E01C-ML01SP2 User Manual

SI24R1 + 2.4GHz 100mW SPI Surface Mount Wireless Module



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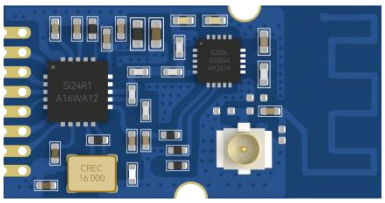
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1. Overview

1.1 Introduction



The E01C-ML01SP2 is a small-sized, PCB -integrated, 2.4GHz patch-type wireless module with a maximum transmit power of 100mW , independently developed based on the domestically produced SI24R1 core .

The product incorporates a power amplifier (PA) and a low-noise amplifier (LNA) on the original basis, which enables the maximum transmit power to reach 100mW while also further improving the receive sensitivity. Overall communication stability is significantly improved compared to products without power amplifiers and low-noise amplifiers.

This product has obtained authoritative certification reports from domestic and international authorities such as FCC , CE , and RoHS , and uses an industrial-grade high-precision 16MHz crystal oscillator.

Since the E01C-ML01SP2 is a pure RF transceiver module, it requires the use of an MCU driver or a dedicated SPI debugging tool.

1.2 Features and Functions

- Ultra-compact size, only 12.8 x 25 mm;
- The RFX2401C power amplifier solution has a maximum transmit power of 100mW and is software-adjustable in multiple levels.
- Under ideal conditions, the communication distance can reach 1.8km ;
- It also features a PCB onboard antenna and an I PX interface, allowing users to choose the appropriate one based on their needs .
- Professional radio frequency shielding cover, anti-interference and anti-static;
- Supports global unlicensed ISM 2.4GHz band;
- Supports over-the-air speeds of 2Mbps, 1Mbps, and 250kbps;
- 125 communication channels to meet the application needs of multi-point communication, packet processing, frequency hopping, etc.
- Connects to the MCU via SPI interface, with a speed of 0-10Mbps;
- It supports power supply from 2.0 to 3.6V, and can guarantee optimal performance even with a power supply greater than 3.3V;
- Industrial-grade standard design, supports long-term use in temperatures ranging from -40°C to + 85 °C ;

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1.3 Application scenarios

- Wearable devices;
- Smart home and industrial sensors, etc.;
- Security systems, positioning systems;
- Wireless remote control, drone;
- Wireless game remote control;
- Healthcare products;
- Wireless voice communication, wireless headphones;
- Applications in the automotive industry.

2. Specifications

2.1 Limiting parameters

Main parameters	Performance		Remark
	Minimum value	Maximum value	
Power supply voltage (V)	0	3.6	Module permanently burned out if voltage exceeds 3.6V
Blocking power (dBm)	-	10	The probability of burning is relatively low when used at close range.
Operating temperature (°C)	-40	85	Industrial grade

2.2 Operating parameters

Main parameters		Performance			Remark
		Minimum value	Typical value	Maximum value	
Operating voltage (V)		2.0	3.3	3.6	≥3.3V can guarantee output power
Communication level (V)		-	3.3	-	Using 5V TTL carries a risk of burnout.
Operating temperature (°C)		-40	-	85	Industrial-grade design
Operating frequency band (GHz)		2.4	-	2.525	Supports ISM band
Power consumption	Emission current	-	120	-	Instantaneous power consumption
	Received current (mA)	-	28.5	-	-
	Dormant current (μA)	-	2	-	Software shutdown
Maximum transmit power (dBm)		19.7	20	20.2	-
Receiver sensitivity (dBm)		-96.5	-96	-97.5	The air speed is 250kbps

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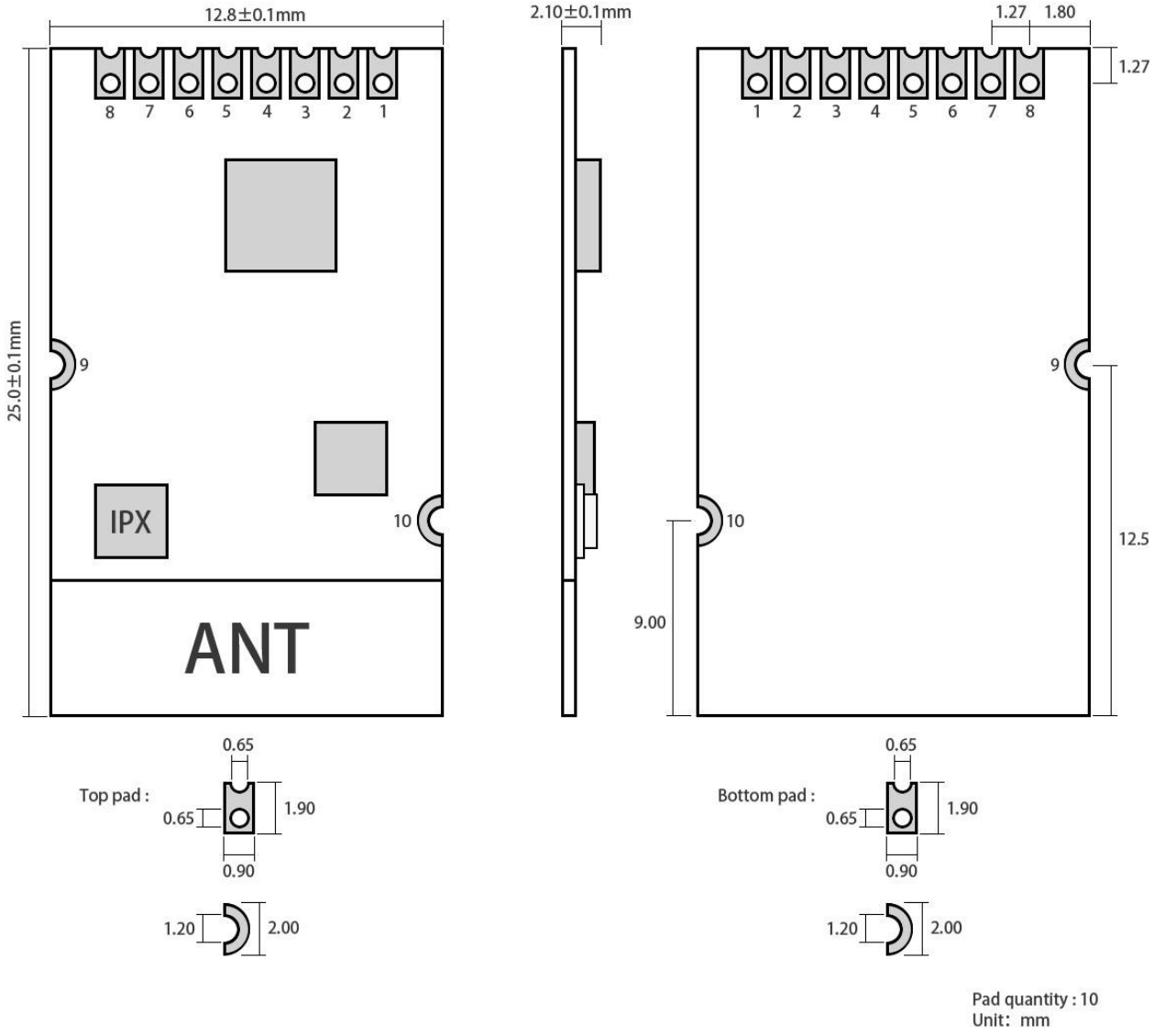
Air speed (bps)	250k	-	2M	User Programming Control

Main parameters	Describe	Remark
Reference distance	1800m	Clear and open terrain, antenna gain 5dBi, antenna height 2.5 meters, air speed 250kbps
FIFO	32Byte	Maximum length of a single transmission
Crystal oscillator frequency	16MHz	-
Modulation method	GFSK	-
Packaging method	patch	-
Interface method	1.27mm pin	-
Communication interface	SPI	0 ~ 10Mbps
External dimensions	12.8 * 25mm	Excluding SMA
Antenna Interface	PCB/IPEX	The default antenna is a PCB antenna, with an equivalent impedance of approximately 50 Ω.

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3. Mechanical Dimensions and Pin Definitions



Pin number	Pin Name	Pin direction	Pin Applications
1	VCC	-	The power supply must be between 2.0 and 3.6V.
2	CE	enter	Module control pins
3	CSN	enter	The module's chip select pin is used to initiate an SPI communication.
4	SCK	enter	Module SPI bus clock
5	MOSI	enter	Module SPI data input pin
6	MISO	Output	Module SPI data output pin
7	IRQ	Output	Module interrupt signal output, active low.
8	GND	-	Ground wire, connected to power reference ground
9	GND	-	Ground wire, connected to power reference ground
10	GND	-	Ground wire, connected to power reference ground

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Chapter 4 Basic Operations

4.1 Hardware Design

- It is recommended to use a DC regulated power supply to power this module, with the power supply ripple coefficient as small as possible, and the module must be reliably grounded;
- Please ensure the correct connection of the power supply positive and negative terminals. Reversing the connection may cause permanent damage to the module.
- Please check the power supply and ensure it is within the recommended voltage range. Exceeding the maximum value will cause permanent damage to the module.
- Please check the power supply stability; the voltage should not fluctuate significantly or frequently.
- When designing power supply circuits for modules, it is often recommended to retain a margin of more than 30% to ensure long-term stable operation of the entire unit.
- The module should be kept as far away as possible from power supplies, transformers, high-frequency traces, and other parts with high electromagnetic interference.
- High-frequency digital traces, high-frequency analog traces, and power traces must avoid the area under the module. If it is absolutely necessary to run the traces under the module, assuming the module is soldered on the Top Layer, lay ground copper on the Top Layer of the module contact area (all copper and well grounded), and run the traces close to the digital part of the module on the Bottom Layer .
- Assuming the module is soldered or placed in the Top Layer, it is also wrong to arbitrarily route traces in the Bottom Layer or other layers, as this will affect the module's stray emissions and reception sensitivity to varying degrees .
- If there are devices around the module that cause significant electromagnetic interference, it will greatly affect the module's performance. Depending on the intensity of the interference, it is recommended to keep them away from the module. If possible, appropriate isolation and shielding can be implemented.
- If there are traces around the module that cause significant electromagnetic interference (high-frequency digital, high-frequency analog, power supply traces), it will greatly affect the module's performance. Depending on the intensity of the interference, it is recommended to keep them away from the module. If possible, appropriate isolation and shielding can be implemented.
- If the communication line uses a 5V level, a 1k-5.1k resistor must be connected in series (not recommended, as there is still a risk of damage) ;
- Try to stay away from TTL protocols that also use a physical layer of 2.4GHz, such as USB 3.0;
- The antenna mounting structure has a significant impact on module performance; therefore, it is essential to ensure that the antenna is exposed, ideally vertically upwards. When the module is installed inside the housing, a high-quality antenna extension cable can be used to extend the antenna to the outside of the housing.
- Antennas must never be installed inside a metal casing, as this will greatly reduce the transmission distance;
- Onboard PCB antennas should be kept away from conductors or other sources of interference as much as possible.

4.2 Software writing

- This module SI24R1+PA+LNA has the same driving method as SI24R1. Users can operate it in accordance with the

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SI24R1 chip datasheet (see SI24R1 datasheet for details) .

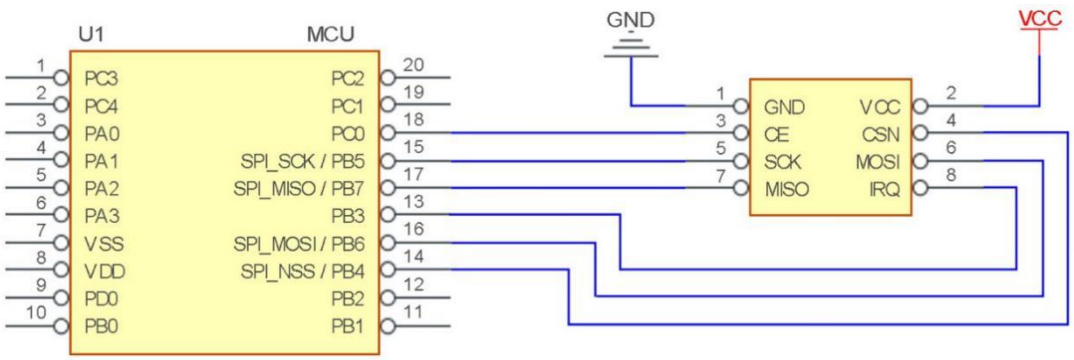
- Power ratings:

S I24R1 Register Settings Table:

Address (Hex)	Mnemonic	Bit	Reset Value	Description
06	RF_SETUP	-	-	RF configuration
-	RF_PWR	2:0	110	Set TX transmit power 111:7dBm 110:4dBm 101:3dBm 100:1dBm 011:0dBm 010: -4dBm 001: -6dBm 000: -12dBm

- 011: Preamplifier 0dBm, output 20 dBm ;
- 010: Preamplifier -4dBm, output 16dBm ;
- 011: Preamplifier -6dBm, output 12dBm ;
- 000: Preamplifier -12dBm, output 6dBm ;
- IRQ is the interrupt pin, which can be used to wake up the microcontroller and achieve fast response; it can be left unconnected and the interrupt status can be obtained by SPI polling (not recommended, as it is detrimental to overall power consumption and has low efficiency) .
- CE can be connected to a high level for a long time, but the module must be set to POWER DOWN mode before writing to the register. It is recommended to control CE with a microcontroller pin .
- The CE pin is connected to the LNA enable pin. When CE=1, the LNA is turned on; when CE=0, the LNA is turned off. This operation is completely consistent with the transmit/receive mode of the nRF24L01; that is, the user does not need to worry about the LNA operation at all .
- If the user requires automatic response, the CE pin must remain high during transmission, not just for more than 10μs as mentioned in the nRF24L01+ manual. The correct operation is: CE=1 to trigger transmission, and continue until transmission is complete before setting CE=0, not after 10μs. The reason is that after the SI24R1+ transmits, it immediately switches to receive mode. If CE=0 at this point, the LNA is already off, which will negatively impact receiver sensitivity.

5. Basic Circuits



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6. Frequently Asked Questions

6.1 Transmission distance is not ideal

- When there are obstacles in line-of-sight communication, the communication distance will be reduced accordingly ;
- Temperature, humidity, and co-channel interference can all lead to increased packet loss rates in communications .
- The ground absorbs and reflects radio waves, and the test results are poor when the ground is close to the ground .
- Seawater has a strong ability to absorb radio waves, so testing results are poor at the seaside .
- If there are metal objects near the antenna, or if it is placed inside a metal casing, the signal attenuation will be very severe .
- Power register settings are incorrect; air speed is set too high (the higher the air speed, the shorter the distance) .
- At room temperature, the power supply voltage is lower than the recommended value; the lower the voltage, the lower the power output .
- The antenna may be poorly matched with the module or have quality issues.

6.2 Modules are easily damaged.

- Please check the power supply and ensure it is within the recommended voltage range. Exceeding the maximum value will cause permanent damage to the module .
- Please check the power supply stability; the voltage should not fluctuate significantly or frequently .
- Please ensure anti-static operation during installation and use, as high-frequency devices are sensitive to electrostatic discharge .
- Please ensure that the humidity is not too high during installation and use, as some components are humidity-sensitive .
- Unless there are special requirements, it is not recommended to use it at excessively high or low temperatures.

6.3 Too high error rate

- If there is interference from a co-channel signal nearby, move away from the source of interference or change the frequency or channel to avoid the interference.
- If the clock waveform on the SPI is not standard , check for interference on the SPI line and ensure that the SPI bus traces are not too long.
- An inadequate power supply can also cause garbled characters, so it is essential to ensure the reliability of the power supply.
- Poor quality or excessive length of extension lines or feeders can also lead to a high bit error rate.

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7. Welding Operation Instructions

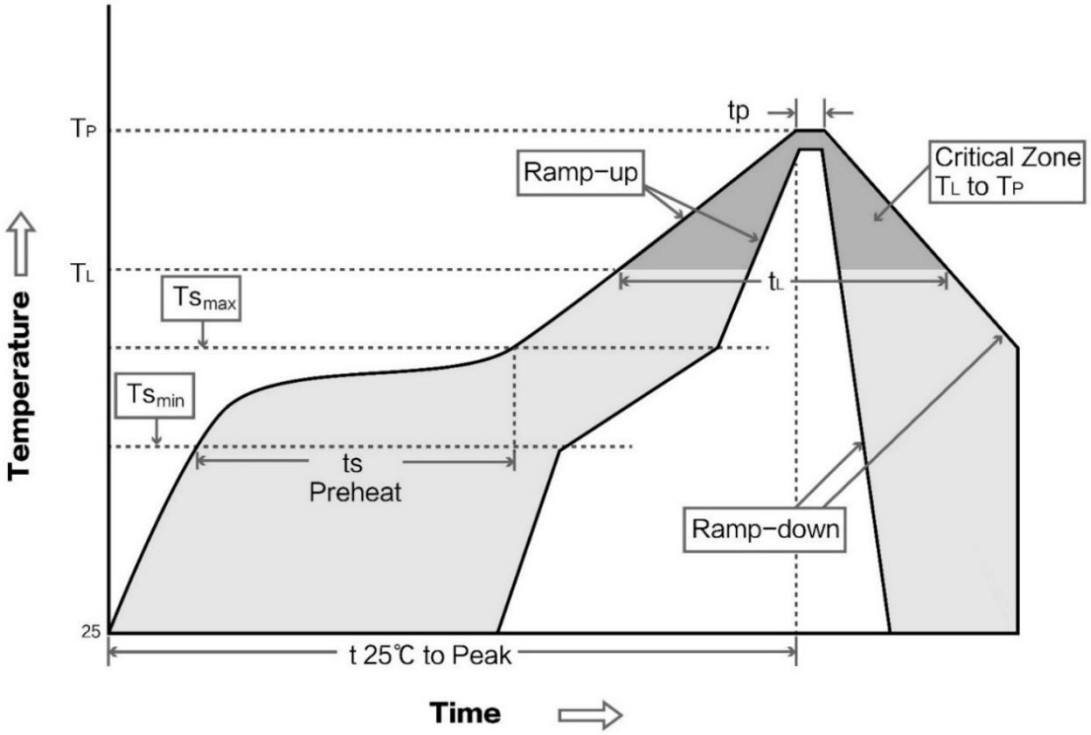
7.1 Reflow soldering temperature

Profile Feature	Curve characteristics	Sn-Pb Assembly	Pb-Free Assembly
Solder Paste	Solder paste	Sn63/Pb37	Sn96.5/Ag3/Cu0.5
Preheat Temperature min (Tsmin)	Minimum preheating temperature	100 ℃	150 ℃
Preheat temperature max (Tsmax)	Maximum preheating temperature	150 ℃	200 ℃
Preheat Time (Tsmin to Tsmax)(ts)	preheating time	60-120 sec	60-120 sec
Average ramp-up rate(Tsmax to Tp)	Average rate of ascent	3 ℃ /second max	3 ℃ /second max
Liquidous Temperature (TL)	Liquid phase temperature	183 ℃	217 ℃
Time(tL)Maintained Above(TL)	Time above the liquidus line	60-90 sec	30-90 sec
Peak temperature (Tp)	Peak temperature	220-235 ℃	230-250 ℃
Aveage ramp-down rate（Tp to Tsmax）	Average rate of descent	6 ℃ /second max	6 ℃ /second max
Time 25 ℃ to peak temperature	from 25 ℃ to peak temperature	6 minutes max	8 minutes max

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7.2 Reflow Soldering Profile



8. Related Models

Module model	Chip solutions	Carrier frequency	Transmit power	Communication distance	Packaging	Antenna type
		Hz	dBm	m		
E01-ML01S	nRF24L01 +	2.4G	0	100	SMD	PCB
E01-ML01D	nRF24L01 +	2.4G	0	100	DIP	PCB
E01-ML01IPX	nRF24L01 +	2.4G	0	200	SMD	IPEX
E01-2G4M13S	nRF24L01 +	2.4G	13	1200	SMD	PCB
E01-ML01SP2	nRF24L01 +	2.4G	20	1800	SMD	PCB/IPEX
E01-ML01SP4	nRF24L01 +	2.4G	20	2000	SMD	IPEX
E01-ML01DP4	nRF24L01 +	2.4G	20	1800	DIP	PCB
E01-ML01DP5	nRF24L01 +	2.4G	20	2500	DIP	SMA-K
E01-2G4M27D	nRF24L01 +	2.4G	27	5000	DIP	SMA-K
All models of wireless modules in the E01 series are interoperable.						

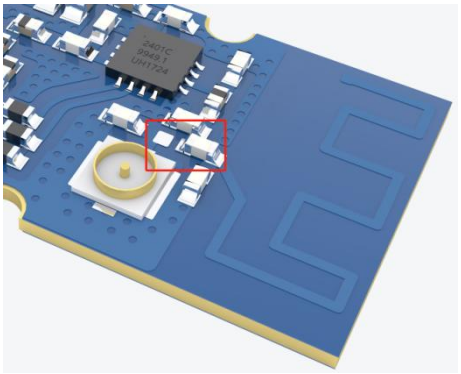
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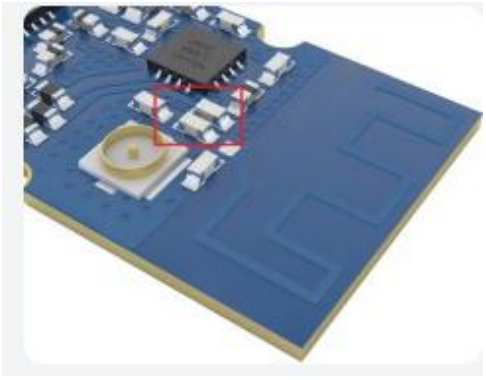
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9. Antenna Guide

Product Model	Type	Frequency band	Gain	Size	Feeder	Interface	Features
		Hz	dBi	mm	cm		
TX2400-NP-5010	Flexible antenna	2.4G	2.0	1 0x50	-	I PEX	Flexible FPC antenna
TX2400-JZ-3	Rubber Antenna	2.4G	2.0	30	-	SMA-J	Ultra-short straight omnidirectional antenna
TX2400-JZ-5	Rubber Antenna	2.4G	2.0	50	-	SMA-J	Ultra-short straight omnidirectional antenna
TX2400-JW-5	Rubber Antenna	2.4G	2.0	50	-	SMA-J	Fixed bending , omnidirectional antenna
TX2400-JK-11	Rubber Antenna	2.4G	2.5	110	-	SMA-J	Bendable rubber rod , omnidirectional antenna
TX2400-JK-20	Rubber Antenna	2.4G	3.0	200	-	SMA-J	Bendable rubber rod , omnidirectional antenna
TX2400-XPL-150	Sucker Antenna	2.4G	3.5	150	150	SMA-J	Miniature suction cup antenna , cost-effective

10. Antenna Selection



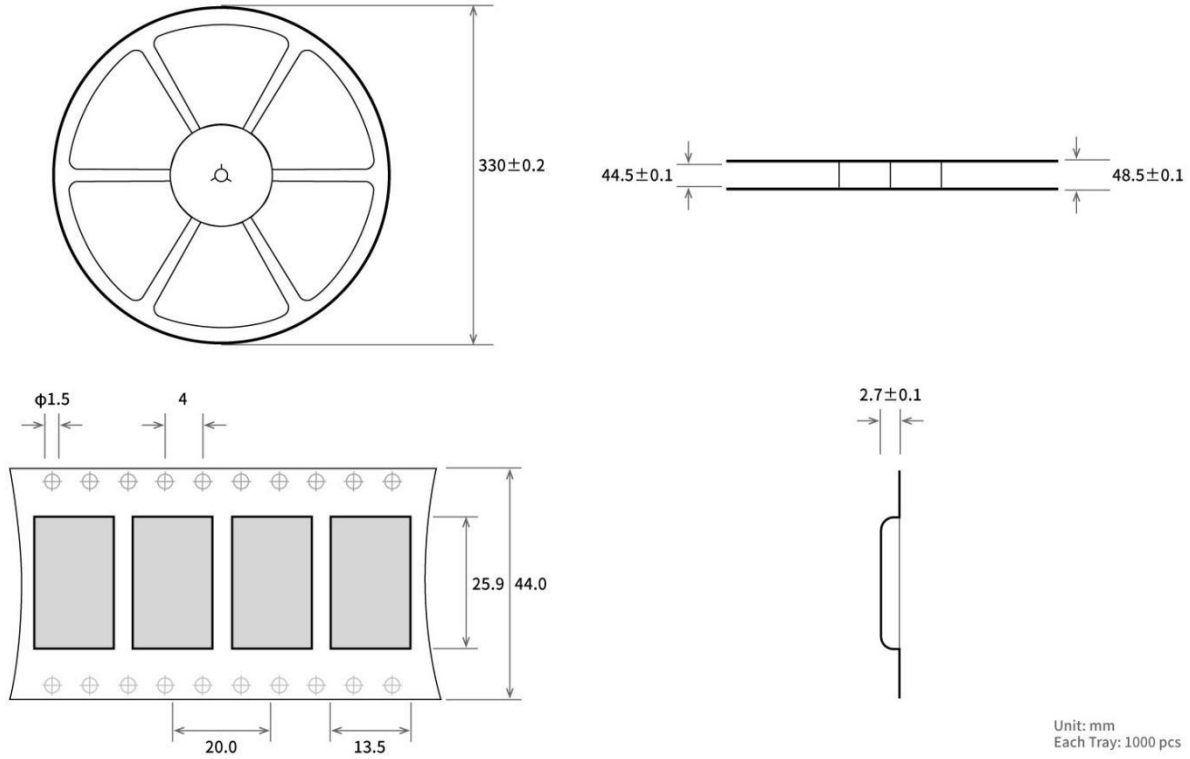


Enable PCB onboard antenna Enable IPEX interface

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11. Bulk Packaging Methods



Revision History

Version	Revision Date	Revision Notes	maintainer
1.0	2017-11-15	Initial version	huaa
1.1	2018-05-22	Content added	huaa
1.2	2018-09-13	Manual Split	huaa
1.3	2019-01-26	Content added	Ray
1.4	2019-11-06	Correcting errors	Ren
1.5	2019-11-18	Correcting errors	Ren
1.6	2026-1-7	Correcting errors	Hao

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