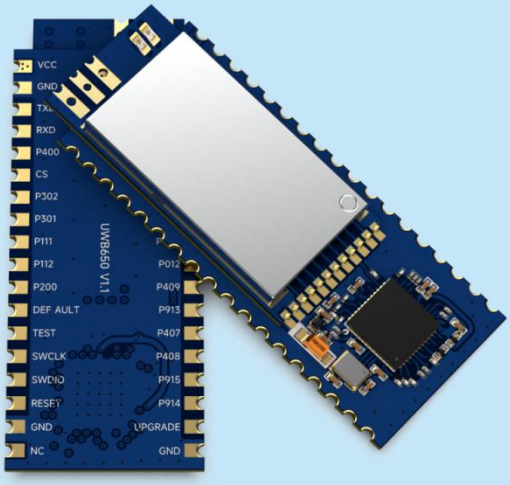
UWB650

- UWB to TTL wireless module, easy to use
- Air data rate up to 6.8 Mbps
- High-precision ranging & indoor positioning
- Transmission distance over 1KM in open area
- AES-128 encryption

Product Specification



Catalogue

Note: Revision History

Revision	Date	Comment
V1.0	2024-6	First release
V2.0	2025-7	Module Function Changes — Revised Documentation Instructions
V2.1	2025-8	Product Image Update
V2.2	2025-9	Mesh Function Added

1. Production Description

UWB650 module, launched by NiceRF, is a wireless communication module based on Ultra Wide Band (UWB) technology and complies with the IEEE 802.15.4-2020 Standard. It is designed using the Qorvo DW3000 UWB chip and integrates a high-performance RF power amplifier, MCU, general-purpose I/O interfaces, and ESD protection components. The UWB650 module combines data communication, ranging, and positioning functions in UWB applications, enabling remote communication, precise distance measurement/positioning, and hardware control via a serial interface.

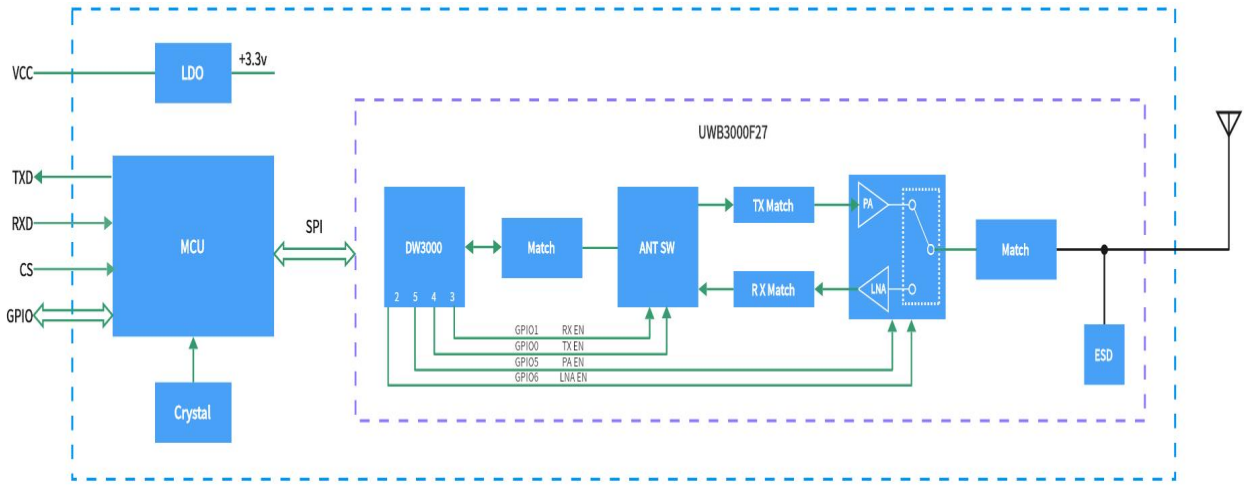
2. Feature

- Comply with IEEE 802.15.4-2020 Standard UWB and communication protocol
- Supports UWB Channel 5 (6489.6 MHz)
- Supports 6.8 Mbps and 850 Kbps RF Rate
- Supports data frame lengths from 0 to 1023 bytes
- Mesh networking
- Multiple-level transmit power adjustment, with a maximum transmit power of 0.5W
- 1 km ultra-long-distance data communication
- Supports two-way ranging methods SS-TWR and DS-TWR, as well as positioning solutions
- Ranging accuracy less than ±10 cm
- Supports multi-tag positioning with precise location calculation
- Electrostatic Protection (ESD)

3. Applications

- Personnel positioning in large-scale industrial production
- Various indoor positioning scenarios
- Underground coal mine positioning
- Hospital staff positioning

4. Block Diagram



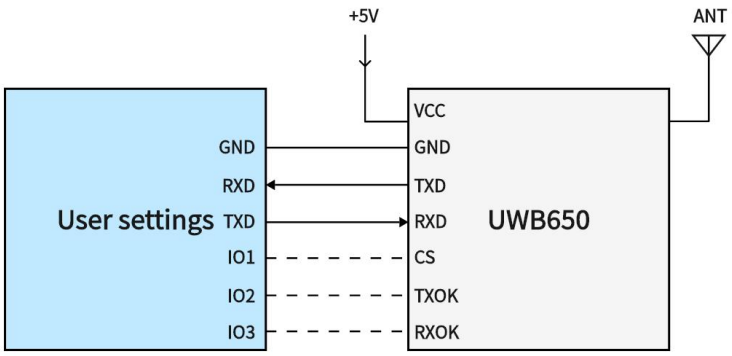
5. Parameters

Parameter	Condition	Min.	Typ.	Max.	Unit
Supply Voltage		3.0	4.2	5.5	V
Operating Temperature Range		-20	25	60	℃
Frequency Range	CH5		6489.6		MHz
RF Data Rate		850k		6.8M	bps
Current Consumption					
Sleep current			< 2.3		mA
Transmit current [1]	Continues Frame mode		300		mA
Receive current			100		mA
Listen receive current	Low-Power SNIFF mode		<65		mA
Standby current	Receive off and no data transmission		27		mA
RF parameter					
Tx Power	@VCC=5.0V	-5		27	dBm
Tx Bandwidth（BW)			499.2		MHz
Receive parameters					
Rx Sensitivity	@850Kbps		-100		dBm
	@6.8Mbps		-94		dBm

1. The transmit current1 parameter refers to the maximum value measured under the module’ s Continuous Frame mode during uninterrupted transmission. In actual use, due to the extremely fast data transmission speed of UWB, the operating current shows no significant fluctuation.

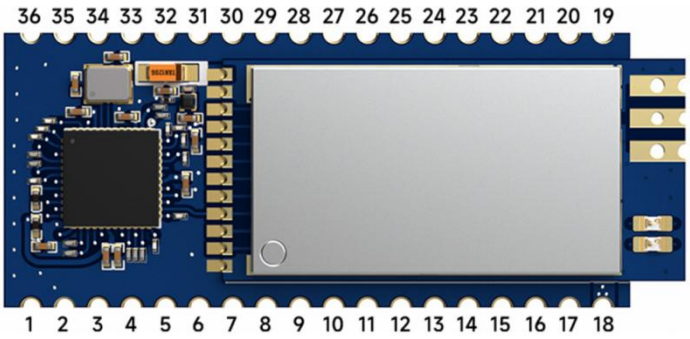
2. When users utilize ranging or positioning functions and set very short intervals between each operation, the module’ s operating current during these processes may be noticeably lower than the reference value. This is a normal phenomenon.

6. Typical Application Circuit



Note: The TXOK and RXOK pins of the module are only functional in data transmission mode.

7. Pin Assignment



Pin No.	Pin definition	I/O	Voltage	Description
1	NC			
2,17,19,36	GND	-	0-3.3V	Connect to the power supply ground
3	RESET	I	0-3.3V	Module reset pin, normal high level, pull low to reset
4	SWDIO	I	0-3.3V	Module programming pins
5	SWCLK	O	0-3.3V	Module programming pins
6	TEST	I	0-3.3V	-
7	DEFAULT	I	0-3.3V	Internal pull-up, hold low for about 10s during operation to force a reboot and restore factory settings.
8	P200	I/O	0-3.3V	Unused I/O pins
9	P112	I/O	0-3.3V	PWM output
10	P111	I/O	0-3.3V	PWM output
11	P301	I/O	0-3.3V	Unused I/O pins
12	P302	I/O	0-3.3V	Unused I/O pins
13	CS	I	0-3.3V	Sleep pin, internally pulled up; the module enters sleep mode when a low level is applied externally
14	P400	I/O	0-3.3V	Unused I/O pins
15	RXD	I	0-3.3V	Serial data input pin, connected to the TXD pin of the external device
16	TXD	O	0-3.3V	Serial data output pin, connected to the RXD pin of the external device
18	VCC	-	3.0-5.5V	External power supply positive terminal
20	P500	I/O	0-3.3V	Unused I/O pins
21	TXOK	O	0-3.3V	Transmit status indicator pin, outputs high level when transmitting data
22	RXOK	O	0-3.3V	Receive status indicator pin, outputs high level when datais received, and outputs low level after reception is complete
23	P011	I/O	0-3.3V	Ranging/positioning status pin, outputs high level during ranging/positioning
24	P010	I/O	0-3.3V	Unused I/O pins

25	P002	I/O	0-3.3V	General I/O output
26	P001	I/O	0-3.3V	General I/O output
27	P000	I/O	0-3.3V	General I/O output
28	P012	I/O	0-3.3V	General I/O output
29	P409	I/O	0-3.3V	General I/O output
30	P913	I/O	0-3.3V	General I/O output
31	P407	I/O	0-3.3V	General I/O output
32	P408	I/O	0-3.3V	General I/O output
33	P915	I/O	0-3.3V	Unused I/O pins
34	P914	I/O	0-3.3V	Unused I/O pins
35	UPGRADE	I	0-3.3V	Internally pulled up; after an external low-level input, the module resets and enters serial upgrade mode

8. Function Description

8.1 Data transmission function

The data frames transmitted by the UWB650 module comply with the IEEE 802.15.4-2020 international standard:

Frame Control	Sequence Number	PAN ID	Destination Address	Source Address	Frame Payload	FCS
2 Bytes	1 Byte	2 Bytes	2 Bytes	2 Bytes	x Bytes	2 Bytes

When the user needs to input data to be sent via the serial port, the data will be filled into the Frame Payload section. When the UWB650 receives data sent from other UWB650 modules, the serial port outputs only the Frame Payload section. The data frame format cannot be modified by the user.

When the UWB650 module is transmitting data, the module's TXOK pin outputs a high level; after transmission is complete, it outputs a low level.

When the UWB650 module receives data, the module's RXOK pin outputs a high level; after data reception is complete, it outputs a low level.

About PAN ID and Address

The PAN ID can be understood as the group ID; only UWB650 modules with the same PAN ID can communicate properly.

The Address is the module's own ID. All modules under the same PAN ID should have different Address values.

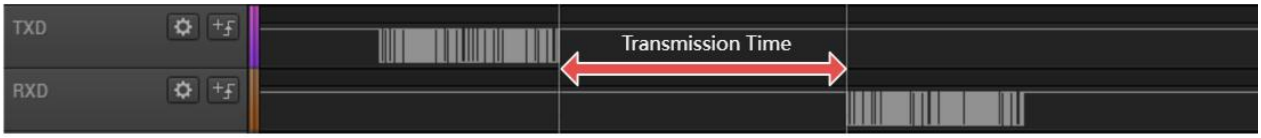
The supported range for both PAN ID and Address values is from 0x0000 to 0xFFFE. In theory, each PAN ID can accommodate up to 65,535 Addresses (UWB650 modules) for communication.

The data transmission function of the UWB650 module has the following features:

- Large single-packet data transmission and reception

Based on the powerful transmit and receive buffer (1023 bytes) of the DW3000 chip, excluding the fixed data frame length, the user can transmit up to 1023 - 11 = 1012 bytes of Frame Payload data in a single packet.

Since the transmitting end of wireless communication receives a certain amount of data from the terminal device or waits for a certain period of time without new data before starting to transmit, and the air transmission of data from the transmitting end to the receiving end of wireless communication also takes time, there will be a certain time delay in the output of data from the transmitting end to the receiving end Under the same conditions, the delay time is fixed (the specific time is jointly determined by the serial port rate, the air rate and the size of the transmitted data packet). As shown in the following figure:



The module's data transmission timing is as follows:

Over-the-air data rate	1 Byte Frame Payload	1012 Bytes Frame Payload
6.8Mbps	1.905ms	12.330ms
850Kbps	2.316ms	20.885ms

- Supports point-to-point and broadcast data transmission

Users can send commands to modify the destination address (i.e., the Destination Address field in the data frame format) to control the UWB650 module to send data to a specified target.

By setting the destination address (the Destination Address field in the data frame format) to 0xFFFF, the UWB650 module will broadcast the subsequent data to all UWB650 modules with the same PAN ID within wireless range.

- CCA (Clear Channel Assessment) mechanism

The UWB650 supports detecting whether other UWB modules are transmitting data over the air before sending its own data. It will only transmit when the channel is clear. This mechanism helps prevent collisions with other data packets in the air, avoiding packet loss or interference.

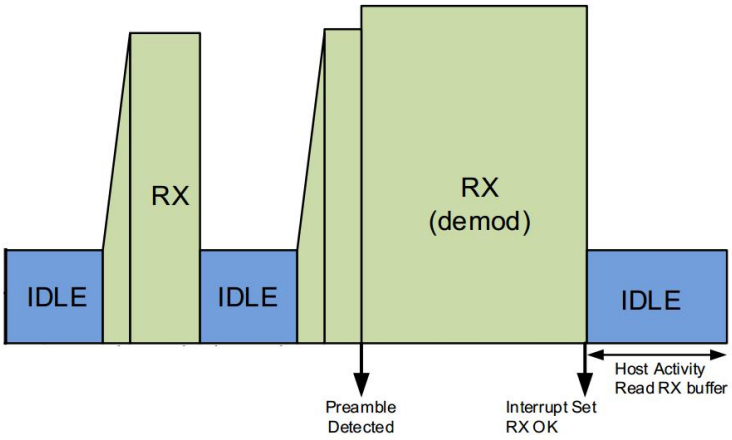
- ACK (Automatic Acknowledgment Request) mechanism

When this function is enabled, the module attaches an ACK request when sending ordinary data. Upon receiving data with an ACK request from the sending UWB650 module, the module will automatically reply with an ACK response to the sender. The sender can confirm whether the data was successfully received through the ACK response.

This mechanism does not apply when the sending UWB650 module is set to broadcast mode.

- SNIFF (Listen Receive) mechanism

The sniff receive mechanism of the UWB650 module is illustrated in the following diagram:



The module continuously switches between receive and IDLE states. Compared to always-on reception, the sniff receive mechanism effectively reduces the module's power consumption, at the cost of potentially missing some data. Both the receive and IDLE states last approximately 16 μs each, resulting in about a 50% receive duty cycle.

When the module is using the ranging or positioning function, sniff receive is temporarily disabled, and the module stays in always-on reception mode until the ranging or positioning function stops.

- Frame filtering function

The UWB650 supports frame filtering. Data that does not meet the following conditions will be directly rejected by the UWB chip inside the UWB650:

The Destination PAN ID field value does not match its own;

The Destination Address field value is not 0xFFFF and does not match its own;

The FCS field (Frame Check Sequence) contains an incorrect value;

The data packet format is not a Data frame;

Other contents that do not comply with the IEEE 802.15.4-2020 international standard format.

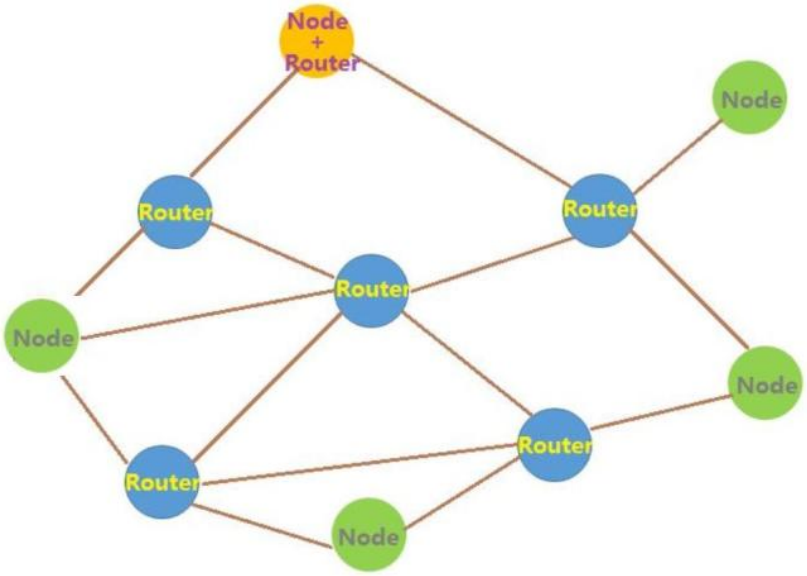
- AES-128 Encryption

The UWB650 supports AES-128 encryption for data transmission. When AES-128 encryption is enabled, the module’s wireless transmission latency will slightly increase, but it provides the best protection for over-the-air data. Users can enable the AES-128 encryption function in applications that require high security for transmitted data.

After enabling AES-128 encryption, the encrypted data packet length will be 16 bytes longer than normal. Therefore, when encryption is enabled, the user can transmit up to 1012 - 16 = 996 bytes of data per single packet.

- Mesh Network Function

The UWB650 supports another way of data transfer using Mesh functionality. In Mesh mode, modules can be configured into nodes and routers through different modules to form a Mesh network as a whole. With Mesh enabled, the module can transfer up to 1004 bytes of data per packet.



Modules configured as routers will broadcast the data within the same network and forward it to other routers/nodes to solve the problem in many practical applications where modules cannot directly transmit data one-to-one.

Modules configured as nodes can send and receive data to other nodes. When data cannot be directly transmitted between nodes due to various factors (such as exceeding the communication range), the data will be received and forwarded by the router module within the communication range to ensure that the data can be successfully received by the target.

The module configured as a node + router will simultaneously possess the functions of both, that is, when the destination address of the data sent by other nodes is not itself, it will use the router function to

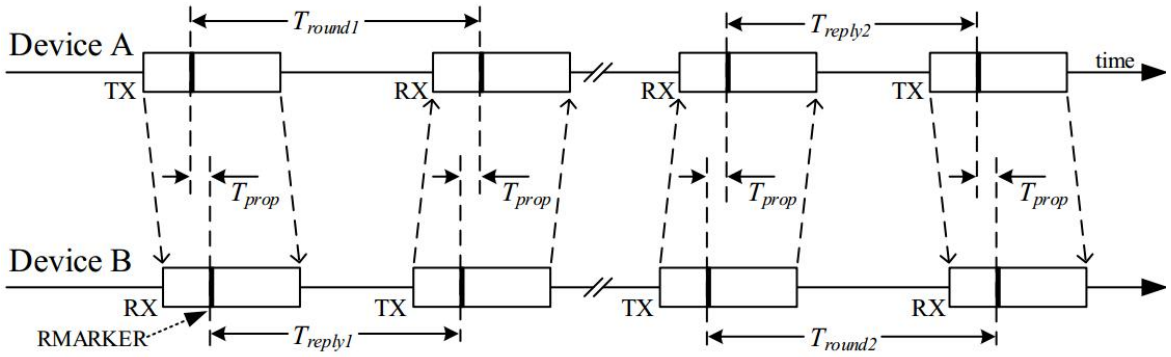
forward it. Conversely, output the data normally.

In a Mesh network, the number of forwarding hops for the same data packet is fixed at 10 times. When the number of forwarding times of the received data packet exceeds the hop count, the data packet will no longer be forwarded. To prevent the phenomenon of repeated transmission and pollution of wireless signals that may occur when there are too many router modules in the network.

The Mesh function can also enable AES-128 encryption to ensure the secure transmission of data. After enabling the data encryption function, a user can transfer a maximum of 1004-16=988 bytes of data per packet.

8.2 Ranging Function

The technical principle of the UWB650 module's ranging function is illustrated in the following diagram:



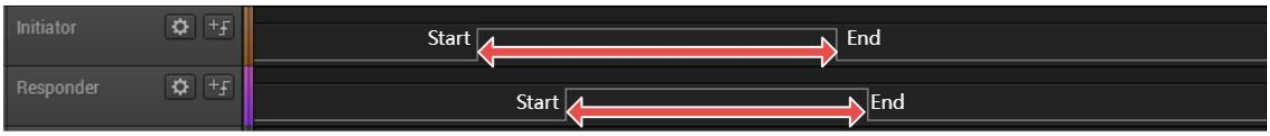
The UWB650 module's ranging function uses a combined approach of Double-Sided Two-Way Ranging (DS-TWR) and Single-Sided Two-Way Ranging (SS-TWR). By obtaining the clock offset of the remote end, it corrects errors during the ranging process to achieve more accurate distance measurements.

This method results in different distance values obtained at the two ends of the ranging, but they generally fall within the error margin. This is a normal phenomenon.

The UWB650 module's ranging function has the following features:

- Short ranging time

Due to the characteristics of the ranging method, the time taken for ranging by the master and the slave is not the same, as shown in the following figure:



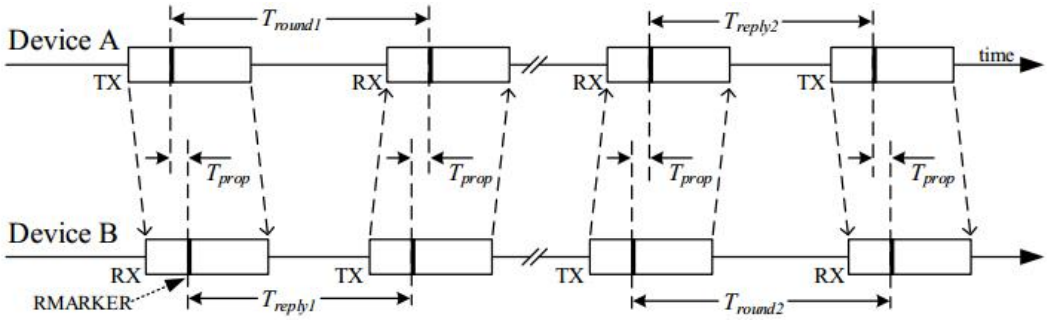
The time used by the module’s ranging process is shown in the following diagram:

Over-the-air data rate	Ranging mode	Ranging time
6.8Mbps	Initiator	4.819ms
	Responder	4.051ms
850Kbps	Initiator	5.545ms
	Responder	4.553ms

Users can obtain the operating status of the ranging function by reading the P011 pin level on the UWB650 module. When the P011 pin outputs a high level, it indicates that the module is performing the ranging process. When it outputs a low level, it indicates that the ranging process has ended

8.3 Positioning Function

The technical principle of the UWB650 module’s positioning function is illustrated in the following diagram:



The UWB650 module uses a positioning solution based on Double-Sided Two-Way Ranging (DS-TWR). When using the positioning function, devices are divided into Tags and Anchors. Users can configure the roles by sending commands.

The UWB650 module supports three-dimensional positioning:

When users set up three base stations, the 2D planar positioning function can be achieved. When using 3D stereoscopic positioning, at least four base stations need to be set up.

8.4 Other Functions

- Sleep Function

Pulling the CS pin of the UWB650 module low will cause the module to enter sleep mode within a short

time (generally less than 25 ms). During this period, the UWB chip also enters sleep mode to deduce power consumption.

Before entering sleep mode, the module’ s serial port will output a response:

```
Enter Sleep
```

Pulling the CS pin high will wake the module from sleep mode within a short time(generally less than 30 ms). After waking up, the module will restore all parameters and states：

After exiting sleep mode, the module’s serial port will output a response:

```
Exit Sleep
```

9. Configuration Commands

The UWB650 module modifies certain runtime parameters through configuration commands.

9.1 Definition

<CR> Carriage Return Character, means 0x0D。

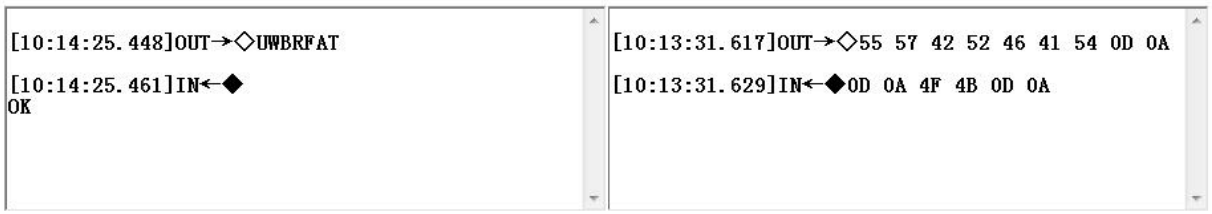
<LF> Line Feed Character,means 0x0A。

<…> Parameter name. Angle brackets will not appear in the command.

[,<…>] Optional command parameter; if not entered, the module will use the most recent user-set value. Square brackets and angle brackets will not appear in the command.

9.2 Configuration Command Format

When users input data through the serial port, the module directly detects whether the data is a configuration command and processes it accordingly. The format of configuration commands is always fixed: they begin with "UWBRFAT" and end with <CR><LF> (Carriage Return and Line Feed). Responses and result codes of commands always start and end with <CR> and <LF>:



Throughout the document, the configuration commands and responses intentionally omit <CR> and <LF>. Users should avoid inputting data packets that begin with "UWBRFAT" and end with <CR><LF> if they do not need to configure parameters, to prevent triggering the module's command detection and thus delaying the execution of functions.

The UWB650 module uses timeout detection to determine the number of bytes received via the serial port. When the first byte is received, a timer of approximately 5 ms is started. If additional bytes are received, the timer resets. Reception continues until either the receive buffer is full or the timer times out, at which point the module stops receiving and begins processing the data.

9.3 Configuration Commands and Their Descriptions

1) To detect whether the module is operating normally

Command	Response
UWBRFAT	OK

2) Get module firmware version

Command	Response
UWBRFAT+VERSION?	V1.2

Note: Due to the possibility of future module firmware updates, the response content of this command is for reference only

3) Restore all module parameters to default values

Command	Response
UWBRFAT+DEFAULT	OK

Note: This command will cause the module to restart, and the module will execute the restart operation after responding with "OK"

After the module completes startup, the serial port will output the following string:

Finished Startup

4) Restart module

Command	Response
UWBRFAT+RESET	OK

Note: The module will execute the restart operation after responding with "OK"

After the module completes startup, the serial port will output the following string:

Finished Startup

5) Save the relevant configurable parameters to Flash memory

Command	Response
UWBRFAT+FLASH	OK

Note: In the subsequent configuration command explanations in the document, commands marked with an asterisk (*) indicate that their related parameters can be saved to Flash using this command. These parameters will be applied directly when the module restarts

6) Configure the module's serial port baud rate*

Command		Response
Query	UWBRFAT+BAUDRATE?	+BAUDRATE=<rate>
Setting	*UWBRFAT+BAUDRATE=<rate>	OK
Explanation	<rate>: Integer type. Each value represents the corresponding serial baud rate: 0:230400bps 1:115200bps（Default value） 2:57600bps 3.38400bps 4.19200bps 5.9600bps **Note:** Other serial port settings of the module are fixed as 8 data bits, 1 stop bit, and no parity bit.	
Example	Query the module's current serial port baud rate: Send：UWBRFAT+BAUDRATE? Response：+BAUDRATE=0 Set the module's serial port baud rate to 9600: Send：UWBRFAT+BAUDRATE=5 Response：OK Error example： Send：UWBRFAT+BAUDRATE=6 Response：ERROR	

7) Configure the UWB chip's over-the-air data transmission rate

Command		Response
Query	UWBRFAT+DATARATE?	+DATARATE=<rate>
Setting	*UWBRFAT+DATARATE=<rate>	OK
Explanation	<rate>: Integer type. Different values represent different over-the-air data transmission rates. 0:850Kbps	

	1:6.8Mbps（Default value）
Example	Query the over-the-air data transmission rate: Send：UWBRFAT+DATARATE? Response：+DATARATE=1 Set the over-the-air data transmission rate: Send：UWBRFAT+DATARATE=0 Response：OK Error example: Send：UWBRFAT+DATARATE=2 Response：ERROR

8) Configure the UWB chip's PAN ID and Address

Command		Response
Query	UWBRFAT+DEVICEID?	+DEVICEID=<id>,<addr>
Setting	*UWBRFAT+DEVICEID=<id>,<addr>	OK
Explanation	<id>: 4-byte hexadecimal string type, range: 0000–FFFE (default value: 0000) <addr>: 4-byte hexadecimal string type, range: 0000–FFFE (default value: 0000)）	
Example	Query PAN ID 和 Address： Send：UWBRFAT+DEVICEID? Response：+DEVICEID=1234,5678 Set PAN ID 和 Address： Send：UWBRFAT+DEVICEID=ABCD,1234 Response：OK Error example Send：UWBRFAT+DEVICEID=FFFF,FFFF Response：ERROR	

9) Configure the module's transmit power

Command		Response
Query	UWBRFAT+POWER?	+POWER=<gear>
Setting	*UWBRFAT+POWER=<gear>	OK

<table>
<tr><td>Explanation</td><td><gear>: Integer type. Range: 0–10. Different values represent different power levels:
<table>
<tr><th>Gear</th><th>Output power (dBm)</th></tr>
<tr><td>0</td><td>-5</td></tr>
<tr><td>1</td><td>-2</td></tr>
<tr><td>2</td><td>2.14</td></tr>
<tr><td>3</td><td>7.5</td></tr>
<tr><td>4</td><td>8.8</td></tr>
<tr><td>5</td><td>11</td></tr>
<tr><td>6</td><td>14</td></tr>
<tr><td>7</td><td>17</td></tr>
<tr><td>8</td><td>20.2</td></tr>
<tr><td>9</td><td>23.7</td></tr>
<tr><td>10 (default value)</td><td>27.7</td></tr>
</table></td></tr>
<tr><td>Example</td><td>Query the module’s transmit power:
Send：UWBRFAT+POWER?
Response：+POWER=0
Set the transmit power:
Send：UWBRFAT+POWER=10
Response：OK
Error example:
Send：UWBRFAT+POWER=11
Response：ERROR</td></tr>
</table>

10) Configure the UWB chip’s preamble parameters

Command		Response
Query	UWBRFAT+PREAMBLECODE?	+PREAMBLECODE=<code>
Setting	*UWBRFAT+PREAMBLECODE=<code>	OK
Explanation	<code>: Integer type. Range: 9–24 (default value: 9). UWB650 modules with different preamble parameters cannot communicate with each other.	
	Query the preamble parameters: Send：UWBRFAT+ PREAMBLECODE? Response：+PREAMBLECODE=9 Set the preamble parameters:	

Example	Send：UWBRFAT+PREAMBLECODE=12 Response：OK Error example: Send：UWBRFAT+PREAMBLECODE=3 Response：ERROR

11) Configure the CCA (Clear Channel Assessment) function

Command		Response
Query	UWBRFAT+CCAENABLE?	+CCAENABLE=<enable>
Setting	*UWBRFAT+CCAENABLE=<enable>	OK
Explanation	<enable>: Integer type. 0: Disable CCA function (default value) 1: Enable CCA function This function is only used in data transmission mode. When CCA is enabled, if the module detects ongoing data transmission in the air before sending normal data, it will stop sending and the serial port will return the following message: CCA FAILURE	
Example	Query whether the CCA function is enabled: Send：UWBRFAT+ CCAENABLE? Response：+CCAENABLE=0 Enable the CCA function: Send：UWBRFAT+CCAENABLE=1 Response：OK Error example: Send：UWBRFAT+CCAENABLE=2 Response：ERROR	

12) Configure the ACK (Automatic Acknowledgment Request) function

Command		Response
Query	UWBRFAT+ACKENABLE?	+ACKENABLE=<enable>
Setting	*UWBRFAT+ACKENABLE=<enable>	OK

Explanation	<enable>: Integer type. 0: Disable ACK request (default value) 1: Enable ACK request When the ACK request is enabled, all data sent by the module in data transmission mod will include an ACK request. If no ACK response is received, the serial port will return the following message: ACK WAIT TIMEOUT If an ACK response is received, the serial port will return the following message: ACK DETECTED
Example	Query whether the ACK function is enabled: Send：UWBRFAT+ACKENABLE? Response：+ACKENABLE=0 Enable the ACK function: Send: UWBRFAT+ACKENABLE=1 Response: OK Error example: Send: UWBRFAT+ACKENABLE=2 Response: ERROR

13) Configure the module's AES-128 key

Command		Response
Query	UWBRFAT+SECURITY?	+SECURITY=<enable>,<key>
Setting	*UWBRFAT+SECURITY=<enable>,<key>	OK
Explanation	<enable>: Integer type. 0: Disable AES encryption (default) 1: Enable AES encryption When AES encryption is enabled, the Frame Payload content sent by the module in da transmission mode will be encrypted to ensure more reliable data transmission. <key>: Hexadecimal string type, length of 32 characters (16 bytes). Default value: 000102030405060708090A0B0C0D0E0F	

Example	Query the status and key of the AES encryption function: Send: UWBRFAT+SECURITY? Response: +SECURITY=0,00112233445566778899AABBCCDDEEFF Enable AES encryption and set the key: Send: UWBRFAT+SECURITY=1,112233445566778899AABBCCDDEEFF00 Response: OK Error example: Send: UWBRFAT+SECURITY=1122334455667788 99AABBCCDDEEFF00 Response: ERROR

14) Set the data transmission target address for the data transmission function

Command		Response
Query	UWBRFAT+TXTARGET?	+TXTARGET=<address>
Setting	*UWBRFAT+TXTARGET=<address>	OK
Explanation	<address>: 4-byte hexadecimal string type. Range: 0000–FFFF (default value: 000 When set to FFFF, data sent by the module's data transmission function will be treat as a broadcast.	
Example	Query the current transmission target: Send: UWBRFAT+TXTARGET? Response: +TXTARGET=AB12 Modify the current transmission target: Send: UWBRFAT+TXTARGET=1234 Response: OK Error example: Send: UWBRFAT+TXTARGET=123 Response: ERROR	

15) Configure the module to display source address information when data is received

Command		Response
Query	UWBRFAT+RXSHOWSRC?	+RXSHOWSRC=<enable>

Setting	*UWBRFAT+RXSHOWSRC=<enable>	OK
Explanation	<enable>: Integer type. 0: Do not display source address information 1: Display source address information (default value) When enabled, the module will show the source address and signal strength upon receiving normal data. For example, when data (123456789) is received from another module (address 1234),with a signal strength of -45.60 dBm: SrcAddr:1234,Rssi:-45.60dBm,Data:123456789	
Example	Query whether source address information is displayed: Send: UWBRFAT+RXSHOWSRC? Response: +RXSHOWSRC=0 Enable displaying source address information: Send: UWBRFAT+RXSHOWSRC=1 Response: OK Error example: Send: UWBRFAT+RXSHOWSRC=2 Response: ERROR	

16) Set the status of the onboard LED of the module:

Command		Response
Query	UWBRFAT+LEDSTATUS?	+LEDSTATUS=<enable>
Setting	*UWBRFAT+LEDSTATUS=<enable>	OK
Explanation	<enable>: Integer type. 0: Disable LED status indication 1: Enable LED status indication (default value) Note: In working state, the red LED blinking indicates the module is transmitting data; the blue LED blinking indicates the module is in receiving mode, but does not necessarily mean data has been received.	
	Query whether the LED status indication is enabled:	

Example	Send: UWBRFAT+LEDSTATUS? Response: +LEDSTATUS=1 Disable LED status indication: Send: UWBRFAT+LEDSTATUS=0 Response: OK Error example: Send: UWBRFAT+LEDSTATUS=2 Response: ERROR

17) Set the module's receive status

Command		Response
Query	UWBRFAT+RXENABLE?	+RXENABLE=<enable>
Setting	*UWBRFAT+RXENABLE=<enable>	OK
Explanation	<enable>: Integer type. 0: Disable receive status 1: Enable receive status (default value) When receive is disabled, the module enters IDLE state. In data transmission mode, it can still send data but cannot receive data. In this state, the module's power consumption is reduced.	
Example	Query whether the receive status is enabled: Send: UWBRFAT+RXENABLE? Response: +RXENABLE=1 Disable receive: Send: UWBRFAT+RXENABLE=0 Response: OK Error example: Send: UWBRFAT+RXENABLE=2 Response: ERROR	

18) Set the module's SNIFF (listen receive) status

Command		Response
Query	UWBRFAT+SNIFFEN?	+SNIFFEN=<enable>
Setting	*UWBRFAT+SNIFFEN=<enable>	OK
Explanation	<enable>: Integer type. 0: Disable sniff receive (default value) 1: Enable sniff receive When sniff receive is enabled by the user, the module will temporarily disable sniff receive while the ranging/positioning function is active. Sniff receive will be re-enabled after these functions are turned off.	
Example	Query whether sniff receive is enabled: Send: UWBRFAT+SNIFFEN? Response: +SNIFFEN=0 Enable sniff receive: Send: UWBRFAT+SNIFFEN=1 Response: OK Error example: Send: UWBRFAT+SNIFFEN=2 Response: ERROR	

19) Set the module's antenna delay

Command		Response
Query	UWBRFAT+ANTDELAY?	+ANTDELAY=<delay>
Setting	*UWBRFAT+ANTDELAY=<delay>	OK
Explanation	<delay>: Integer type. Range: 0–65535. Default value: 16400. The module's antenna delay parameter. The antenna delay parameter directly affects the error in ranging and positioning results. Calibrating the antenna delay can make the ranging results as close as possible to the actual distance. When users utilize our company's UWB antennas, they can apply the correspondi	

<table>
<tr><td></td><td>antenna delay parameters based on different models.
<table><tr><th>Antenna type</th><th>Suggested antenna delay value</th></tr><tr><td>UWB-PCB-X</td><td>16433</td></tr><tr><td>UWB-PCB-D</td><td>16476</td></tr><tr><td>UWB-ZT50</td><td>16408</td></tr><tr><td>UWB-ZT50</td><td>16452</td></tr></table>For specific parameters of each model of antenna, please consult our company.
If our company's UWB antenna is not used, the antenna delay needs to be calibrat manually by yourself. For details on how to calibrate the antenna delay, please refer the document "How to Calibrate Antenna Delay for UWB650 Module.pdf".。</td></tr>
<tr><td>Example</td><td>Query antenna delay parameter:
Send: UWBRFAT+ANTDELAY?
Response: +ANTDELAY=16400
Set antenna delay parameter:
Send: UWBRFAT+ANTDELAY=12345
Response: OK
Error example:
Send: UWBRFAT+LEDSTATUS=123456
Response: ERROR</td></tr>
</table>

20) The module’s ranging function

Command		Response
Setting	UWBRFAT+RANGING=<number>,<addr>	+RANGING=(<distance>),(<rssi>)
Explanation	<number>：integer，The number of target addrs。 <addr>: 16-bit 4-byte hexadecimal type. The target address for ranging when the module acts as the initiator. Range: 0000–FFFE. Multiple addresses can be entered, and the number of addresses must be the same as the value of the <number> parameter. Multiple addresses should be separated by commas. The module will perform the ranging process to the target module in the order of the addresses in the command. After the ranging is completed, the ranging information will be output simultaneously. The module will perform the ranging process to the target modules in the order	

	addresses specified in the command. After ranging is complete, the module outputs the ranging information accordingly. <distance>: Floating-point string type. The distance information output after ranging is completed. Up to two decimal places are supported. If ranging fails, this value will be -1. <rssi>: Floating-point string type. The signal strength information of the other end output after ranging is completed. Up to two decimal places are supported. Note: After the other end receives the ranging signal from the initiator, it will also output the ranging information after completion.
Example	Get the distance to the module with address 0001: Send: UWBRFAT+RANGING=1,0001 Response: +RANGING=(12.34),(-56.78) Distance information output by the module with address 0001: Get the distances to the modules with addresses 0002 and 0003 simultaneously: Send: UWBRFAT+RANGING=2,0002,0003 Response: +RANGING=(34.12,26.17),(-53.23,-49.15) Get the distance to the module with address 0004, but ranging failed: Send: UWBRFAT+RANGING=1,0004 Response: +RANGING=(-1),(0.00) Error example: Send: UWBRFAT+RANGING=123,456 Response: ERROR

21) The module's positioning function

Command		Response
Setting	UWBRFAT+LOCATION=<addr>	+LOCATION=(<x>,<y>,<z>),(<distance>),(<rssi>)
Explanation	<addr>: 4-byte hexadecimal type. The target anchor addresses when the module acts as a Tag for positioning. Range: 0000–FFFE. At least 3 addresses must be entered, up to 8 addresses can be entered, separated by commas. The module initiates the positioning process to the target modules in the order specified by the command, and outputs the positioning result after completion.	

	<x>: The calculated current x-coordinate of the module after positioning is completed. Up to 2 decimal places are supported. Unit: meters (m). <y>: The calculated current y-coordinate of the module after positioning is completed. Up to 2 decimal places are supported. Unit: meters (m). <z>: The calculated current z-coordinate of the module after positioning is completed. Up to 2 decimal places are supported. Unit: meters (m). <distance>: Floating-point string type. The distance information output after positioning is completed. Up to 2 decimal places are supported. If the distance is unavailable, this value will be -1. <rssi>: Floating-point string type. The signal strength information of the other end output after ranging is completed. Up to 2 decimal places are supported. If distance measurement fails, this value will be 0.
Example	There are 3 nearby anchors (0001, 0002, 0003). Get the relative position to these 3 anchors: Send: UWBRFAT+LOCATION=0001,0002,0003 Response: +LOCATION=(12.34,34.56,56.78),(11.22,33.44,55.66),(-45.45,-56.56,-67.67) Error example (insufficient number of anchor addresses entered): Send: UWBRFAT+RANGING=0001,0002 Response: ERROR

22) Set anchor addresses

Command		Response
Query	UWBRFAT+COORDINATE?	+COORDINATE=<x>,<y>,<z>
Setting	*UWBRFAT+COORDINATE= <x>,<y>,<z>	OK
Explanation	<x>: Integer type, representing the x-coordinate of the anchor in centimeters. Value range: 0–100000 (default: 0) <y>: Integer type, representing the y-coordinate of the anchor in centimeters. Value range: 0–100000 (default: 0) <z>: Integer type, representing the z-coordinate of the anchor in centimeters. Value range: 0–100000 (default: 0）	
Example	Query the module's own coordinates when acting as an Anchor: Command: UWBRFAT+COORDINATE? Response: +COORDINATE=12345,0,54321 Set the module's own coordinates:	

	Command: UWBRFAT+COORDINATE=12345,54321,100 Response: OK Response：OK

23) Set Ranging Offset

Command		Response
Query	UWBRFAT+DISTOFFSET?	+DISTOFFSET=<offset>
Setting	*UWBRFAT+DISTOFFSET=<offset>	OK
Explanation	<offset>: Integer type. Range: -500 to 500. Default value: 0. Specifies the offset value applied to the measured distance when the module performs ranging or positioning functions. Unit: cm. When the offset is a positive value, the module will add it to the measured result; when it is negative, the module will subtract it from the result.	
Example	Query distance offset value: Send: UWBRFAT+DISTOFFSET? Response: +DISTOFFSET=34 Set distance offset value: Send: UWBRFAT+DISTOFFSET=100 Response: OK	

10. Frequently Asked Questions

1. How many modules should a user purchase?

The actual number depends on the application scenario. For example:

1) If only simple 1-to-1 ranging or 1-to-1 data transmission is needed, then only 2 modules are required.

2）For basic 2D positioning setup and evaluation, at least 4 modules are needed — 3 as Anchors and 1 as a Tag.

3) For 3D positioning, at least 5 modules are required — 4 as Anchors and 1 as a Tag.

2. What is the relationship between usage range and ranging accuracy?

Due to the high transmission power of the UWB650 module, multipath effects are more significant in close-range areas (around 100cm × 100cm), which can cause greater fluctuation in ranging data. It is recommended to use the modules in a larger open space. Alternatively, in close-range scenarios,

consider lowering the transmission power to reduce the influence of multipath effects.

3. How does the UWB650 module connect to a computer?

The module only provides a UART interface for external communication. To connect it to a PC, a TTL-to-USB converter is required — one end connects to the module, the other to the PC. A corresponding driver must also be installed for proper operation.

We provide compatible TTL-to-USB tools. Please contact us for more information.

Why is there no ACK response when ACK request is enabled and ordinary data is sent?

Please check whether the transmission target address (UWBRFAT+TXTARGET) is set to a specific device address. When set to 0xFFFF (broadcast), the module does not request ACK, so no ACK response will be received.

5. Are additional accessories needed after purchasing the modules?

Besides a 5V power supply for the module (to be prepared by the user), if outdoor testing is required, we recommend using tripods to support the Anchors. The tripod should ideally be taller than 2 meters.

6. How does obstruction affect UWB ranging?

1）Solid walls: The UWB650 module's signal cannot penetrate solid walls. If ranging is still successful around a corner, the result must be inaccurate because the signal has reflected.

2）Glass walls: Glass walls significantly affect UWB ranging accuracy.

3）Poles, trees, and other elongated objects: Accuracy depends on the distance between modules. For example, when modules are approximately 100 meters apart, such obstacles in between have minimal impact. However, if the obstacle is within 1 meter of the antenna, ranging results are likely to drift significantly.

4）Cardboard, wooden boards, etc.: As long as they're not particularly thick (≤5 cm), the impact on accuracy is small, though the signal strength will still decrease.

5）Metal plates: These absorb UWB signals severely. If placed close to the module, electromagnetic waves cannot propagate to the other side of the metal, resulting in communication failure.

7. Why is the ranging accuracy poor, or communication distance short?

1）Check whether there are obstructions or strong electromagnetic interference between modules.

2）Check if other UWB devices using the same frequency band are active nearby.

3）Check whether the antennas on the modules are properly installed.

8. Why is the positioning accuracy poor?

1）Verify that the coordinates of the anchors are correctly measured and set.

2）Ensure anchors are installed at a height of at least 2 meters above ground.

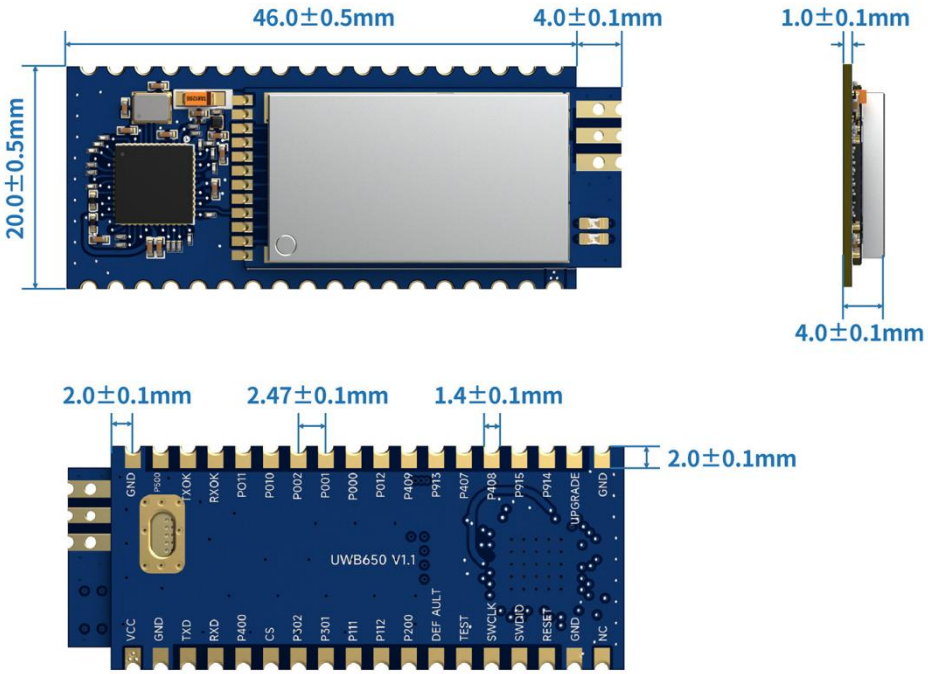
3） Check whether the tag is unable to communicate with some anchors. Try repositioning the problematic anchor(s), recalibrate, and retest.

4）Check for obstructions between the tag and the anchors.

5）Verify that the anchors are on the same horizontal plane (if the application requires it).

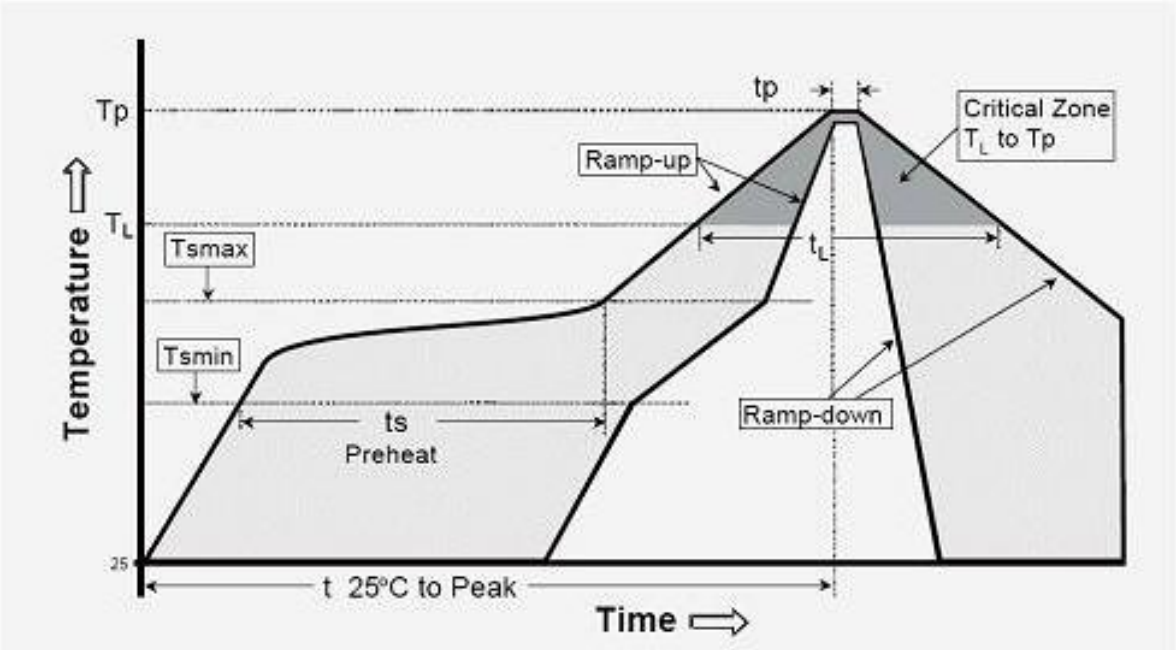
6）Check whether the tag is located far outside the area enclosed by the anchors.

11. Dimension (Unit： mm)



Appendix： Reflow Chart for SMT Technology

We recommend you should obey the IPC related standards in setting the reflow profile:



IPC/JEDEC J-STD-020B the condition for lead-free reflow soldering	big size components （thickness >=2.5mm）
The ramp-up rate (Tl to Tp)	3℃/s (max.)
preheat temperature - Temperature minimum (Tsmin) - Temperature maximum (Tsmax) - preheat time (ts)	 150℃ 200℃ 60~180s
Average ramp-up rate(Tsmax to Tp)	3℃/s (Max.)
- Liquidous temperature(TL)	217℃
- Time at liquidous(tL)	60~150 second
peak temperature(Tp)	245+/-5℃