



# **TS24-U Module Datasheet**

Version: 20221128

## Contents

|          |                                                          |           |
|----------|----------------------------------------------------------|-----------|
| <b>1</b> | <b>Product overview</b>                                  | <b>2</b>  |
| 1.1      | Features . . . . .                                       | 2         |
| 1.2      | Applications . . . . .                                   | 2         |
| 1.3      | Change history . . . . .                                 | 3         |
| <b>2</b> | <b>Module interfaces</b>                                 | <b>4</b>  |
| 2.1      | Dimensions and footprint . . . . .                       | 4         |
| 2.2      | Pin definition . . . . .                                 | 5         |
| <b>3</b> | <b>Electrical parameters</b>                             | <b>9</b>  |
| 3.1      | Absolute electrical parameters . . . . .                 | 9         |
| 3.2      | Normal working conditions . . . . .                      | 9         |
| 3.3      | TX and RX power consumption . . . . .                    | 10        |
| 3.4      | Working current . . . . .                                | 10        |
| <b>4</b> | <b>RF parameters</b>                                     | <b>12</b> |
| 4.1      | Basic RF features . . . . .                              | 12        |
| 4.2      | TX performance . . . . .                                 | 12        |
| 4.3      | RX performance . . . . .                                 | 12        |
| <b>5</b> | <b>Antenna information</b>                               | <b>14</b> |
| 5.1      | Antenna type . . . . .                                   | 14        |
| 5.2      | Antenna interference reduction . . . . .                 | 14        |
| <b>6</b> | <b>Packaging information and production instructions</b> | <b>17</b> |
| 6.1      | Mechanical dimensions . . . . .                          | 17        |
| 6.2      | Side view . . . . .                                      | 18        |
| 6.3      | Schematic diagram of footprint . . . . .                 | 18        |
| 6.4      | Production instructions . . . . .                        | 19        |
| 6.5      | Recommended oven temperature curve . . . . .             | 21        |
| 6.6      | Storage conditions . . . . .                             | 24        |
| <b>7</b> | <b>MOQ and packaging information</b>                     | <b>25</b> |
| <b>8</b> | <b>Appendix: Statement</b>                               | <b>26</b> |



TS24-U is a Matter over Thread module that Tuya has developed. It consists of a highly integrated RF processing chip EFR32MG24, a few peripherals, a built-in 802.15.4 PHY/MAC Thread network protocol stack, and rich library functions.

## 1 Product overview

TS24-U is embedded with a low-power 32-bit ARM Cortex-M33 core, 1536-KB flash program memory, 256-KB RAM, and abundant peripheral resources. It integrates all function libraries of the Thread MAC and TCP/IP. You can develop embedded Thread products as required.

### 1.1 Features

- Embedded ARM Cortex-M 33 processor having a low-power 32-bit CPU and having DSP instructions and floating-point units, which can also function as an application processor
- Clock rate: 78 MHz
- Wide operating voltage: 2.0 to 3.8 V
- Peripherals: 9 GPIOs, 1 UART, 2 ADCs, and 5 PWMs
- Thread connectivity
  - Support 802.15.4 MAC/PHY
  - Working channels 11 to 26 @2.400 to 2.483 GHz, air interface rate: 250 Kbps
  - Up to +19dBm output power
  - 35 uA/MHz power consumption during running; 5-μA sleep current
  - PCB antenna inside
  - Onboard antenna with a gain of -1 dBi
  - Operating temperature: -40°C to 105°C
  - Support hardware encryption and AES 128/256

### 1.2 Applications

- Intelligent building
- Smart household and home appliances
- Smart socket and light
- Industrial wireless control
- Baby monitor
- Network camera
- Intelligent bus

### 1.3 Change history

| Update date | Updated content            | Version after update |
|-------------|----------------------------|----------------------|
| 2022/09/08  | This is the first release. | V1.0.0               |

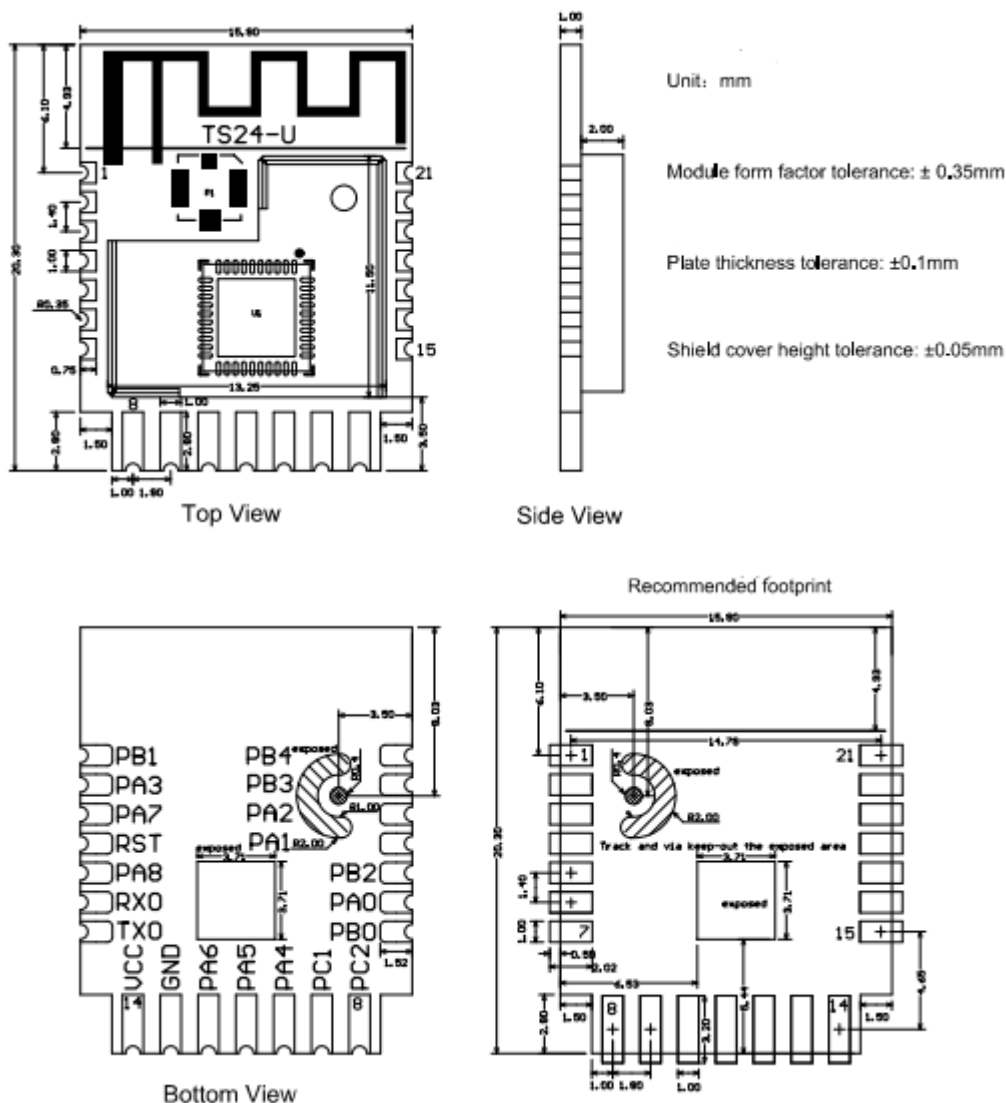
## 2 Module interfaces

### 2.1 Dimensions and footprint

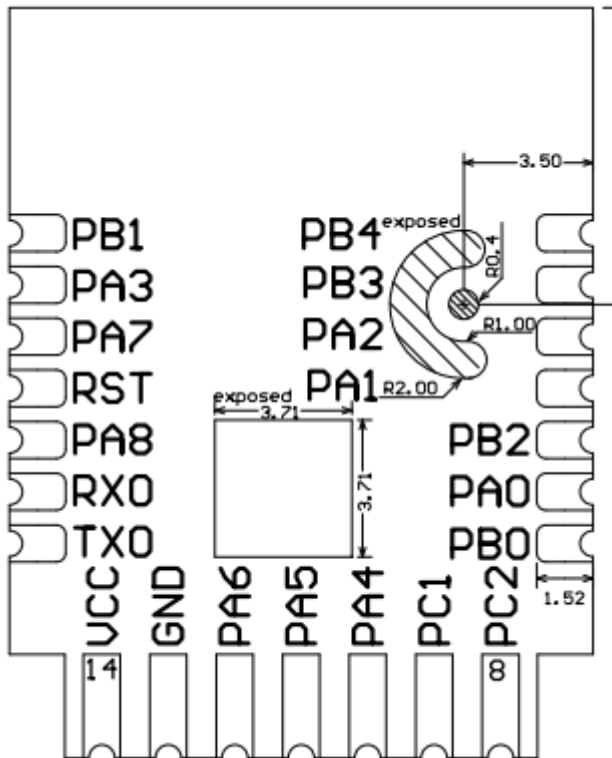
TS24-U has 3 lines of pins. The spacing of pins at the two sides is  $1.4 \pm 0.1$  mm, and the spacing of pins at the bottom is  $1.8 \pm 0.1$  mm.

The dimensions of the TS24-U are  $20.3 \pm 0.35$  mm (L)  $\times$   $15.8 \pm 0.35$  mm (W)  $\times$   $3.0 \pm 0.1$  mm (H).

The dimensions of TS24-U are as follows:



## 2.2 Pin definition



| Pin number | Symbol | Type | Function                                                         |
|------------|--------|------|------------------------------------------------------------------|
| 1          | PB4    | I/O  | Common I/O pin, which corresponds to PB04 on the internal IC     |
| 2          | PB3    | I/O  | Common I/O pin, which corresponds to PB03 on the internal IC     |
| 3          | PA2    | I/O  | Burning pin, SWDIO, which corresponds to PA02 on the internal IC |

| Pin number | Symbol | Type | Function                                                         |
|------------|--------|------|------------------------------------------------------------------|
| 4          | PA1    | I/O  | Burning pin, SWCLK, which corresponds to PA01 on the internal IC |
| 5          | PB2    | I    | ADC pin, which corresponds to PB02 on the internal IC            |
| 6          | PA0    | I/O  | Common I/O pin, which corresponds to PA00 on the internal IC     |
| 7          | PB0    | I/O  | Common I/O pin, which corresponds to PB00 on the internal IC     |
| 8          | PC2    | I/O  | Support hardware PWM and correspond to PC02 on the internal IC   |
| 9          | PC1    | I/O  | Support hardware PWM and correspond to PC01 on the internal IC   |
| 10         | PA4    | I/O  | Support hardware PWM and correspond to PA04 on the internal IC   |

| Pin number | Symbol | Type | Function                                                                           |
|------------|--------|------|------------------------------------------------------------------------------------|
| 11         | PA5    | I/O  | Support hardware PWM and correspond to PA05 on the internal IC                     |
| 12         | PA6    | I/O  | Support hardware PWM and correspond to PA06 on the internal IC                     |
| 13         | GND    | P    | Power supply reference ground                                                      |
| 14         | VCC    | P    | Power supply pin (3.3V)                                                            |
| 15         | TX0    | I/O  | UART_TXD0, burning authorization pin, which corresponds to PD03 on the internal IC |
| 16         | RX0    | I/O  | UART_RXD0, burning authorization pin, which corresponds to PD02 on the internal IC |
| 17         | PA8    | I    | ADC pin, which corresponds to PA08 on the internal IC                              |

| Pin number | Symbol | Type | Function                                                              |
|------------|--------|------|-----------------------------------------------------------------------|
| 18         | RST    | I/O  | Reset pin, low active, which corresponds to RESETn on the internal IC |
| 19         | PA7    | I/O  | Common I/O pin, which corresponds to PA07 on the internal IC          |
| 20         | PA3    | I/O  | Common I/O pin, which corresponds to PA03 on the internal IC          |
| 21         | PB1    | I/O  | Common I/O pin, which corresponds to PB01 on the internal IC          |

**Note:**

- P indicates a power supply pin and I/O indicates an input/output pin.
- Pin 3, 4, 13, 14, and 18 are burning pins, which are not exposed by default. During routing, customers should bypass them.

### 3 Electrical parameters

#### 3.1 Absolute electrical parameters

| Parameter                      | Description          | Minimum value | Maximum value | Unit |
|--------------------------------|----------------------|---------------|---------------|------|
| T <sub>s</sub>                 | Storage temperature  | -50           | 150           | °C   |
| V <sub>BAT</sub>               | Power supply voltage | 2.0           | 3.8           | V    |
| ESD voltage (human body model) | TAMB-25°C            | -             | 2             | KV   |
| ESD voltage (machine model)    | TAMB-25°C            | -             | 0.5           | KV   |

#### 3.2 Normal working conditions

| Parameter      | Description           | Minimum value | Typical value | Maximum value | Unit |
|----------------|-----------------------|---------------|---------------|---------------|------|
| T <sub>a</sub> | Operating temperature | -40           | -             | 105           | °C   |
| VCC            | Operating voltage     | 2.0           | 3.3           | 3.8           | V    |
| VIL            | I/O low level input   | -             | -             | VDD*0.3       | V    |
| VIH            | I/O high level input  | VDD*0.7       | -             | -             | V    |
| VOL            | I/O low level output  | -             | -             | VDD*0.2       | V    |

| Parameter | Description           | Minimum value | Typical value | Maximum value | Unit |
|-----------|-----------------------|---------------|---------------|---------------|------|
| VOH       | I/O high level output | VDD*0.8       | -             | -             | V    |

### 3.3 TX and RX power consumption

| Working status | Mode | Rate     | Transmit power/receive | Average value | Peak value (Typical value) | Unit |
|----------------|------|----------|------------------------|---------------|----------------------------|------|
| Transmit       | -    | 250Kbps  | +19dBm                 | 175           | 180                        | mA   |
| Transmit       | -    | 250 Kbps | +10 dBm                | 55            | 60                         | mA   |
| Transmit       | -    | 250 Kbps | +0 dBm                 | 22            | 24                         | mA   |
| Receive        | -    | 250Kbps  | Constantly receive     | 7             | 9                          | mA   |

### 3.4 Working current

| Working mode | Working status, Ta = 25°C                       | Average value | Maximum value (Typical value) | Unit | Remark             |
|--------------|-------------------------------------------------|---------------|-------------------------------|------|--------------------|
| EZ mode      | The module is in fast network connection state. | 450           | 500                           | μA   | Low Power Firmware |

| Working mode       | Working status, Ta = 25°C                                    | Average value | Maximum value (Typical value) | Unit | Remark             |
|--------------------|--------------------------------------------------------------|---------------|-------------------------------|------|--------------------|
| Connected and busy | The module is connected to the network and in running state. | 150           | 200                           | μA   | Low Power Firmware |
| Connected and idle | The module is connected to the network and in idle state.    | 55            | 70                            | μA   | Low Power Firmware |
| Deep sleep mode    | Deep sleep mode, reserve 192-KB flash                        | 5             | -                             | μA   |                    |

## 4 RF parameters

### 4.1 Basic RF features

| Parameter              | Description                       |
|------------------------|-----------------------------------|
| Working frequency      | 2.405 to 2.480 GHz                |
| Zigbee standard        | IEEE 802.15.4                     |
| Data transmission rate | 250 Kbps                          |
| Antenna type           | PCB antenna with a gain of -1 dBi |

### 4.2 TX performance

TX performance

| Parameter                                    | Minimum value | Typical value | Maximum value | Unit |
|----------------------------------------------|---------------|---------------|---------------|------|
| Output power (250Kbps)                       | -30           | 15            | 19            | dBm  |
| Output power adjustment stepping             | -             | 0.5           | 1             | dBm  |
| Output spectrum adjacent channel suppression | -             | -31           | -             | dBc  |
| Frequency error                              | -15           | -             | 15            | ppm  |

### 4.3 RX performance

RX sensitivity

| Parameter                         | Minimum value | Typical value | Maximum value | Unit |
|-----------------------------------|---------------|---------------|---------------|------|
| PER<8%, RX sensitivity (250 Kbps) | -104          | -104          | -103          | dBm  |

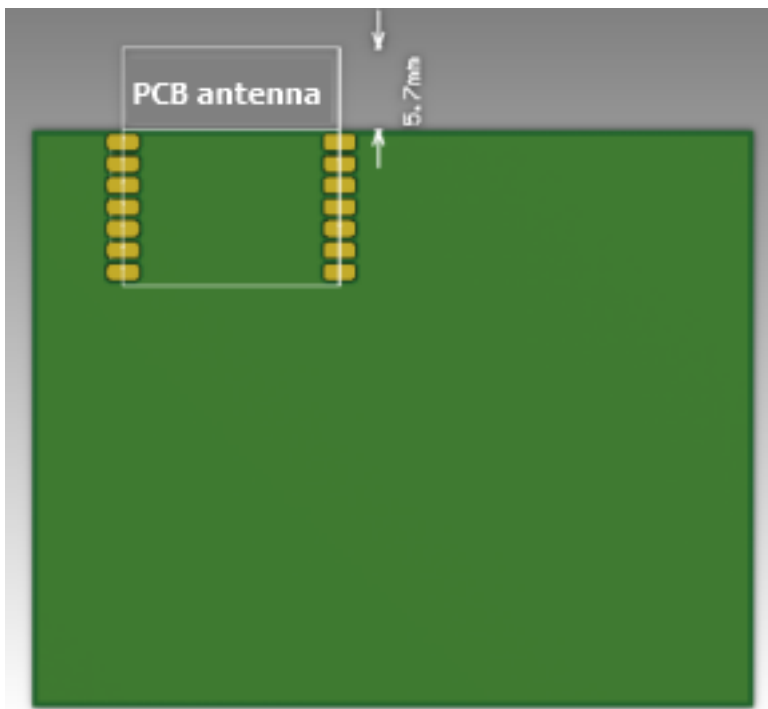
## 5 Antenna information

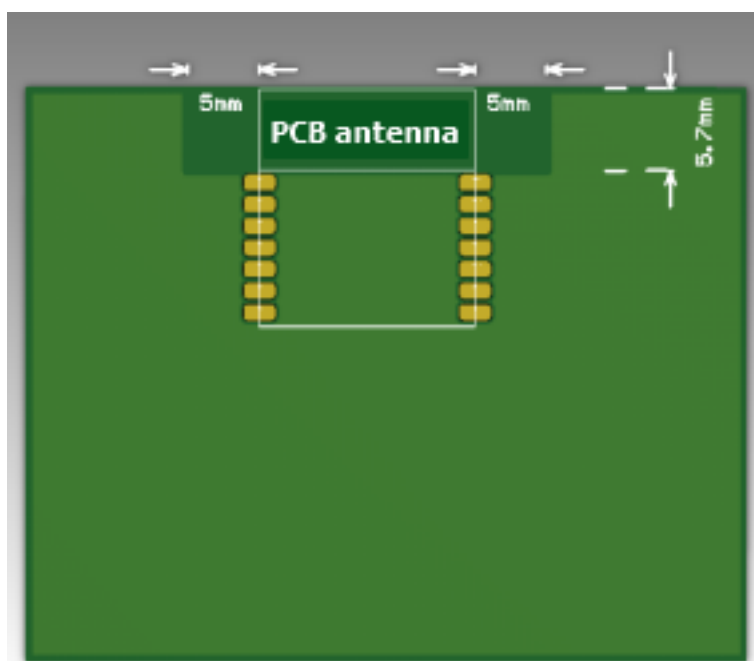
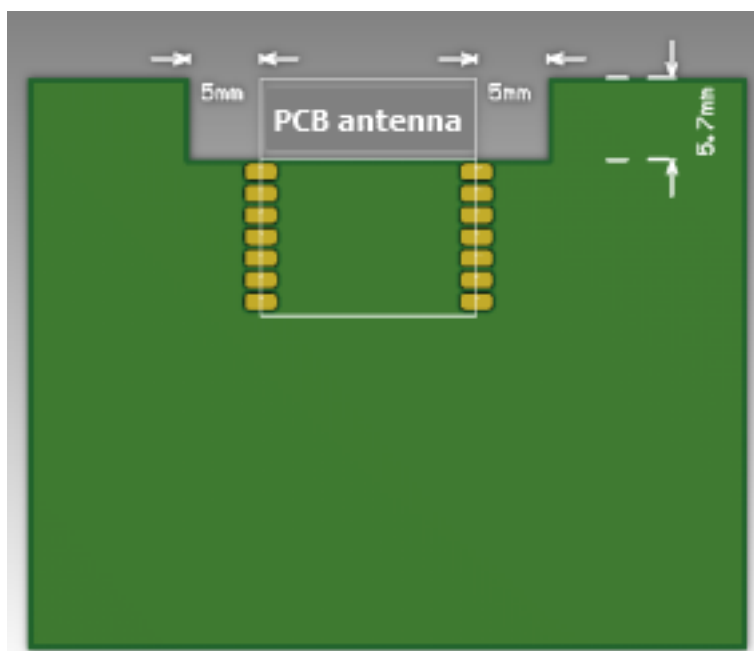
### 5.1 Antenna type

TS24-U uses the PCB antenna.

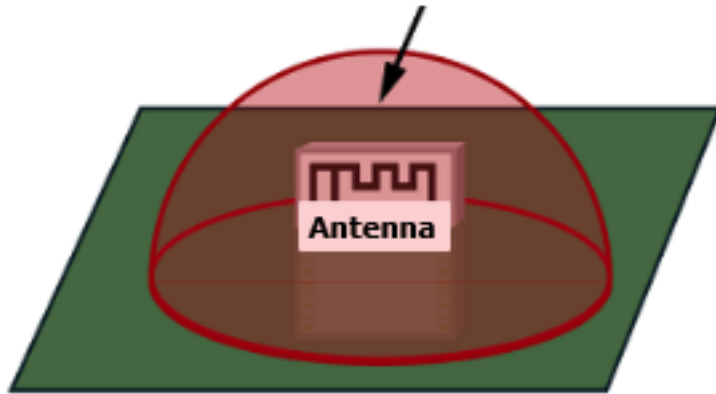
### 5.2 Antenna interference reduction

To ensure optimal RF performance when the Thread module uses a PCB antenna, it is recommended that the antenna be at least 15 mm away from other metal parts. To prevent adverse impact on the antenna radiation performance, avoid copper or traces within the antenna area on the PCB.





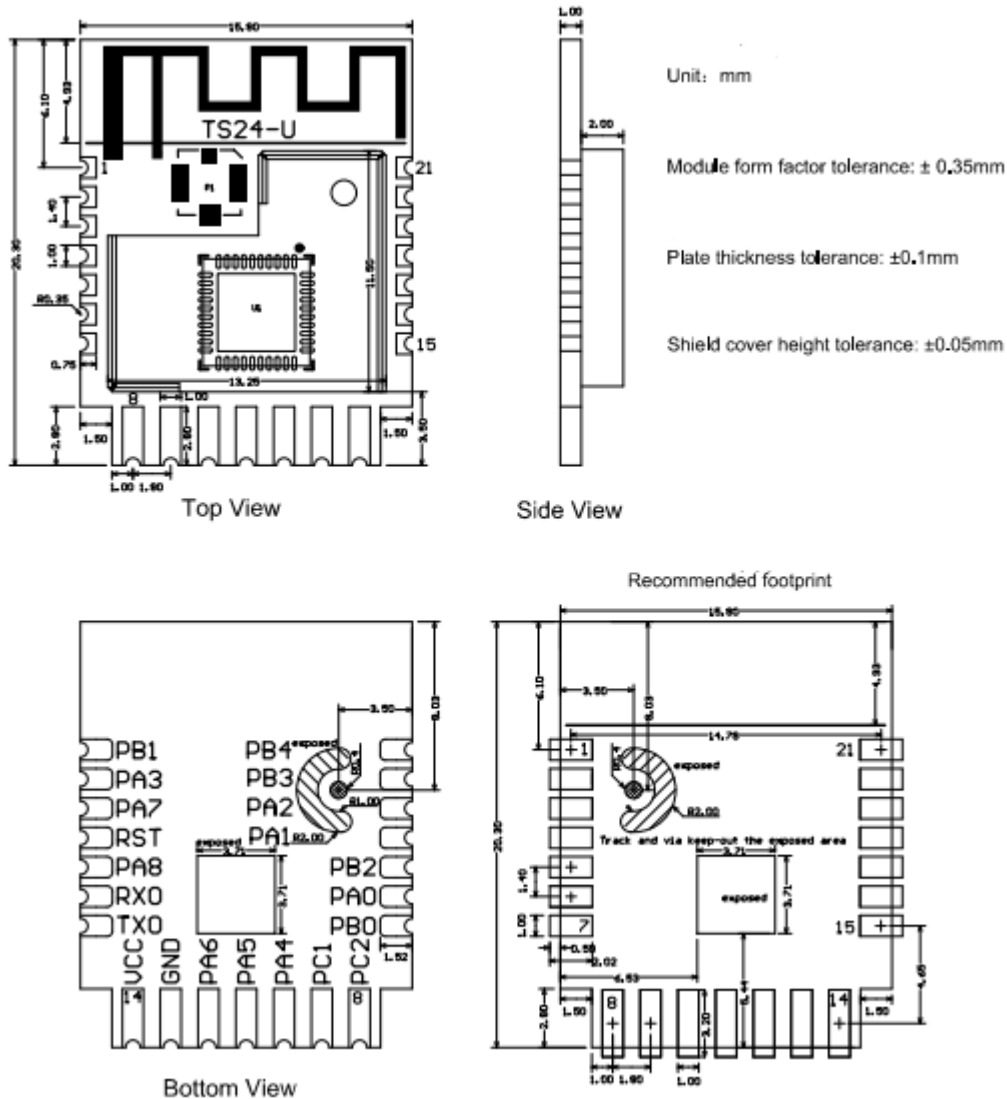
**Do not place any metal in the red area above the antenna.  
The recommended diameter of the circular arc is greater than 3 cm.**



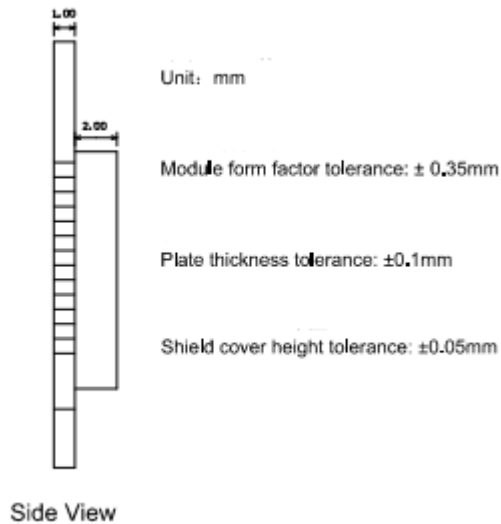
## 6 Packaging information and production instructions

### 6.1 Mechanical dimensions

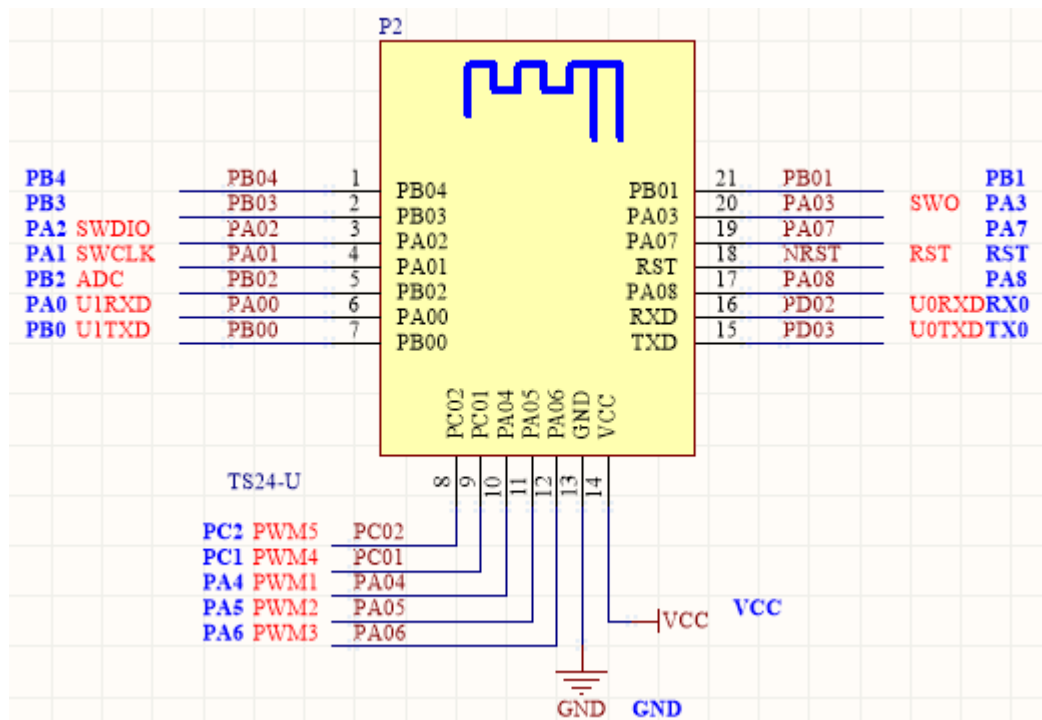
The PCB dimensions are  $20.3 \pm 0.35$  mm (W)  $\times$   $15.8 \pm 0.35$  mm (L)  $\times$   $1.0 \pm 0.1$  mm (H).



## 6.2 Side view



## 6.3 Schematic diagram of footprint



## 6.4 Production instructions

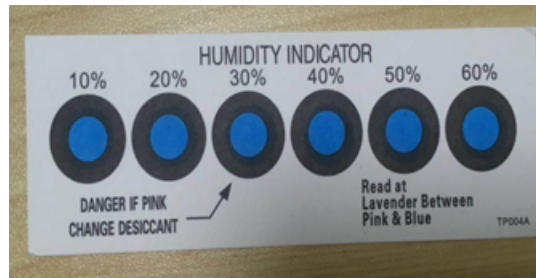
1. For the modules that can be packaged with the SMT or in an in-line way, you can select either of them according to the PCB design solutions of customers. If a PCB is designed to be SMT-packaged, package the module with the SMT. If a PCB is designed to be in-line-packaged, package the module in an in-line way. After being unpacked, the module must be soldered within 24 hours. Otherwise, it needs to be put into the drying cupboard where the relative humidity is not greater than 10%; or it needs to be packaged again under vacuum and the exposure time needs to be recorded (the total exposure time cannot exceed 168 hours).

- (SMT process) SMT devices:
  - Mounter
  - SPI
  - Reflow soldering machine
  - Thermal profiler
  - Automated optical inspection (AOI) equipment
- (Wave soldering process) Wave soldering devices
  - Wave soldering equipment
  - Wave soldering fixture
  - Constant-temperature soldering iron
  - Tin bar, tin wire and flux
  - Thermal profiler
- Baking devices:
  - Cabinet oven
  - Anti-electrostatic and heat-resistant trays
  - Anti-electrostatic and heat-resistant gloves

2. Storage conditions for a delivered module:

- The moisture-proof bag must be placed in an environment in which the temperature is below 40°C and the relative humidity is lower than 90%.
- The shelf life of a dry-packaged product is 12 months from the date when the product is packaged and sealed.

- There is a humidity indicator card (HIC) in the packaging bag.



**Figure 1:** HIC-SMT and in-line module.png

3. The module needs to be baked in the following cases:

- The packaging bag is damaged before unpacking.
- There is no humidity indicator card (HIC) in the packaging bag.
- After unpacking, circles of 10% and above on the HIC become pink.
- The total exposure time has lasted for over 168 hours since unpacking.
- More than 12 months have passed since the sealing of the bag.

4. Baking settings:

- Temperature: 40°C and  $\leq 5\%$  RH for reel package and 125°C and  $\leq 5\%$  RH for tray package (please use the heat-resistant tray rather than plastic container)
- Time: 168 hours for reel package and 12 hours for tray package
- Alarm temperature: 50°C for reel package and 135°C for tray package
- Production-ready temperature after natural cooling:  $< 36^\circ\text{C}$
- Re-baking situation: If a module remains unused for over 168 hours after being baked, it needs to be baked again.
- If a batch of modules is not baked within 168 hours, do not use the reflow soldering or wave soldering to solder them. Because these modules are Level-3 moisture-sensitive devices, they are very likely to get damp when exposed beyond the allowable time. In this case, if they are soldered at high temperatures, it may result in device failure or poor soldering.

5. In the whole production process, take electrostatic discharge (ESD) protective measures.

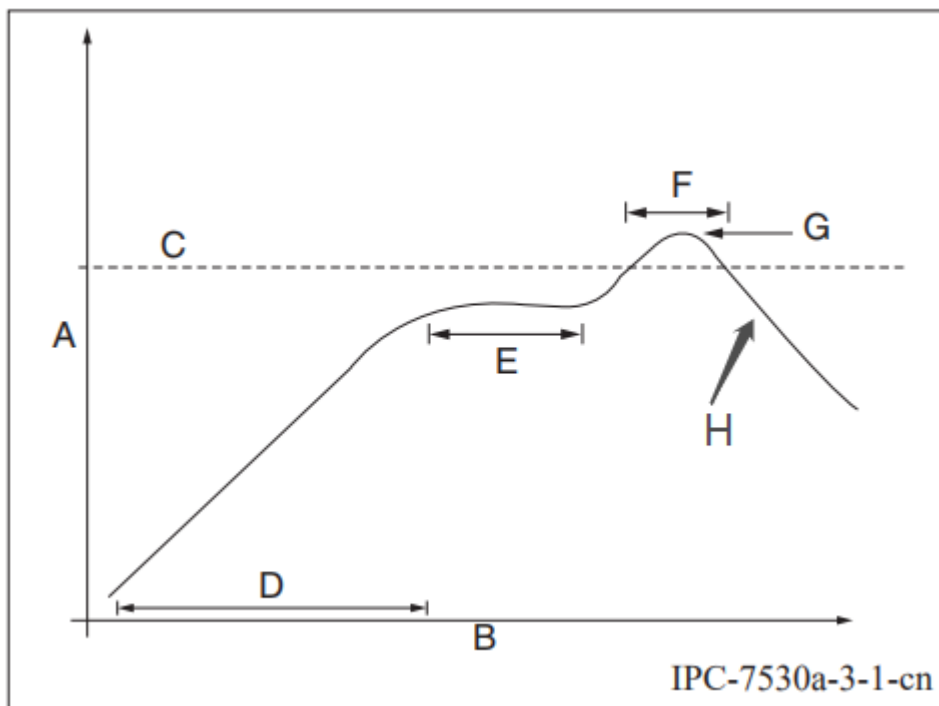
6. To guarantee the passing rate, it is recommended that you use the SPI and AOI to monitor the quality of solder paste printing and mounting.

## 6.5 Recommended oven temperature curve

Select a proper soldering manner according to the process. For the SMT process, please refer to the recommended oven temperature curve of reflow soldering. For the wave soldering process, please refer to the recommended oven temperature curve of wave soldering. There are some differences between the set temperatures and the actual temperatures. All the temperatures shown in this module datasheet are obtained through actual measurements.

### Manner 1: SMT process (Recommended oven temperature curve of reflow soldering)

Set oven temperatures according to the following curve.



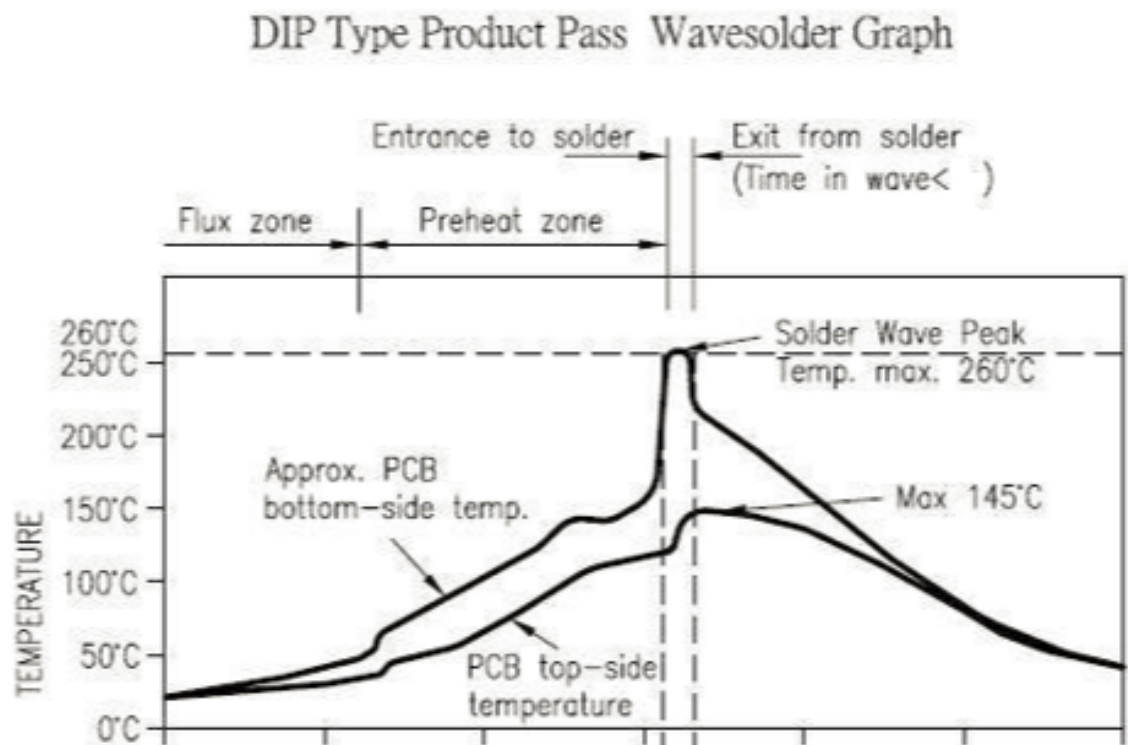
- A: Temperature axis
- B: Time axis
- C: Liquidus temperature: 217 to 220°C
- D: Ramp-up slope: 1 to 3°C/s
- E: Duration of constant temperature: 60 to 120s; the range of constant temperature: 150 to 200°C

- F: Duration above the liquidus: 50 to 70s
- G: Peak temperature: 235 to 245°C
- H: Ramp-down slope: 1 to 4°C/s

**Note:** The above curve is just an example of the solder paste SAC305. For more details about other solder pastes, please refer to Recommended oven temperature curve in the solder paste specifications.

## Manner 2: Wave soldering process (Oven temperature curve of wave soldering)

Set oven temperatures according to the following temperature curve of wave soldering. The peak temperature is  $260^{\circ}\text{C} \pm 5^{\circ}\text{C}$ .



| Suggestions on oven temperature curve of wave soldering |              | Suggestions on manual soldering temperature |            |
|---------------------------------------------------------|--------------|---------------------------------------------|------------|
| Preheat temperature                                     | 80 to 130 °C | Soldering temperature                       | 360±20°C   |
| Preheat time                                            | 75 to 100s   | Soldering time                              | < 3s/point |
| Peak contact time                                       | 3 to 5s      | NA                                          | NA         |
| Temperature of tin cylinder                             | 260±5°C      | NA                                          | NA         |
| Ramp-up slope                                           | ≤2°C/s       | NA                                          | NA         |
| Ramp-down slope                                         | ≤6°C/s       | NA                                          | NA         |

## 6.6 Storage conditions

|                                                                                                                                                                                         |                                                                          |                                                                                                                                                                    |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                                                        | <b>Caution</b><br>This bag contains<br><b>MOISTURE-SENSITIVE DEVICES</b> | <div style="border: 1px solid black; padding: 5px; display: inline-block;"><b>LEVEL</b><br/><b>3</b></div><br><small>If blank, see adjacent bar code label</small> |
| <p>1. Calculated shelf life in sealed bag: 12 months at <math>&lt;40^{\circ}\text{C}</math> and <math>&lt;90\%</math> relative humidity (RH)</p>                                        |                                                                          |                                                                                                                                                                    |
| <p>2. Peak package body temperature: <u>260</u> <math>^{\circ}\text{C}</math><br/><small>If blank, see adjacent bar code label</small></p>                                              |                                                                          |                                                                                                                                                                    |
| <p>3. After bag is opened, devices that will be subjected to reflow solder or other high temperature process must be</p>                                                                |                                                                          |                                                                                                                                                                    |
| <p>a) Mounted within: <u>168</u> hours of factory conditions<br/><small>If blank, see adjacent bar code label</small><br/><math>\leq 30^{\circ}\text{C}/60\% \text{ RH}</math>, or</p>  |                                                                          |                                                                                                                                                                    |
| <p>b) Stored per J-STD-033</p>                                                                                                                                                          |                                                                          |                                                                                                                                                                    |
| <p>4. Devices require bake, before mounting, if:</p>                                                                                                                                    |                                                                          |                                                                                                                                                                    |
| <p>a) Humidity Indicator Card reads <math>&gt;10\%</math> for level 2a - 5a devices or <math>&gt;60\%</math> for level 2 devices when read at <math>23 \pm 5^{\circ}\text{C}</math></p> |                                                                          |                                                                                                                                                                    |
| <p>b) 3a or 3b are not met</p>                                                                                                                                                          |                                                                          |                                                                                                                                                                    |
| <p>5. If baking is required, refer to IPC/JEDEC J-STD-033 for bake procedure</p>                                                                                                        |                                                                          |                                                                                                                                                                    |
| <p>Bag Seal Date: _____<br/><small>If blank, see adjacent bar code label</small></p>                                                                                                    |                                                                          |                                                                                                                                                                    |
| <p><b>Note: Level and body temperature defined by IPC/JEDEC J-STD-020</b></p>                                                                                                           |                                                                          |                                                                                                                                                                    |

## 7 MOQ and packaging information

| Product model | MOQ (pcs) | Packing method | Modules per reel | Reels per carton |
|---------------|-----------|----------------|------------------|------------------|
| TS24-U        | 4400      | Tape reel      | 1100             | 4                |

## 8 Appendix: Statement

**FCC Caution:** Any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate this device. The module is limited to installation in mobile or fixed applications.

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.

**Note:** This device has been tested and found to comply with the limits for a Class B digital device, according to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This device generates, uses, and can radiate radio frequency energy and, if not installed and used following 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 device does cause harmful interference to radio or television reception, which can be determined by turning the device 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 device and receiver.
- Connect the device to 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 device complies with FCC radiation exposure limits set forth for an uncontrolled rolled environment. This device should be installed and operated with a minimum distance of 20cm between the radiator and your body.

### Important Note

This radio module must not be installed to co-locate and operate simultaneously with other radios in the host system except following FCC multi-transmitter product procedures. Additional testing and device authorization may be required to operate simultaneously with other radios.

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 to the end-user.

The host product manufacturer is responsible for compliance with any other FCC rules that apply to the host not covered by the modular transmitter grant of certification. The final host product still requires Part 15 Subpart B compliance testing with the modular transmitter installed. The separate approval is required for all other operating configurations including portable configurations with respect to Part 2.1093 and different antenna configuration.

The end-user manual shall include all required regulatory information/warnings as shown in this manual, including “This product must be installed and operated with a minimum distance of 20 cm between the radiator and user body”. The OEM integrator is responsible for ensuring that the end-user has no manual instructions to remove or install module.

This device has got an FCC ID: 2ANDL-TS24-U. The end product must be labeled in a visible area with the following: “Contains Transmitter Module FCC ID: 2ANDL-TS24-U”.

This device is intended only for OEM integrators under the following conditions:

The antenna must be installed such that 20cm is maintained between the antenna and users, and the transmitter module may not be co-located with any other transmitter or antenna.

As long as the 2 conditions above are met, further transmitter tests will not be required. However, the OEM integrator is still responsible for testing their end product for any additional compliance requirements required with this module installed.

#### **Declaration of Conformity European Notice**



Hereby, Hangzhou Tuya Information Technology Co., Ltd declares that this module product is in compliance with essential requirements and other relevant provisions of Directive 2014/53/EU, 2011/65/EU. A copy of the Declaration of conformity can be found at <https://www.tuya.com>.



This product must not be disposed of as normal household waste, in accordance with the EU directive for waste electrical and electronic equipment (WEEE-2012/19/EU). Instead, it should be disposed of by returning it to the point of sale, or to a municipal recycling collection point.

The device could be used with a separation distance of 20cm from the human body.