply Range	Supply voltage 3.0 – 3.6V; typical 3.3V; supply current > 1A
Supported Interface	SPI
Programmable Bit Rate	Up to 300kbps

2.1. Electrostatic Requirements

Ra-01SH-P is an ESD-sensitive device and requires special precautions during handling.



Figure 2 ESD Protection Diagram

Note:

The Ra-01SH-P module is an electrostatic-sensitive device (ESD) and requires special ESD precautions. It should normally be handled as an ESD-sensitive component. Proper ESD handling and packaging procedures must be followed throughout the processing, transportation, and operation of any application incorporating the Ra-01SH-P module. Do not touch the module with bare hands or solder it with a non-ESD-safe soldering iron, as this may damage the module.

2.2. Electrical Characteristics

Table 2 Electrical Characteristics

Parameter	Min	Typ	Max	Unit
Supply Voltage 3V3	3.0	3.3	3.6	V
IO Output High Level (VOH)	$0.9 \times VDDIO$	-	VDDIO	V
IO Output Low Level (VOL)	0	-	$0.1 \times VDDIO$	V
IO Input High Level (VIH)	$0.7 \times VDDIO$	-	VDDIO + 0.3	V
IO Input Low Level (VIL)	-0.3	-	$0.3 \times VDDIO$	V

Table 3 SPI Interface Characteristics

Symbol	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 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-level time for SPI access interval	-	20	-	-	ns
T_DATA	DATA hold and setup time	-	250	-	-	ns
Fsck	SCK frequency	-	-	-	-	ns

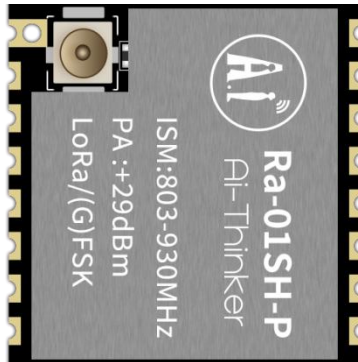
2.3. Power Consumption

The following power consumption data are measured under a 3.3V power supply and 25°C ambient temperature.

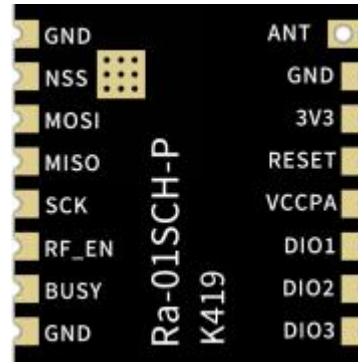
Table 4 Power Consumption

Mode	Min	Avg	Max	Unit
TX	-	690	-	mA
RX	-	13	-	mA
Deep Sleep (RF_EN: internal 10kΩ pull-up, external pull-down)	-	360	-	μA
Standby (RF_EN: internal 10kΩ pull-up, external pull-down)	-	970	-	μA
Deep Sleep (RF_EN: without internal 10kΩ pull-up, external pull-down)	-	6.5	-	μA
Standby (RF_EN: without internal 10kΩ pull-up, external pull-down)	-	620	-	μA

3. Appearance and Dimensions



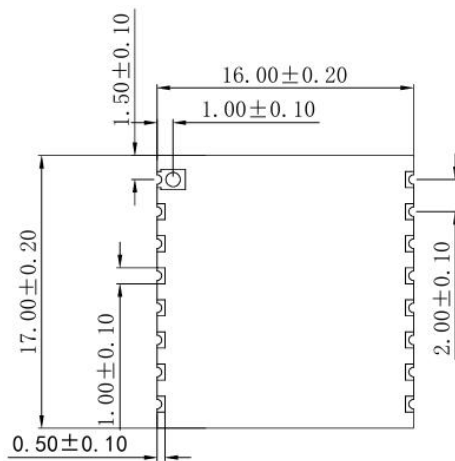
Top View



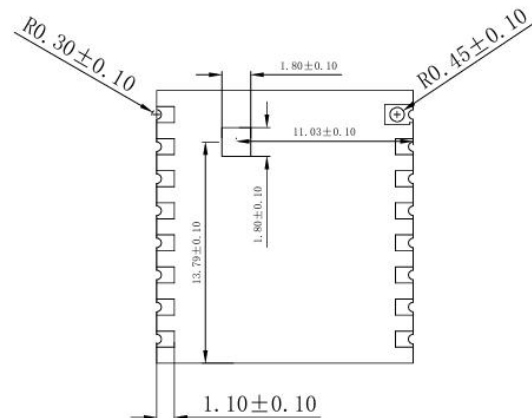
Bottom View

Figure 3 Appearance Diagram

(The rendering is for reference only; the actual product shall prevail.)



Top View

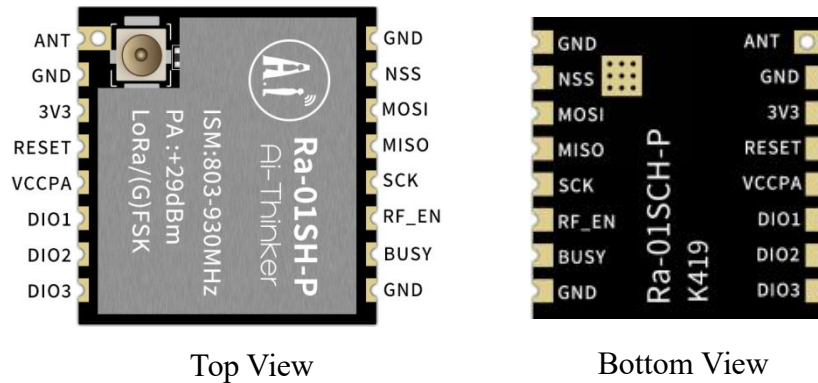


Bottom View

Figure 4 Dimensional Diagram (Unit: mm)

4. Pin Definition

The Ra-01SH-P module exposes a total of 16 pins, as shown in the pin diagram. The pin function definition table provides the detailed interface specifications.



Top View

Bottom View

Figure 5 Pin Diagram

Table 5 Pin Function Definition

No.	Name	Function
1	ANT	Antenna connection
2	GND	Ground
3	3V3	3.3V typical power supply
4	RESET	Reset pin
5	VCCPA	FEM chip supply pin. The module supplies power internally; leave this pin floating.
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
11	RF_EN	FEM chip enable pin, active high; internally pulled up by default. High level: operating state. Low level: 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. Must be reliably connected to ground to improve heat dissipation.

All general-purpose IO pins of the SX1262 are available in LoRa™ mode. Their mapping depends on the configuration of the RegDioMapping1 and RegDioMapping2 registers.

Table 6 IO Port Function Mapping

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	-	-	-

5. Schematic

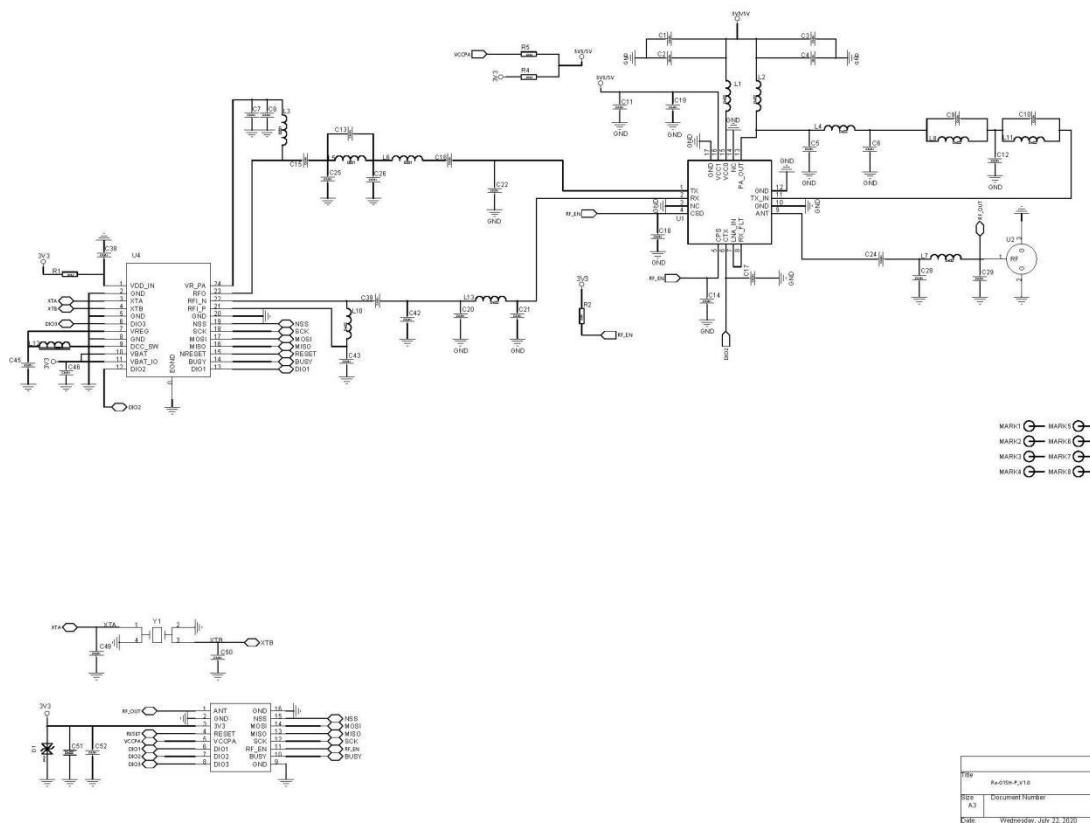


Figure 6 Schematic

6. Design Guide

6.1. Application Reference Circuit

(1) Special Pin Description

■ VCCPA pin

The module internally provides 3.3V supply to the PA chip, so this pin can be left floating.

■ RF_EN pin

RF_EN is the enable pin for the module's built-in PA chip. When it is at a high level, the module's RF is in normal transmit and receive state; when it is at a low level, the module's RF function is disabled, which can reduce the module's power consumption.

In the default BOM configuration, RF_EN has an internal 10k Ω pull-up resistor and is therefore in the normal transmit/receive state by default. For low-power applications, use an external MCU to drive this pin low. When the pin is low, the default internal pull-up may cause leakage current. If the internal pull-up resistor is not required, contact Ai-Thinker to modify the BOM.

Table 7 RF Switch Truth

Mode	RF_EN
FEM powered off	0
FEM operating	1

The module therefore has four BOM configurations:

1. VCCPA floating; RF_EN with an internal 10k Ω pull-up resistor (default configuration).
2. VCCPA floating; RF_EN without an internal pull-up resistor.
3. VCCPA connected; RF_EN with an internal 10k Ω pull-up resistor.
4. VCCPA connected; RF_EN without an internal pull-up resistor.

(2) Typical Application Circuit

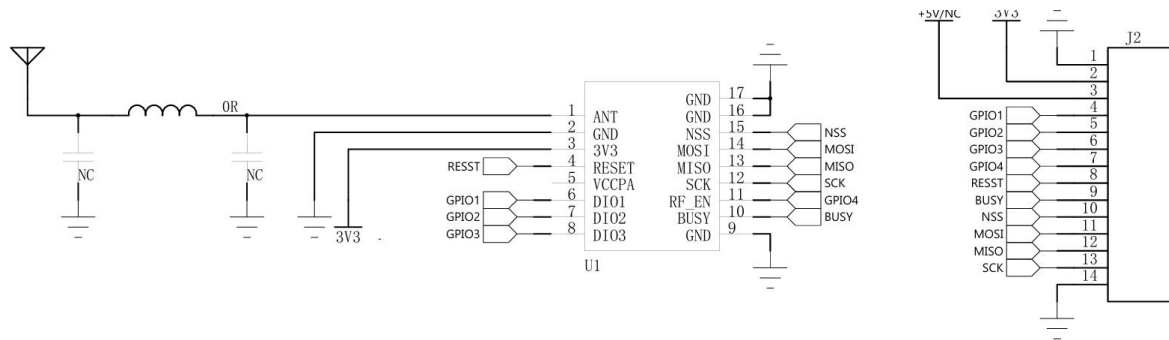


Figure 7 Typical Application Circuit

- VCCPA is powered internally by the module, so it can be left floating.
- For low-power applications, it is recommended that an external MCU GPIO control the module's RF_EN pin.
- The transmit-power level configured in the module's SX1262 must not exceed 3dBm. Otherwise, excessive power may damage the PA.
- When the module is transmitting, do not leave the module antenna port floating. No-load transmission produces a very high VSWR and creates a high risk of FEM chip damage. If leaving the ANT port floating cannot be avoided, the maximum power of the TX input signal must not exceed 0dBm to prevent chip damage.
- The module's RF_EN voltage must comply with the recommended value (1.2 – 3.6V), and the voltage must not exceed the module's 3V3 supply voltage. During power-on, it must be ensured that the module's 3V3 is powered on before RF_EN; simultaneous power-up is also acceptable.
- During antenna matching and tuning, the impedance may not yet be matched, resulting in a very high VSWR. Do not transmit at saturated power during this process, as excessive VSWR may damage the chip. Transmit at saturated power only after antenna impedance tuning has been completed.
- The supply current must meet the specification requirements. If the available current is limited, the module may not reach saturated transmit power.

(3) Additional Notes

- In addition to the SPI interface used for communication with the host MCU, BUSY/DIO1 shall be connected to an IO pin of the host MCU.

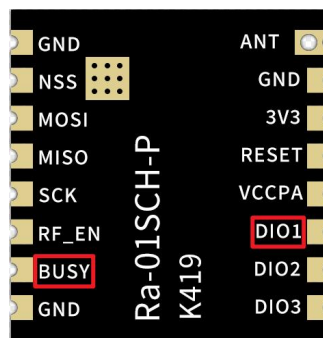


Figure 8 BUSY/DIO1 Application Notes

- When the antenna is soldered to the main board, reserve a pi-type matching network at the antenna interface.

6.2. Recommended PCB Footprint Dimensions

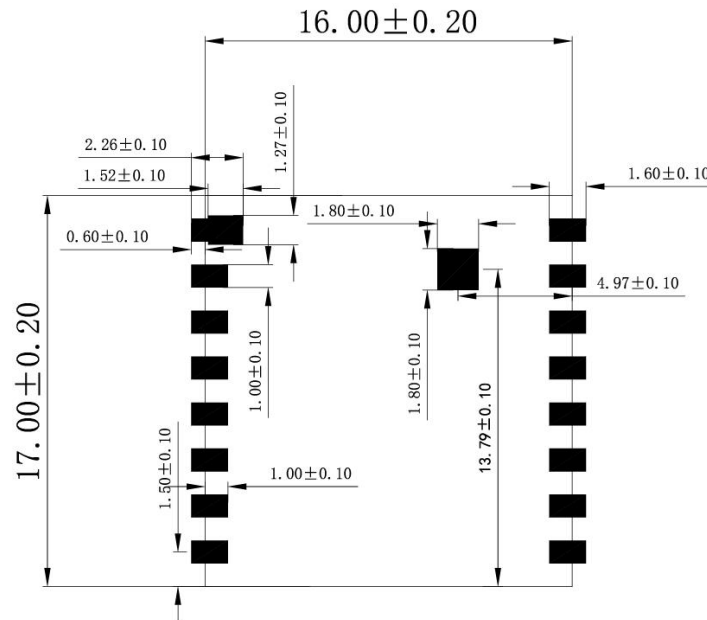


Figure 9 Recommended PCB Footprint Dimensions (Unit: mm)

6.3. Antenna Installation

- The Ra-01SH-P requires an external antenna. The castellated pads on the module can be routed to the main board.
- To achieve optimal antenna performance, install the antenna away from metal components.
- The antenna installation structure has a significant effect on module performance. Ensure that the antenna is exposed and preferably oriented vertically upward. If the module is installed inside an enclosure, use a high-quality antenna extension cable to extend the antenna outside the enclosure.
- Never install the antenna inside a metal enclosure, as this will significantly reduce the transmission distance.

6.4. Power Supply

- Recommend 3.3V voltage, with a peak current above 1A.
- If using DC-DC, it is recommended to control the ripple within 100mV.
- It is recommended to reserve positions for dynamic response capacitors in the DC-DC power supply circuit to optimize output ripple when the load changes significantly.
- It is recommended to add an ESD protection device to the 3.3V power interface.

- When designing the module power-supply circuit, it is recommended to reserve at least 30% additional current margin, which is beneficial for the long-term stable operation of the complete device.
- Pay attention to the correct connection of the positive and negative power terminals. Reverse connection may permanently damage the module.

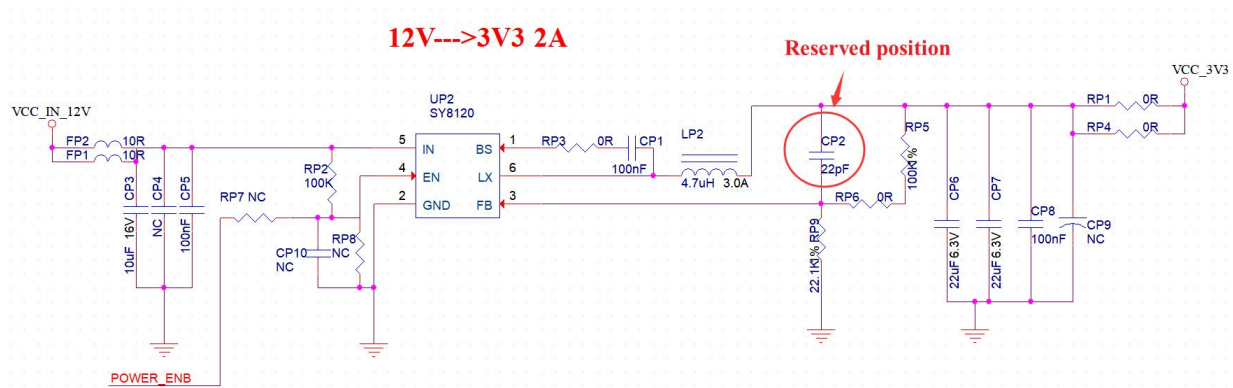


Figure 10 DC-DC Buck Circuit

6.5. GPIO Level Shifting

- Some I/O pins are brought out from the module. To use these I/O pins, it is recommended to connect a 10-100Ω resistor in series with each I/O pin. This helps suppress overshoot, stabilize signal levels, and benefits both EMI and ESD protection.
- The pull-up or pull-down configuration for special I/O pins must refer to the instructions in the specification, as it affects the module boot configuration.
- The module I/O pins level is 3.3V. If the host controller I/O voltage level does not match the module, a level-shifting circuit should be added.
- If an I/O pin is directly connected to a peripheral interface or pin headers, it is recommended to reserve space for an ESD protection device near the connector on the I/O trace.

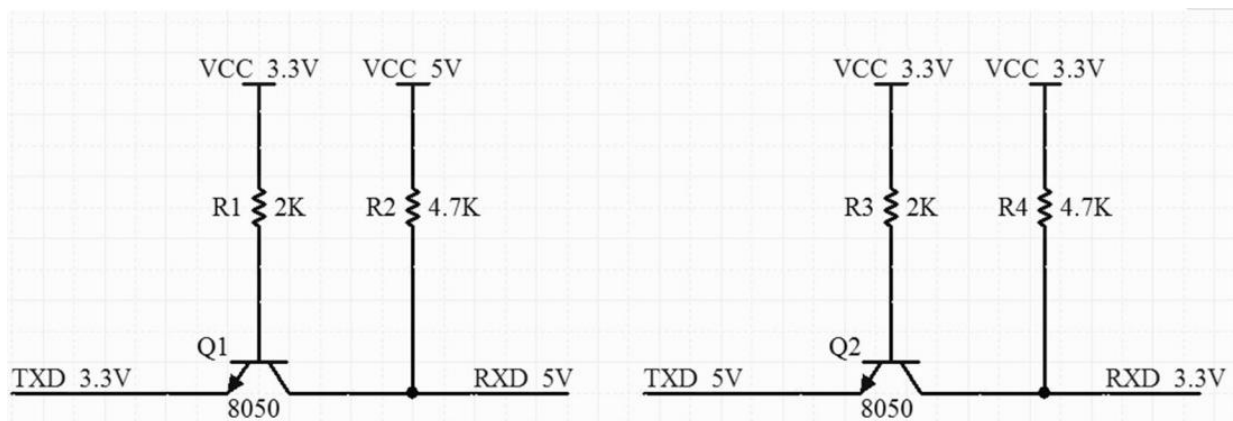


Figure 11 Level-shifting Circuit

6.6. Software Development

- The maximum input power of the FEM chip must not exceed +3dBm; otherwise, the FEM chip may be damaged. The user must configure the SX1262 output power strictly. An output power of 0dBm to 3dBm is recommended.
- This module consists of an SX1262 and peripheral circuitry. The user can operate it entirely according to the SX1262 datasheet.
- DIO1 and DIO2 are general-purpose IO pins and can be configured for multiple functions.
- The TX/RX RF switch can be controlled by the external MCU, or jointly controlled by the external MCU and DIO2 of the SX1262.
- Differences between LLCC68 and SX1262/SX1268:

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

Configurable spreading factors and receive bandwidths for SX1262/SX1268:

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.

Configurable spreading factors and receive bandwidths for LLCC68:

LoRa @ RX/TX, BW = 125, 250, or 500 kHz

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

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

- Obstacles along the line of sight will reduce the communication distance.
- Temperature, humidity, and co-channel interference may increase the packet loss rate.
- The ground absorbs and reflects radio waves; so the test performance is poor close to the ground.
- Seawater strongly absorbs radio waves, so the test performance is poor near the seaside.
- Metal objects near the antenna, or installation inside a metal enclosure, can cause severe signal attenuation.
- Incorrect power-register settings or an excessively high over-the-air data rate can reduce distance. (the higher data rate, the shorter transmission distance.)
- At room temperature, a supply voltage below the recommended value reduces transmit power; the lower the voltage, the lower the transmit power.
- Poor matching between the antenna and module, or poor antenna quality.

7.2. Precautions for Module Use

- Check the power supply and ensure it is within the recommended supply voltage. Exceeding the maximum value may permanently damage the module.
- Check power-supply stability. The voltage must not fluctuate substantially or frequently.
- Follow anti-static procedures during installation and use; as high-frequency components are sensitive to static electricity.
- Ensure that the humidity is not too high during installation and use, as some components are moisture-sensitive devices.
- If there are no special requirements, it is not recommended to use it under excessively high or low temperatures.

7.3. Sources of Interference to the Module

- Co-channel signals nearby may cause interference. Move away from the interference source or change the frequency or channel to avoid it.
- The clock waveform on the SPI is not compliant. Check if there is interference on the SPI lines. The SPI bus traces should not be too long.
- An unstable power supply may also cause garbled characters, so ensure the reliability of the power supply.
- Poor quality or excessively long extension cables and feeders can also lead to a high bit error rate.

8. Storage Conditions

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

The moisture sensitivity level (MSL) of the module is level 3.

The module must be used within 168 hours after vacuum bag removal under conditions of $25 \pm 5^{\circ}\text{C}$ and 60% RH. Otherwise, the module requires baking before being returned to production.

9. Reflow Soldering Profile

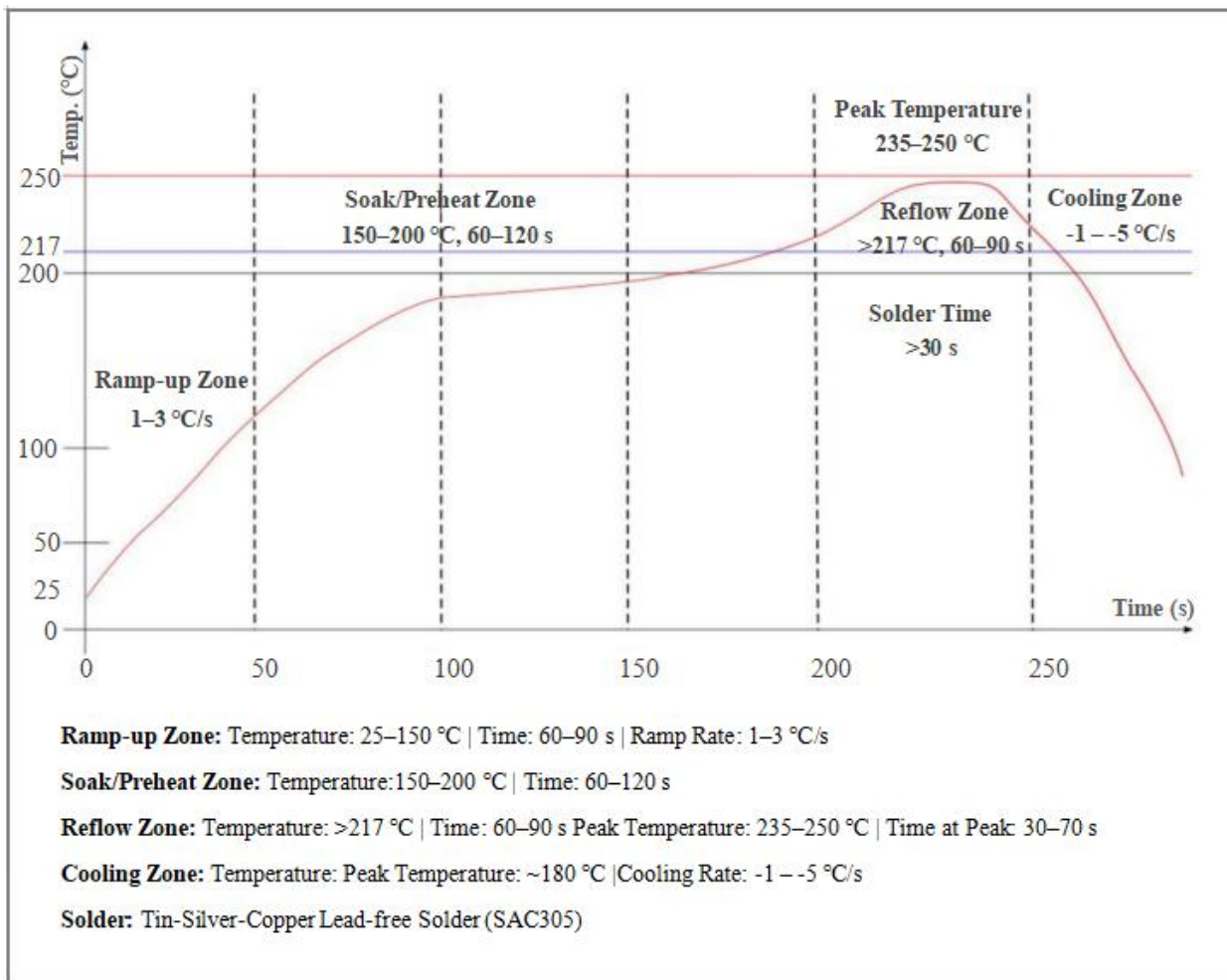


Figure 12 Reflow Soldering Profile

10. Packaging Information

The Ra-01SH-P is packaged in tape and reel, with 800 pcs/reel. As shown in the figure below:



Figure 13 Tape and Reel Packaging Diagram

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