



# **UWB Mini3sPlus User Manual V1.5**

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# 1 Introduction to YCHIOT positioning development kits and accessories

## 1.1 UWB Mini3sPlus series and its kits

Items	Brief introduction	Description
UWB Mini3 Development boards	The module adopts STM32F105RCT6 single-chip microcomputer as the main control chip. Through SPI, read and write UWB DWM1000 modules. The module anchor Tag is integrated and switched through the DIP switch. In addition, the module is as large as a dollar coin, making it ideal for developing small Tags.	<ul style="list-style-type: none"> <li>• UWB Mini Hardware PDF Schematic</li> <li>• Official data sheets are available</li> </ul>
UWB Mini3s Development boards	The module adopts STM32F103T8U6 single-chip microcomputer as the main control chip. Through SPI, read and write the UWB DW1000 module. The communication distance can reach 80 meters.	<ul style="list-style-type: none"> <li>• Support USB virtual serial port, provide host computer demonstration</li> <li>• Provide official data sheets, seller technical support</li> </ul>
UWB Mini3sPlus Development boards	The module adopts STM32F103T8U6 single-chip microcomputer as the main control chip. Through SPI, read and write the UWB DW1000 module. The communication distance can reach 300 meters.	<ul style="list-style-type: none"> <li>• Support USB virtual serial port, provide host computer demonstration</li> <li>• Provide official data sheets, seller technical support</li> </ul>

## 1.2 Comparison of detailed parameters of the UWB series modules of the YCHIOT

	Mini3 module	Mini3sPlus module	ProTag
Release time	2015.8.2	2017.5.17	2018.4.28
characteristic	Small size	The distance is long	Rechargeable, long distance
PCB size	30mm*23mm	58mm*24mm	50mm*35mm
PCB plates	Ordinary 2-layer board	High frequency 4-layer board	High frequency 4-layer board
Power supply interface	USB/positive and negative binding posts	USB/positive and negative binding posts	USB
USB communication interface	√	√	√
TTL serial interface	√	√	√
SWD download and debug interface	√	√	√
Main control chip	STM32F105RBT6	STM32F103T8U6	STM32F103T8U6

Lithium battery management chip	×	×	√
antenna	Ceramic on-board antenna	External rod antenna	Ceramic on-board antenna
Transmit power	-45dbm/Mhz	-22dbm/Mhz	-30dbm/Mhz
Working channel	CH2 / CH5	CH2	CH2
Stable and effective coverage radius	30m	300m	200m
Ranging accuracy error	<10 cm	<10 cm	<10 cm
Positioning accuracy error	<15cm	<15 cm	<15 cm

## 1.3 UWB Mini3sPlus Overview

### 1.3.1 UWB Mini3sPlus Overview

The UWB Mini3sPlus module uses STM32F103T8U6 microcontroller as the main control chip. Peripheral circuits include: DW1000 chip, power module, LED indication module, reset circuit, etc. The module can be used both as a anchor and as a tag, switching via USB commands.

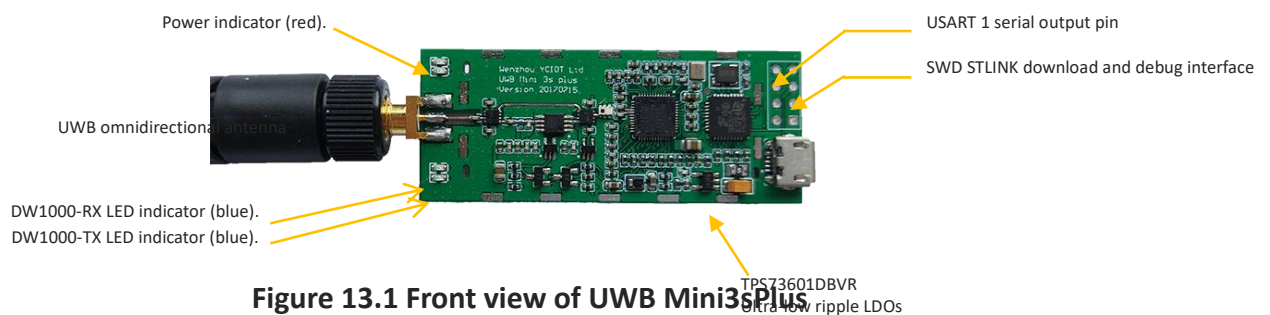


Figure 13.1 Front view of UWB Mini3sPlus

### 1.3.2 Hardware parameters

Table 13.2 UWB Mini3sPlus hardware parameters

Basic parameters		Wireless parameters	
PCB process	4-layer high-frequency board	Communication rate	110 kbit/s vs. 6.8 Mbit/s
Power supply interface	micro-USB(5.0V) / Binding post	Operating frequency	3.7GHz ~ 4.2GHz
Communication interface	micro-USB(5.0V) / 串口 (3.3V TTL)	Work channel	CH2 / CH5
Download the interface	SWD (VCC SDIO SCK GND)	Transmit power	-22dbm/MHZ
Main controller	STM32F103T8U6(64pin)	Maximum package length	1023 bytes
External crystal oscillator	8Mhz	Communication distance	>300m(无遮挡)
PCB size	58mm*24mm	Data jitter	Typical ± 10 cm, general shield ±

			30 cm
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### 1.3.3 IO allocation

**Table 13.3 R&D series UWB positioning module hardware IO port distribution**

	Mini3s	Mini3sPlus	ProTag	Pin remarks
PA0	DW_RSTn	DW_RSTn	DW_RSTn	
PA1	-	-	PGOOD	0: USB has power input and charging 1: No USB access
PA2	-	-	CHG	0: The battery is not fully charged 1: The battery is fully charged
PA3	-	USB-EN	USB-EN	
PA4	DW_NSS	DW_NSS	DW_NSS	
PA5	DW_SCK	DW_SCK	DW_SCK	
PA6	DW_MISO	DW_MISO	DW_MISO	
PA7	DW_MOSI	DW_MOSI	DW_MOSI	
PA8	DW_EXTON	DW_EXTON	DW_EXTON	
PA9	USART1_TX	USART1_TX	USART1_TX	Serial port 1-TXD
PA10	USART1_RX	USART1_RX	USART1_RX	Serial port 1-RXD
PA11	USB-DM	USB-DM	USB-DM	USB interface
PA12	USB-DP	USB-DP	USB-DP	USB interface
PA13	SWDIO	SWDIO	SWDIO	SWD interface
PA14	SWCLK	SWCLK	SWCLK	SWD interface
PA15	-	-	-	Accelerometer chip selection
PB0	DW_WUP	DW_WUP	DW_WUP	
PB1	-	-	ADC_VBAT	The ADC value x2 is the lithium battery voltage
PB2	BOOT1	BOOT1	BOOT1	
PB3	-	-	BQ_TD_EN	0: Charging enabled 1: Charging incapacitated
PB4	-	-	POWER	0: Power off the DW1000 1: Power on the DW1000
PB5	DW_IRQN	DW_IRQN	DW_IRQN	
PB6	LED1	LED1	LED1	Normally controllable LEDs
PB7	-	-	LED2	Normally controllable LEDs

### 1.3.4 Supported UWB Bands

UWB transmit power is less than WIFI and there should be no personal injury. The Mini3sPlus works on Channel 2 to maximize performance.

**Table 1.34 UWB IEEE802.15.4-2011 DWM1000 supported UWB channels**

UWB channel UWB Channel	Center Frequency (MHz) Centre Frequency	Frequency Band (MHz) Band	Bandwidth (MHz) Bandwidth
1	3494.4	3244.8 – 3744	499.2

2	3993.6	3744 – 4243.2	499.2
3	4492.8	4243.2 – 4742.4	499.2
4	3993.6	3328 – 4659.2	1331.2*
5	6489.6	6240 – 6739.2	499.2
7	6489.6	5980.3 – 6998.9	1081.6*

Note: The maximum receive bandwidth of the DWM1000 is about 900MHz

### 1.3.5 Channel 2 Test

The antenna of the UWB Mini3sPlus was connected to the spectrum analyzer FSL6 (Rohde & Schwarz), and the center frequency of Channel 2 was measured to be 4 GHz, with a maximum gain of -23.12dBm as shown in the figure below.

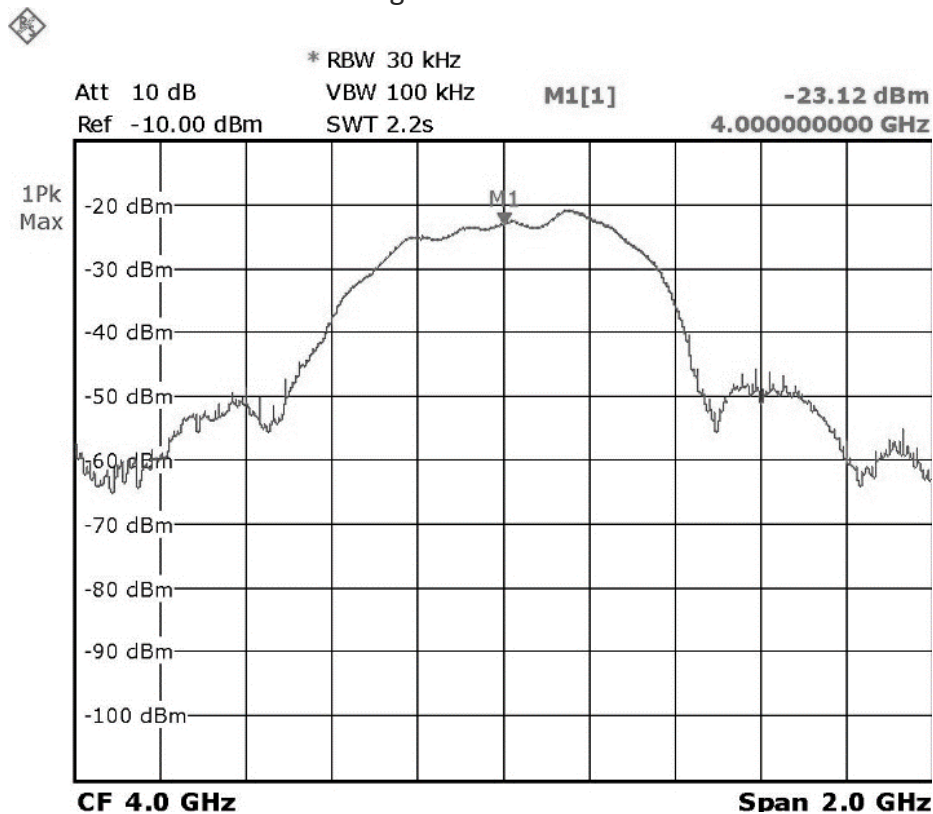


Figure 1.35. Transmit power test

## 1.4 Glossary of technical terms

Table 1.4 Abbreviations of technical terms

Shorthand	Full name in English	meaning
ANCHOR		A anchor, also known as a beacon anchor, is a node that has obtained location coordinates in advance by other means
DW1000		A chip from Decawave
DWM1000		A module from Decawave
PSR	preamble symbol repetitions	The leading symbol is repeated
RTLS	real time location system	Real-time location system

TOF	time of flight	The TOF time-of-flight ranging method mainly uses the time of flight of the signal to and from two asynchronous transceivers (or reflected surfaces) to measure the distance between nodes.
TWR	two-way ranging	The bidirectional ranging method, i.e. two asynchronous transceivers (Transceiver) can obtain the ranging value.
UWB	Ultra-wide band	UWB (Ultra Wideband) is a carrier-less communication technology that uses non-sine wave narrow pulses in the nanosecond to picosecond order to transmit data.



## 2 Research and innovation of the actual project application of UWB of the Internet of Things

### 2.1 Where can UWB Mini3sPlus be used?

According to the needs provided by customers and the actual application situation, after a series of technical return visits, UWB Mini3 indoor positioning products have been applied in the following application scenarios: such as airport halls, exhibition halls, warehouses, supermarkets, libraries, underground parking lots, mines and other environments. The specific scenarios are as follows:

- smart luggage, smart stroller;
- factory container and cargo positioning;
- Help visitors find the appropriate attractions and public facilities in the playground;
- supermarket personnel positioning;
- Helping visitors to understand exhibits and view exhibitions more effectively in museums;
- Positioning of mine personnel and the working condition of the roadheader;

### 2.2 What are the advantages and disadvantages of mainstream indoor positioning technologies at home and abroad?

In recent years, some technology giants, including Google, Microsoft, Apple, Broadcom, etc., as well as some world-famous universities, have been researching indoor positioning technology. According to the research and investigation of domestic and foreign literature, Bluetooth, wireless radio frequency, etc., have been widely used in indoor positioning in offices, homes, factories and other scenarios. The advantages and disadvantages of mainstream indoor positioning technologies at home and abroad are shown in the following table:

**Table 2.4 Advantages and disadvantages of mainstream indoor positioning technologies at home and abroad**

Indoor positioning technology	merit	shortcoming
Ultrasonic positioning technology	High precision and simple structure.	It is greatly affected by the multipath effect and non-line-of-sight propagation, and at the same time, it requires a large amount of investment in underlying hardware facilities, and the cost is too high.
Bluetooth location technology/ibeacon	The equipment is small in size, easy to integrate, and easy to popularize.	For complex space environments, the stability of the Bluetooth system is slightly poor, and it is greatly interfered by noise signals.
Radio Frequency Identification (RFID) technology	The size of the logo is relatively small, and the cost is relatively low.	It has a short range of functions, does not have communication capabilities, and is not easy to integrate into other systems.
UWB ultra-bandwidth	Strong penetration, low power consumption, good anti-multipath	It will have a certain impact when encountering shelters, metals, etc.,

technology	effect, high security, low system complexity, and can provide accurate positioning accuracy.	and the price is slightly expensive, and there is still some distance from large-scale production.
SLAM technology	Create a map in a completely unknown environment under the condition of its own uncertain position, and use the map for autonomous positioning and navigation.	The amount of image data is huge, and the equipment is very expensive, which is suitable for research and not suitable for mass production.

## 3 Q&A on technical questions

### 3.1 Principle

#### 3.1.1 What is the ranging principle of UWB?

In the two-way-time of flight (TW-TOF) method, each module generates an independent timestamp from the start-up. Module A's transmitter transmits a request pulse signal at  $T_{a1}$  on its timestamp, and module B transmits a responsive signal at  $T_{b2}$ , which is received by module A at its own timestamp  $T_{a2}$ . At one time, it was possible to calculate the flight time of the pulse signal between the two modules, and thus determine the flight distance  $S$ .

$$S = C \times [(T_{a2} - T_{a1}) - (T_{b2} - T_{b1})] / 2 \quad (C \text{ is the speed of light})$$

#### 3.1.2 How does UWB positioning work?

- 1) Distance = Speed of light \* Time difference / 2; XY plane, 3 circles, able to determine a point;
- 2) XYZ space, 4 circles, able to determine a spatial point;

### 3.2 Operation

#### 3.2.1 Can this module measure distance through walls?

Answer: Penetrating the wall will cause signal blockage, resulting in ranging failure. This is determined by the principle of UWB positioning. Small obstacles, such as tables and chairs, do not have a great impact on the accuracy of positioning.

#### 3.2.2 Precautions for the installation of this module

- The UWB module is at least 1m away from obstacles such as walls, tables, shelves, and metal cabinets. Otherwise, the positioning data will be affected, resulting in inaccurate ranging results;
- Try not to get obscured around the antenna. When the user is making a standard measurement, please place the anchor on a tripod **and be more than 1.5 meters away from the ground**
- During the test, please screw the antenna on to ensure the best performance of the module;
- If customers need signal through the wall for ranging, they can purchase the Mini3sPlus module, which adds RF power amplifier circuit to ensure that the signal stably passes through the wall;

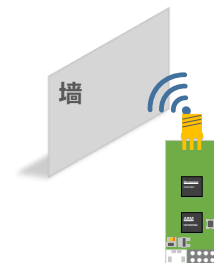


Figure 3.2.2 Precautions for installing anchor Tags

#### 3.2.3 Why does the anchor heat up when in use?

A: There will be a fever, which is normal. However, it will not burn out the module, so please feel free to use it.

#### 3.2.4 Can the mini-map of the host computer be customized?

A: It can be customized, PNG format import is supported, and it can be drawn with Microsoft Office

Visio .

### 3.2.5 TOF and TDOF are the main sources of error

- 1) Signal impairment. The ranging information for indoor positioning is based on the assumption that the distance is measured in the case of line-of-sight, and if there is non-line-of-sight, such as an obstacle in the middle or through reflection, it will cause the reception time to become longer, and the measured distance will become larger.
- 2) The anchor coordinates are incorrect. The coordinates of the tag are relative to the coordinates of the anchor Anchor, if the coordinates of the anchor itself are wrong, then our positioning data is meaningless.
- 3) Clock synchronization error. Each anchor will have a slight gap in their clocks, but if the gap is 1ns, there will be an error of 30 centimeters, so if we can synchronize the time of all anchors in the system, we can further improve the positioning accuracy.

## 4 UWB MINI3sPlus Positioning Kit Test Instructions

The UWB Mini3sPlus positioning system consists of at least four UWB Mini3sPlus modules, i.e. 3 anchors + 1 tags. After that, tags and anchors can be purchased to realize the expansion of the Tags and number of the system, and the DEMO can support up to 4 anchors + 8 tags. However, this does not mean that this system can only support a maximum of 8 tags, and through custom development, it can support tens of thousands of tags.

### 4.1 ANCHOR AND TAG MODE CONFIGURATION

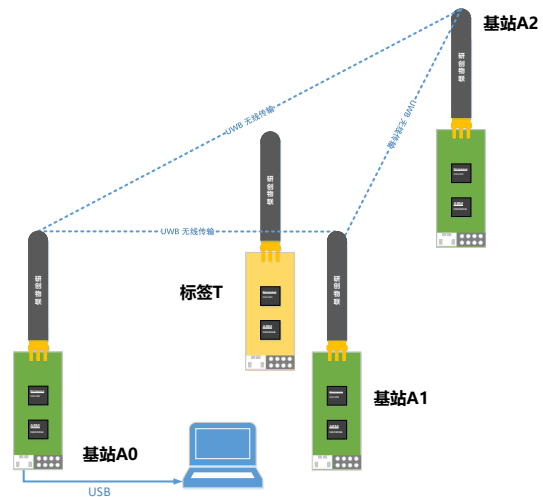
The mode configuration has been set at the factory, if there are no special circumstances, there is no need to change, the module can be tested at hand, and [this step can be skipped](#).

For users who purchase 8 tags and below, the product supports AT+SW commands, [see Chapter 9.1 for details](#)

For users who purchase 9 tags and above, the product supports AT+QSET commands, [see Chapter 9.2 for details](#)

### 4.2 Scenario 1: Indoor 2D positioning (3 anchors + 1 Tag test)

- 1) Hardware platform construction
- 2) Install the virtual serial port driver. See Section 6.4 of this section;
- 3) The A0 anchor is directly connected to USB;
- 4) Open the host computer software DecaRangeRTLS .exe, if it appears as shown in Figure 4.2.2, there may be the following reasons:
  - The installation of the virtual serial port driver failed, and the software could not find COMx;
  - The USB cable is not connected to the hardware, the Micro-USB cable does not support communication, or a damaged Micro-USB cable is used



Note 1: Most Win7 users can not open the host computer, but you can see the DecaRangeRTLS .exe background process, encounter this problem (currently unable to solve the problem), please try on another computer;

Note 2: Some high-resolution screen users (2K screen or 4K screen users) will have the problem of incomplete text display on the host computer, and can be displayed by adjusting the separator;

- 5) All tags are powered by power banks;
- 6) A1/A2 anchor is powered by power bank;

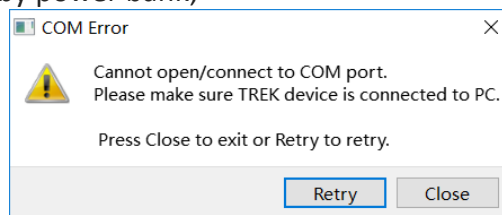


Figure 4.2.2 The host computer cannot communicate

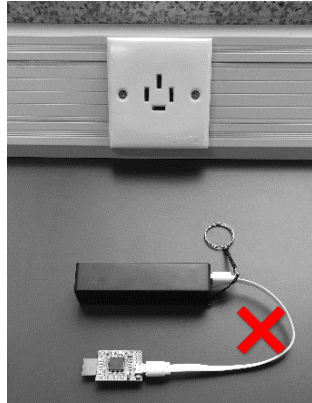
- 7) Precautions for product placement

The placement of anchors and tags directly affects the accuracy of ranging, and directly affects the accuracy and precision of positioning. Here are a few common placement mistakes:

- Place the module near the metal. Whether it is a built-in ceramic antenna or an external rod antenna, the antenna signal will be directly absorbed by the metal when it encounters it
- Placing the module flat on the table, sticking the module to the wall, and holding the antenna in your hand will affect the beam of the UWB antenna and cause a certain multipath effect



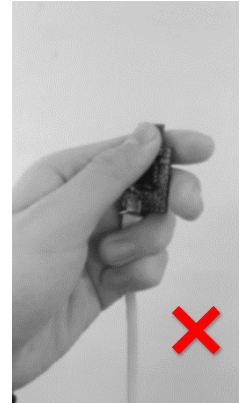
Place the module near the metal



Place the module flat on the desktop



Glue the module to the wall



Hold the antenna in your hand

The correct installation method is shown in the figure below:



#### 8) Operating software DecaRangeRTLS

- In the Settings option, check Tracking/Navigation Mode (checked by default).
- Turn on the host computer, and the [distance data in the Tag / Anchor Tables has begun](#) to jump, indicating that the ranging has begun.
- In the anchor table in the upper left corner, select Anchor ID 0/1/2, and enter the XYZ relative coordinates of the anchor according to the actual anchor placement. Generally speaking, we set A0 to (0,0,1.5), which means that the height of A0 is 1.5m. By default, A0, A1, and A2 are at the same height in the software, so these three anchors need to be at the same height when they are placed.
- When the anchor coordinates are successfully set, the coordinates can be solved (the equation has a solution for the real root), otherwise the coordinates of the Tag will not be displayed

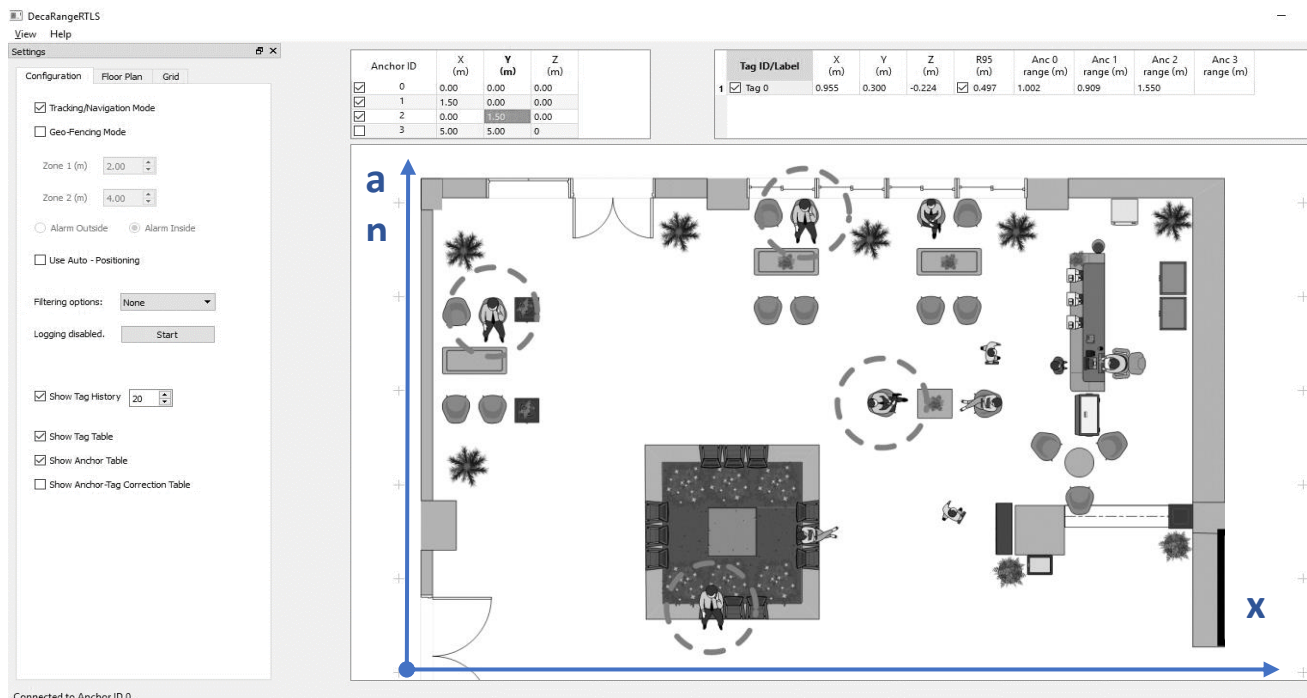


Figure 4.2.7 Screenshot and use of PC-RTLS presentation software

### 4.3 Scenario 2: Indoor 3D positioning (4 anchors + multi-Tag test)

- For a larger positioning system, it is best to need four anchors. In order to obtain good z-axis accuracy, for the case of 4 anchors, it is best to place A3 at a height of 1 m or 0.5 m higher than A0/A1/A2, A0/A1/A2 is in the same plane, and in addition, the distance fitting described in Chapter 8 needs to be completed. In the case of no obstruction, better results can be obtained.
- The procedure is the same as in Section 4.2.

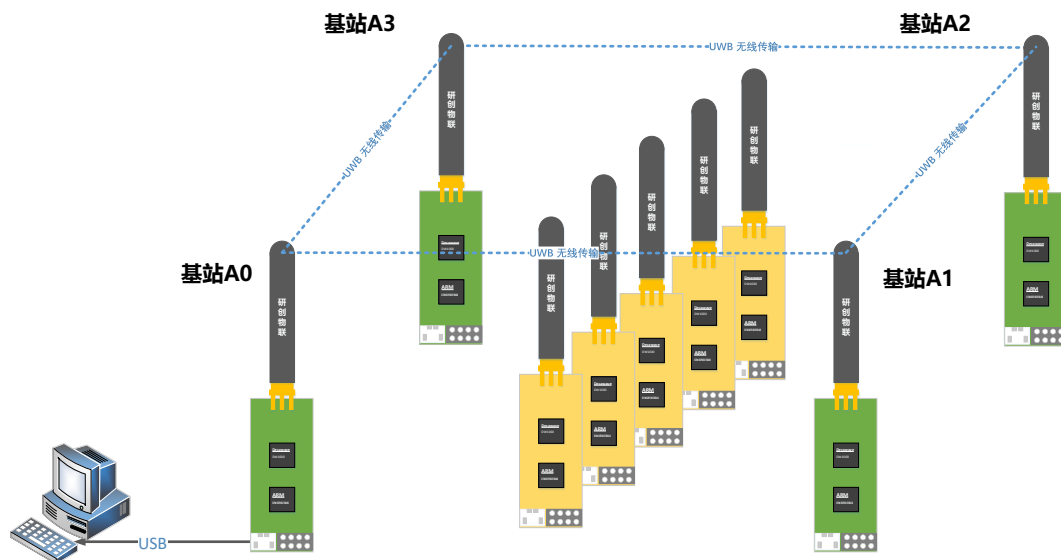


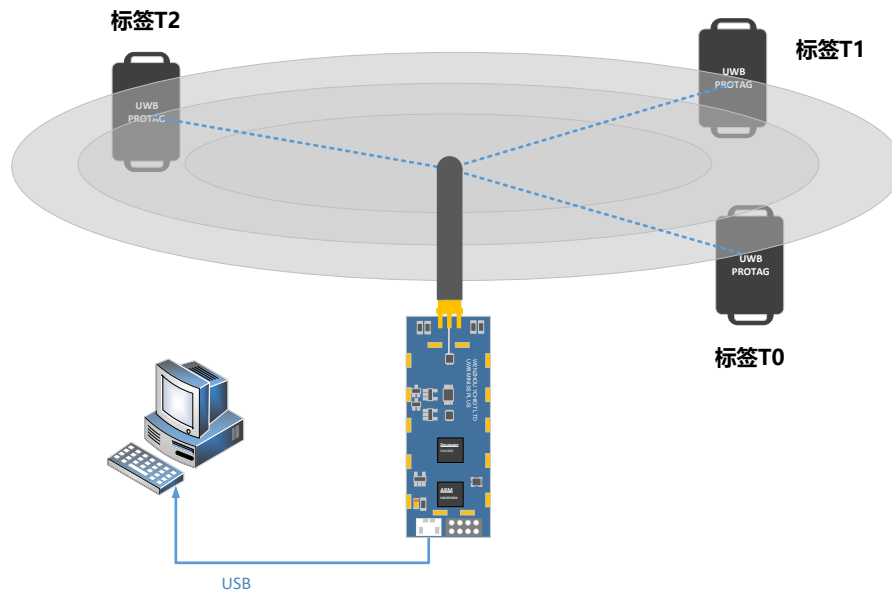
Figure 4.3.1 Schematic diagram of positioning 4 anchor + multi-Tag hardware platform

### 4.4 Scenario 3: Out-of-range alarm (1 anchor + 3 tag test)

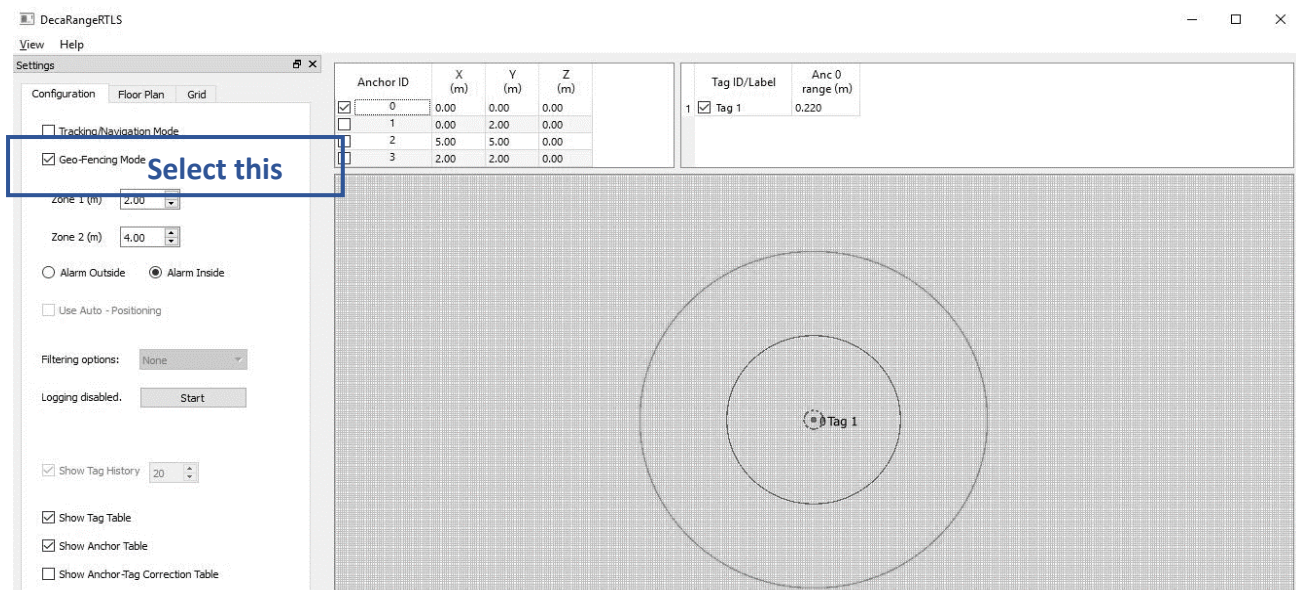
- hardware networking;
- Install the virtual serial port driver (same as above);



- 3) A0 Connect to a computer via USB (same as above);
- 4) Open the host computer software DecaRangeRTLS .exe (ibid.).
- 5) All tags are powered by a power bank;  
Note: If there is only 1 tag (1 anchor 1 tag), you can also test in this mode. Anchor A0 must be present.
- 6) Operating software: Set to Geo-Fencing Mode



**Figure 4.4.1** Schematic diagram of the hardware platform of 1 anchor + 3 tag for over-range alarm



**Figure 4.4.2** Schematic diagram of the 1 anchor + 3 Tag software platform for over-range alarm



## 5 UWB Series Networking Kit Smart Link (optional).

### 5.1 Positioning system data onboarding solution

The UWB Smart Link networking kit development board is designed to transmit the *TOF Report Message data output from the serial port of the UWB Mini 3/ Mini3s/ 3s Plus module* to the remote server, so that developers can remotely manage and monitor the UWB positioning data. The development board is equipped with MXCHIP's powerful WIFI module, which can realize data access to the network through simple settings.

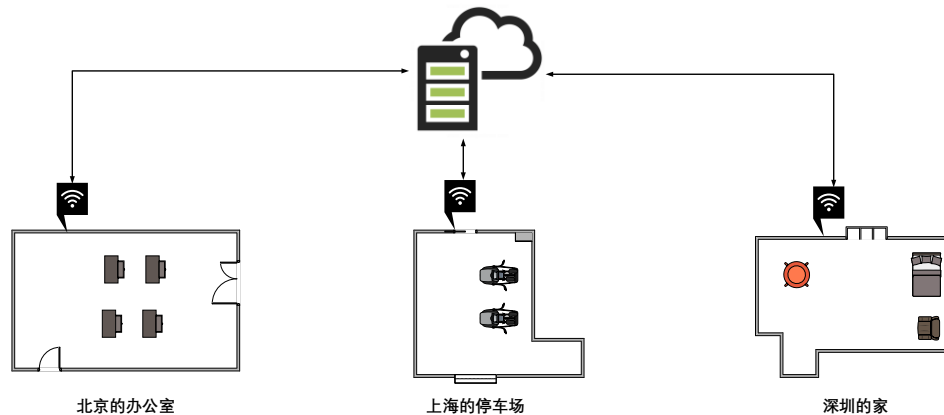
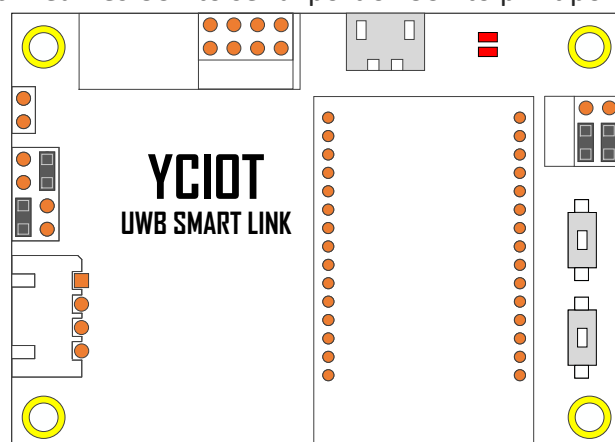


Figure 5.1 Schematic diagram of positioning data entering the network

### 5.2 Introduction to the UWB Smart Link Hardware Module of the Networking Kit

- 1) The 2\*4 Header interface in the upper left corner is compatible with *UWB Mini 3/ Mini3s/ 3s Plus*, plug and play, [please flash the latest development version of the firmware before use, and enable the serial output of the UWB module.](#)
- 2) THE WIFI MODULE ADOPTS THE MXCHIP EMW3162. Built-in high-performance, low-power Cortex-M3 microcontroller, 128KB RAM + 1MB Flash. The module runs the MiCO IoT operating system and supports secondary development, allowing users to use MiCO's TCP/IP protocol stack and multiple security encryption algorithms to implement various embedded Wi-Fi applications.
- 3) The TTL to USB chip adopts CH340, which is a USB bus adapter chip developed by Jiangsu Qinheng Company (WCH), which realizes USB to serial port or USB to print port;



For more information, see UWB Smart Link Instruction Manual V1.3.

Data link: <https://pan.baidu.com/s/1eSvGMRK> Password: GDP2

## 6 Secondary development of UWB Mini3sPlus module

### 6.1 Development environment and tools

Before the secondary development, a series of software drivers need to be installed to ensure the basic conditions of development. The required installation software is already in the provided Baidu Cloud network disk.

**Table 6.1.1 UWB Mini Suite Development Software**

tool	function
ST-LINK	ST-LINK is a development tool that allows you to emulate and download STM8 and STM32 online. Function spike J-Llink.
KEIL-MDK5.20	STM32 development platform, Keil series software is used by more than 80% of China's software and hardware engineers, but all electronics-related majors will begin to learn from microcontroller and computer programming, and learning microcontroller will naturally use Keil software. Keil's sales and technical support services are provided by Mir Technology, Emdoor Electronics and Inbeite, who are ARM partners and leading embedded solution providers in China.
DecaRangeRTLS.exe	Indoor positioning host computer, support positioning graphic interface display, support map import
XCOM	Punctual Atom is an excellent serial port debugging assistant software developed by Punctuality Atom

### 6.2 Mini3sPlus firmware update

#### 6.2.1 Install the ST-LINK program burning downloader driver

Open [en.stsw-link009zip](#), click OK or Next to complete the installation of the ST-LINK driver. Plug in the STLINK downloader and find its driver in the Device Manager.



Figure 6.2.1 PHYSICAL IMAGE OF THE STLINK DOWNLOADER

#### 6.2.2 STLINK is connected to the Mini3sPlus hardware

If you need to upgrade or modify the firmware of UWB Mini3, you need to use STLINK to update the firmware, as shown in the following figure.

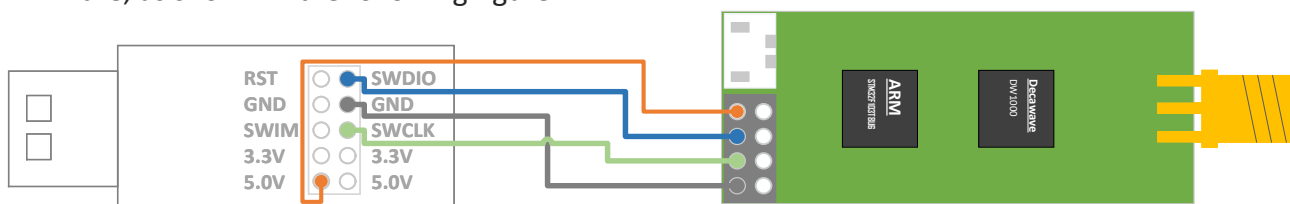


Figure 6.2.2 How to connect STLINK V2 Downloader to Mini3sPlus hardware

### 6.2.3 Install the development environment Keil

For the Keil installation tutorial, see the manual document aps003-UWB module firmware update installation tutorial. In Keil, you can use the built-in Download function to download programs for UWB modules.

### 6.2.4 STLINK DOWNLOAD SETTINGS

The UWB module program can also be updated through the STLINK Utility software. For details about how to implement STLINK Utility, see aps003-UWB Module Firmware Update and Installation Tutorial

## 6.3 The method of Mini3sPlus to output data from the serial port

### 6.3.1 External serial port equipment/RS232/485, etc

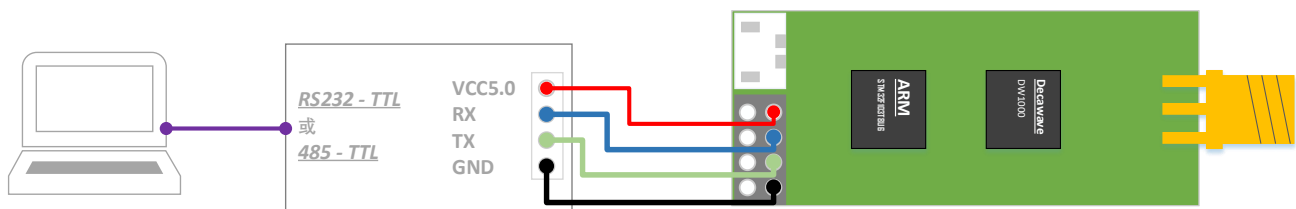


Figure 63.1.1 UWB Mini3sPlus module is connected to TTL to RS232 module or TTL to 485 module

UWB Mini3s is connected to an external BLE 4.0 serial Bluetooth module, which can realize the data viewing of Android phones and Apple mobile phones.

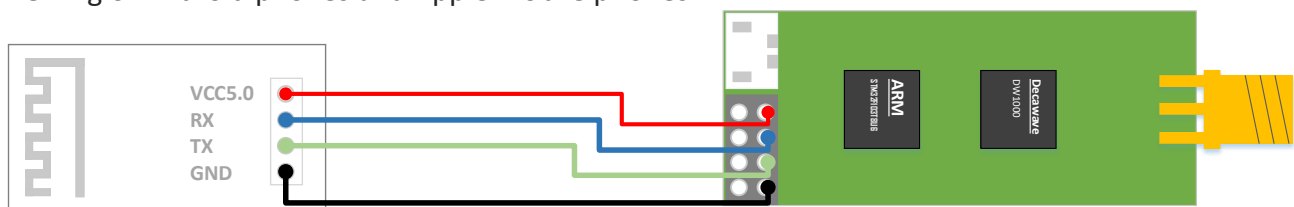


Figure 63.1.2 The UWB Mini3sPlus module is connected to the Bluetooth module

Raspberry Pi or Arduino is a development board with a TTL level of 5V, and when connected to a UWB module, a current limiting resistor of 27R~51R needs to be connected in series.

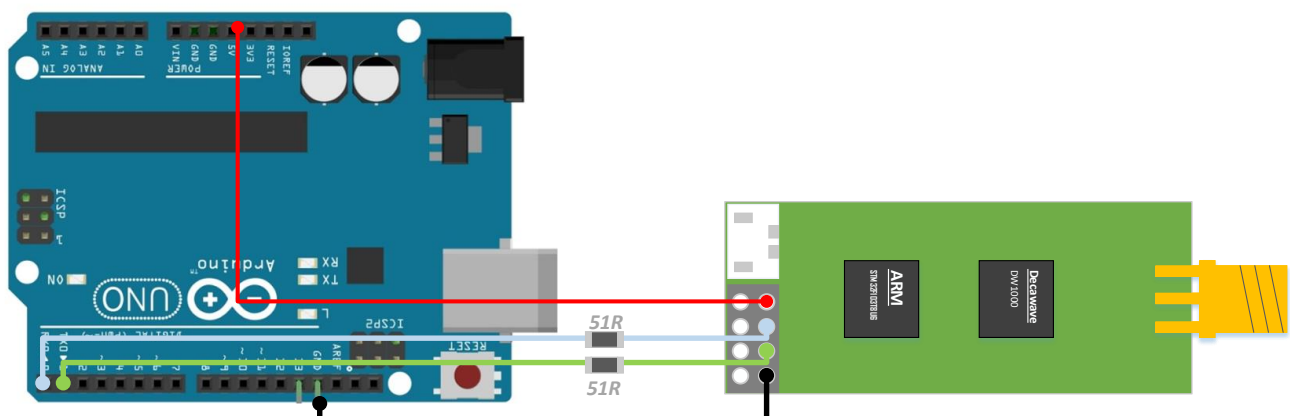


Figure 63.1.3 The UWB Mini3sPlus module is connected to a microcontroller (Arduino).

### 6.3.2 Open the Serial Port Debugging Assistant to view

Baud rate 115200bps, 8 bits of data, 1 bit of stop, no check bits. Connect as shown in Figure 6.3.1 and open the XCOM serial debugging assistant on the computer to observe the TOF Report Message data stream.

```
mc 01 00000451 00000000 00000000 00000000 0188 89 00022640 a0:0
mr 01 00000451 00000000 00000000 00000000 0188 89 40224022 a0:0
mc 01 0000046e 00000000 00000000 00000000 0189 8a 00022758 a0:0
mr 01 0000046e 00000000 00000000 00000000 0189 8a 40224022 a0:0
mc 01 00000431 00000000 00000000 00000000 018a 8b 00022870 a0:0
mr 01 00000431 00000000 00000000 00000000 018a 8b 40224022 a0:0
mc 01 00000448 00000000 00000000 00000000 018b 8c 00022988 a0:0
mr 01 00000448 00000000 00000000 00000000 018b 8c 40224022 a0:0
mc 01 0000046e 00000000 00000000 00000000 018c 8d 00022aa0 a0:0
mr 01 0000046e 00000000 00000000 00000000 018c 8d 40224022 a0:0
mc 01 0000047c 00000000 00000000 00000000 018d 8e 00022bb8 a0:0
mr 01 0000047c 00000000 00000000 00000000 018d 8e 40224022 a0:0
mc 01 00000451 00000000 00000000 00000000 018e 8f 00022cd0 a0:0
mr 01 00000451 00000000 00000000 00000000 018e 8f 40224022 a0:0
mc 01 0000045f 00000000 00000000 00000000 018f 90 00022de8 a0:0
mr 01 0000045f 00000000 00000000 00000000 018f 90 40224022 a0:0
mc 01 00000443 00000000 00000000 00000000 0190 91 00022f00 a0:0
mr 01 00000443 00000000 00000000 00000000 0190 91 40224022 a0:0
mc 01 0000042c 00000000 00000000 00000000 0191 92 00023018 a0:0
mr 01 0000042c 00000000 00000000 00000000 0191 92 40224022 a0:0
```

Figure 6.3.2 TOF Report Message Data Flow

## 6.4 How Mini3sPlus outputs data from a USB virtual serial port

### 6.4.1 Install the ST virtual serial port driver

The virtual serial port driver is a driver released by ST. Please refer to our official account for the installation method.



### 6.4.2 Open the Serial Port Debugging Assistant to view

USB virtual serial port adaptive baud rate, data bits, stop bits, and check bits. Therefore, the above parameters do not need to be modified and selected, click "Open Serial Port" to observe the TOF Report Message data stream.

```
mc 01 00000451 00000000 00000000 00000000 0188 89 00022640 a0:0
mr 01 00000451 00000000 00000000 00000000 0188 89 40224022 a0:0
mc 01 0000046e 00000000 00000000 00000000 0189 8a 00022758 a0:0
mr 01 0000046e 00000000 00000000 00000000 0189 8a 40224022 a0:0
mc 01 00000431 00000000 00000000 00000000 018a 8b 00022870 a0:0
mr 01 00000431 00000000 00000000 00000000 018a 8b 40224022 a0:0
mc 01 00000448 00000000 00000000 00000000 018b 8c 00022988 a0:0
mr 01 00000448 00000000 00000000 00000000 018b 8c 40224022 a0:0
mc 01 0000046e 00000000 00000000 00000000 018c 8d 00022aa0 a0:0
mr 01 0000046e 00000000 00000000 00000000 018c 8d 40224022 a0:0
mc 01 0000047c 00000000 00000000 00000000 018d 8e 00022bb8 a0:0
mr 01 0000047c 00000000 00000000 00000000 018d 8e 40224022 a0:0
mc 01 00000451 00000000 00000000 00000000 018e 8f 00022cd0 a0:0
mr 01 00000451 00000000 00000000 00000000 018e 8f 40224022 a0:0
mc 01 0000045f 00000000 00000000 00000000 018f 90 00022de8 a0:0
mr 01 0000045f 00000000 00000000 00000000 018f 90 40224022 a0:0
mc 01 00000443 00000000 00000000 00000000 0190 91 00022f00 a0:0
mr 01 00000443 00000000 00000000 00000000 0190 91 40224022 a0:0
mc 01 0000042c 00000000 00000000 00000000 0191 92 00023018 a0:0
mr 01 0000042c 00000000 00000000 00000000 0191 92 40224022 a0:0
```

Figure 6.4.2 TOF Report Message Data Flow

## 7 PC upper computer communication data format and secondary development

### 7.1 Introduction to RTLS host computer

This section introduces the use of PC host computers. This host computer software is developed using QT 5.7.0 MinGM and written in C++. Qt is a cross-platform C++ graphical user interface application development framework developed by Wonder Technology in 1991. It can be used to develop both GUI and non-GUI programs, such as console tools and servers. Qt is an object-oriented framework that uses special code generation extensions (called meta-object compilers) as well as some macros that are easily extensible and allow component programming. In April 2014, Qt Creator 3.1.0, a cross-platform integrated development environment, was officially released, which realized full support for iOS, added plug-ins such as WinRT and Beautifier, abandoned GDB debugging support without Python interface, integrated Clang-based C/C++ code modules, and made adjustments to Android support, so as to achieve full support for iOS, Android, and WP.

The main functions realized by this host computer are:

- 1) Establish a connection with the virtual COM port of the UWB module;
- 2) Read the TOF report message from the UWB module;
- 3) a list of anchors, in which the actual location of the anchors can be set;
- 4) Tag list, which can show the distance of the tag from the anchor and the location of the tag (XYZ coordinates);
- 5) Map display, support custom import of a PNG format map, can achieve zoom and coordinate fine-tuning;
- 6) other parameter settings;

### 7.2 RTLS host computer interface

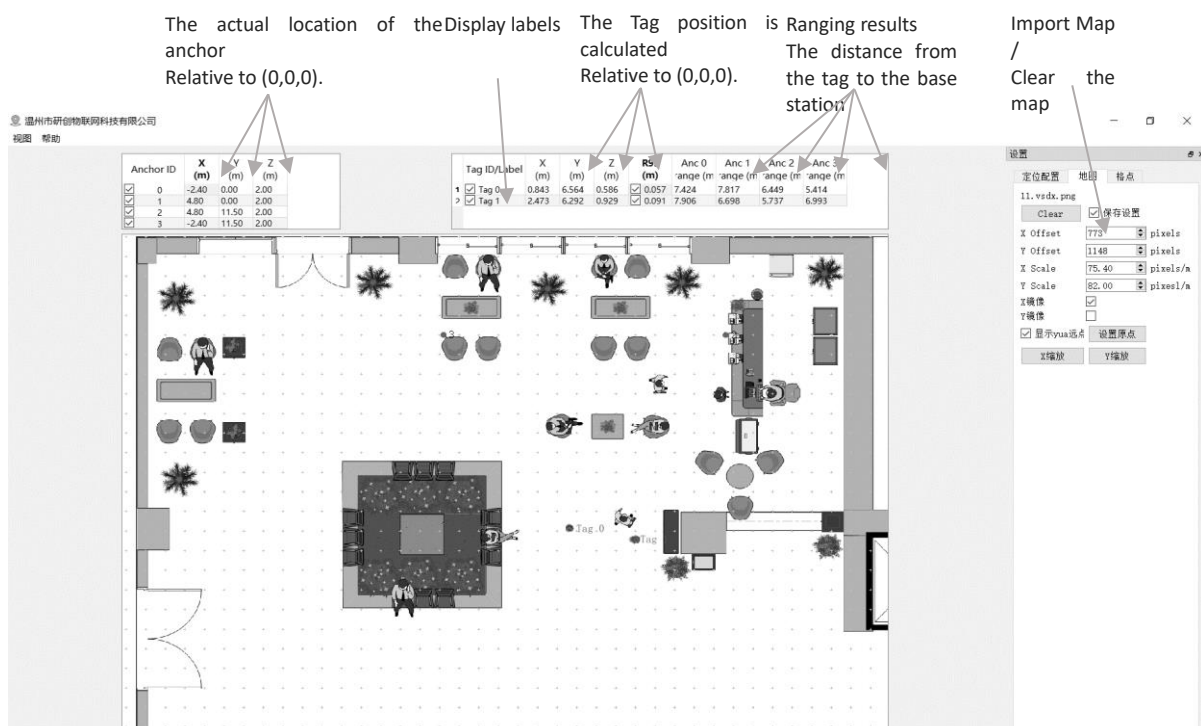


Figure 7.2 RTLS host computer interface

## 7.2.1 Graphics

### 7.2.1.1 Tag and Anchor Tables

The tag table contains the tag ID, ranging information, and positioning coordinates.

Double-click the Tag tag to modify the R95 statistical variable

	Tag ID/Label	X (m)	Y (m)	Z (m)	R95 (m)	Anc 0 range (m)	Anc 1 range (m)	Anc 2 range (m)	Anc 3 range (m)
1	<input type="checkbox"/> Tag 6	3.846	2.628	2.272	<input type="checkbox"/>	4.736	3.484	4.169	

Whether or not to display the Tag Lable Tag ranging value from the module (tag-anchor distance).

solved location

The

**图 7.2.1.1.1 Tag Table**

- R95 Statistical Variable References:  
<https://baike.baidu.com/item/%E7%BD%AE%E4%BF%A1%E5%8C%BA%E9%97%B4/7442583?fr=aladdin>
- The position of the tag solution is calculated according to the distance between the tag and the anchor, and the specific solution method is described in Section 7.5

	Anchor ID	X (m)	Y (m)	Z (m)
<input checked="" type="checkbox"/>	0	0.00	0.00	3.00
<input checked="" type="checkbox"/>	1	6.00	0.00	3.00
<input checked="" type="checkbox"/>	2	0.00	4.00	3.00
<input type="checkbox"/>	3	5.00	5.00	3.00

**图 7.2.1.1.2 Anchor Table**

Anchor Tables contain the ID of the anchor anchor and the location information of the anchor.

## 7.2.2 状态栏 Status Bar

The status bar in the lower left corner reads as follows:

- "DecaRangeRTLS Anchor/Tag ID Mode" – Open the software and the COM port is successfully connected
- "Connected to Anchor/Tag/Listener ID" – The tag/anchor is connected and receiving TOF data
- "No location solution" – The software cannot solve the coordinates based on the ranging data
- "Open error" – The software failed to open the virtual serial port

### 7.2.3 View Settings

The view settings consist of three tables: configuration, floorplan, and grid.

- Configuration Table

name	description
Tracking/Navigation Mode	Positioning mode
Geo-Fencing Mode	Out-of-range alarm mode
Zone1	Scope 1
Zone2	Scope 2
Alarm Outside/Inside	Alarm outside the circle/inside the circle
Show Tag History (N)	Displays the last N historical points
Show Tag Table	Display Tag Table
Show Anchor Table	Display Anchor Table
Auto Positioning	Auto-positioning mode, in which the anchor position does not need to be set, is carried out
Filtering	Set up data filtering
Logging	Whether to generate logs

- Grid Table

name	description
Width	Width, in meters
Height	Height, in meters
show	Whether to display grid points

- Floor Plan tab

name	description
Open	Open a map and import the software
X offset	In pixels in the X direction, pan the map
And offset	In pixels in the Y direction, pan the map
X scale	In the X direction, in pixels, zoom the map
The scale	In pixels in the Y direction, zoom the map
Flip X	The X-axis is the axis of symmetry, and mirroring is performed
Flip Y	The Y axis is the axis of symmetry, and mirroring is performed
show	Whether to display the origin
Set Origin	Set the origin
X Scale button	Clicking this button will bring up a widget that measures the distance on the map, enters the actual distance, and sets the X zoom value
Y mælikvarði hnappur	Clicking this button will bring up a widget that measures the distance on the map, enters the actual distance, and sets the Y zoom value

## 7.3 TOF Report Message

Open any serial port debugging assistant, no need to set parameters such as baud rate, you



can observe that the anchor A0 transmits data to the USB of the PC through the USB virtual serial port in the following format:

1. mr 0f 000005a4 000004c8 00000436 000003f9 0958 c0 40424042 a0:0
2. ma 07 00000000 0000085C 00000659 000006B7 095B 26 00024BED a0:0
3. mc 0f 00000663 000005a3 00000512 000004cb 095f c1 00024c24 a0:0

MID MASK RANGE0 RANGE1 RANGE2 RANGE3 NRANGES RSEQ DEBUG aT:A

**Table 7.3.1 TOF data format table**

content	function
MID	There are three types of message IDs: mr, mc, and ma MR stands for Tag-Anchor Distance (Native Data) mc stands for tag-anchor distance (optimized and corrected data for positioning tags) MA stands for Anchor-Anchor Distance (corrected and optimized for anchor automatic positioning)
MASK	Indicates which messages are valid for RANGE0, RANGE1, RANGE2, RANGE3; 例如: MASK=7 (0000 0111) 表示 RANGE0, RANGE1, RANGE2 都有效
RANGE0	If MID = mc or mr, it represents the distance from Tag x to anchor 0 in mm
RANGE1	If MID = mc or mr, it represents the distance from Tag x to anchor 1 in millimeters If MID = ma, it represents the distance from anchor 0 to anchor 1 in millimeters
RANGE2	If MID = mc or mr, it represents the distance from Tag x to anchor 2 in mm If MID = ma, it represents the distance from anchor 0 to anchor 2 in millimeters
RANGE3	If MID = mc or mr, it indicates the distance from Tag x to anchor 3 in mm If MID = ma, it represents the distance from anchor 1 to anchor 2 in mm
NRANGES	Unit Raw Range count value (will add up)
RSEQ	range sequence number 计数值 (会不断累加)
DEBUG	If MID=ma, it represents the TX/RX antenna delay
aT:A	T is the Tag ID and A is the anchor ID The ID mentioned here is just a short ID, and the full ID is a 64 bit ID

## 7.4 Log Files

When using the host computer, click "Start", and in the Log folder, a *log file in yyyyymmdd\_hhmmssRTLS\_log.txt text format will be generated, which means as follows:*

**Table 7.4 Definitions of log files**

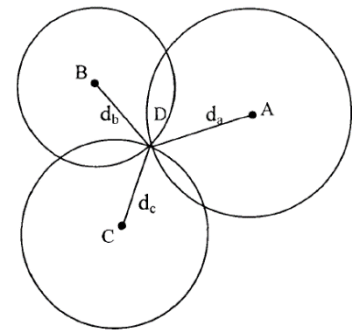
Log content	meaning
Q:151734568:DecaRangeRTLS:LogFile:Ver. 2.10 TREK:Conf:Anchor0:1:Chan2	15:17, 34s, 568ms, version V2.10; currently connected to A0, 6.8M, Channel 2

T:151734600:AP:0:-2.4:0:0 T:151734600:AP:1:4.8:0:0 T:151734600:AP:2:4.8:11.5:0 T:151734600:AP:3:-2.4:11.5:0	15:17, 34 秒, 600ms, Anchor Position 0 (X, Y, Z)
D:151734614:RR:0:0:8808:8808:147:27185 T:151734614:RR:0:1:9174:9174:147:27185 T:151734614:RR:0:2:5668:5668:147:27185 T:151734614:RR:0:3:4815:4815:147:27185	RR: Range Report: TagID: AnchorID: Reported Range: Corrected Range: Sequence#: Range Number
T:151734614:LE:0:2627:146:[0.743669,7.9919,- 1.89245]:8794:9160:5687:4773	LE: Location Estimate: TagID: LE Count: Sequence #:[x,y,z]: Range to A0: Range to A1: Range to A2: Range to A3:
T:151734614:TS:0 avx:0.786699 a:0.00351 avz:- 1.93044 r95:0.0732666	TS: Tag Statistics: TagID: Average X: Average Y: Average Z

## 7.5 Principles and calculation methods of trilateration

### 7.5.1 Theoretical basis of trilateration

The principle of trilateration is shown in the figure on the right, with three nodes A, B, and C as the center of the circle, and the coordinates are, the three circumferences intersect at one point D, the intersection point D is the moving node, A, B, and C are the reference nodes, and the distances between A, B, and C and the intersection point D are  $d_a, d_b, d_c$  respectively. Suppose the coordinates of the intersection point D are  $(X, Y)$ ,  $(X_a, Y_a)$ ,  $(X_b, Y_b)$ ,  $(X_c, Y_c)$   $d_a, d_b, d_c, X, Y$ .



$$\begin{cases} \sqrt{(X - X_a)^2 + (Y - Y_a)^2} = d_a \\ \sqrt{(X - X_b)^2 + (Y - Y_b)^2} = d_b \\ \sqrt{(X - X_c)^2 + (Y - Y_c)^2} = d_c \end{cases} \quad (7.5.1)$$

From Eq. 7.5.1, the coordinates of the intersection D can be obtained:

$$\begin{pmatrix} X \\ Y \end{pmatrix} = \begin{pmatrix} 2(X_a - X_c) & 2(Y_a - Y_c) \\ 2(X_b - X_c) & 2(Y_b - Y_c) \end{pmatrix}^{-1} \begin{pmatrix} X_a^2 - X_c^2 + Y_a^2 - Y_c^2 + d_c^2 - d_a^2 \\ X_b^2 - X_c^2 + Y_b^2 - Y_c^2 + d_c^2 - d_b^2 \end{pmatrix} \quad (7.5.2)$$

The defect of trilateration is that because the hardware and power consumption of each node are not the same, the measured distance cannot be an ideal value, so that the above three circles may not just intersect at one point, but in practice, they must intersect in a small area, so there is a certain error in the  $(X, Y)$  coordinate value calculated by this method. In this way, a certain algorithm is needed to estimate a relatively ideal position as the optimal solution for the coordinates of the current moving node.

### 7.5.2 Trilateration Function

In the trilateration.cpp file, the function `GetLocation()` implements the following functions: the coordinates (unit: m) of the incoming anchor and the distance (unit: mm) from each anchor to the tag, and calculates the best solution (unit: m) of the tag.

As mentioned in the previous section, because the measured distance cannot be ideal, the above three circles may not exactly meet one point, so when the anchor A0/A1/A2 is working, from a mathematical point of view, there will be two solutions, and when A0/A1/A2/A3 is working, there must be an optimal solution. A3 is the auxiliary anchor, and after A0/A1/A2 completes a Trilateration algorithm, two solutions are obtained, and the solution closest to the A3 sphere is taken as the optimal solution.

Note: trilateration.cpp file, is the source code of the PC side, 4 anchors and more than 4 tags, free of charge.

### 7.5.3 Is the Z-axis less accurate than the X-axis Y-axis?

As shown in the figure, A0/A1/A2 is 3 anchors, T0 is the Tag, LA0T0 LA1T0 LA2T0 is the distance from each anchor to the Tag. In the case of completely accurate ranging, the calculated Tag coordinate should be at T0, however, since the actual measured value LA0T0 LA1T0 LA2T0 may be on the large side, the solved position is at T0'. Because A0/A1/A2 are all in the xoy plane, most of the ranging errors will be accumulated on the z-axis, resulting in jitter of the z-axis data.

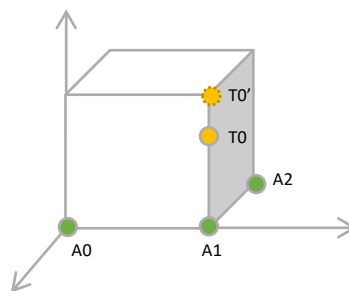


Figure 7.5.3 Schematic diagram of Z-axis data error

## 8 UWB product development

### 8.1 Mini3sPlus Data Calibration Method

Some customers have reported that the measured value of the UWB module is always larger than the actual distance, and some users have reported that the measured value of the UWB module is smaller than the actual distance, what is going on? This is because the site we use is different, and it is disturbed by factors such as latitude and longitude, air quality, environmental obstacles, altitude, etc., so in the process of productization, the module must be calibrated.

In general, calibration only needs to be performed once in the field, and the correction coefficient is obtained through the ranging of 1 Anchor and 1 Tag, and it is not necessary to calibrate each Anchor and Tag.

Using Microsoft 2016 Excel software, data fitting is performed and fitting formulas are generated. There are many fitting formulas, the simplest being linear equations.

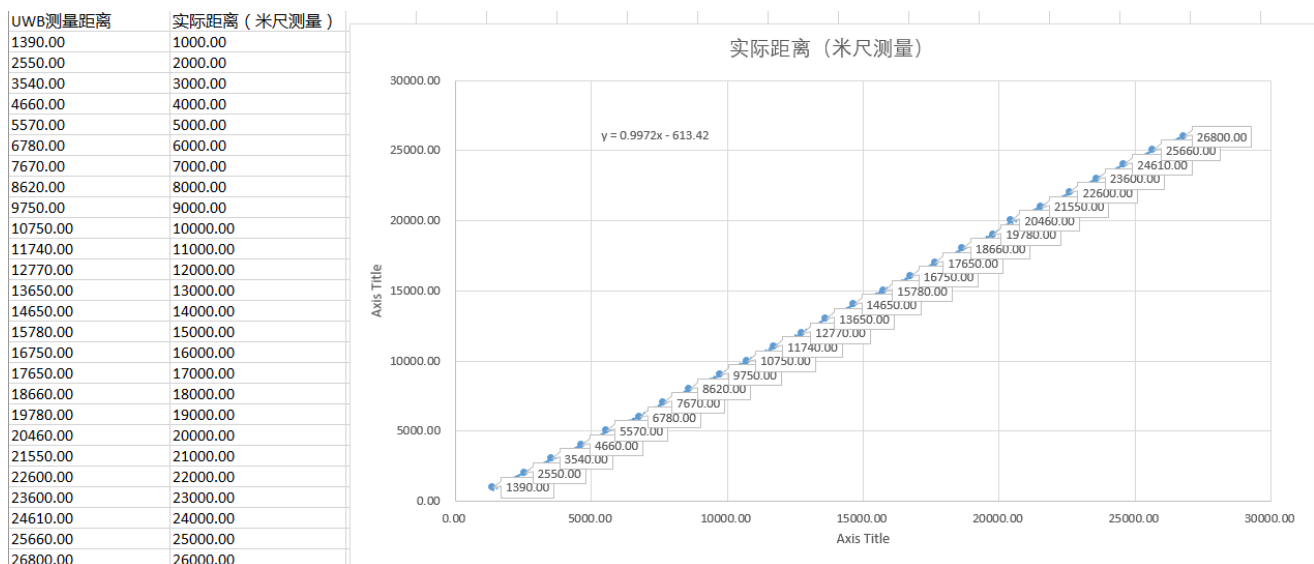


Figure 8.1 Mini3sPlus calibration EXCEL table

There are instancegetidist\_mm (0), instancegetidist\_mm (1), instancegetidist\_mm (2), instancegetidist\_mm (3) of the four variables, and each distance needs to be substituted into the calibration formula just calculated. In the main.c function, the original program is:

```
1. n = sprintf((char*)&usbVCOMout[0], "mc %02x %08x %08x %08x %08x %04x %02x %08x %c%d:%d\r\n",
2.   valid, instancegetidist_mm(0), instancegetidist_mm(1),
3.   instancegetidist_mm(2), instancegetidist_mm(3),
4.   l, r, rangeTime,
5.   (instance_mode == TAG)? 't': 'a', taddr, aaddr);
```

Let's change it to:

```
1. n = sprintf((char*)&usbVCOMout[0], "mc %02x %08x %08x %08x %08x %04x %02x %08x %c%d:%d\r\n",
2.   valid, (int)((instancegetidist_mm(0)*0.9972)-613.42), (int)((instancegetidist_mm(1)*0.9972)-613.42),
3.   (int)((instancegetidist_mm(2)*0.9972)-613.42), (int)((instancegetidist_mm(3)*0.9972)-613.42),
4.   l, r, rangeTime,
5.   (instance_mode == TAG)? 't': 'a', taddr, aaddr);
```

To recompile the software, you only need to download the program to the UWB module connected to the computer, and you don't need to download every module. With data correction, the UWB module measures the distance values with a very high degree of accuracy.

## 8.2 A way to further increase the ranging refresh rate

If only one tag is used, you can use the following methods to increase the refresh rate of ranging:

- Change ANCTOANCTWR (Anchor-Anchor Ranging) to 0;
- Change MAX\_TAG\_LIST\_SIZE (maximum number of tags) to 1;
- CHANGE MAX\_ANCHOR\_LIST\_SIZE (MAXIMUM NUMBER OF ANCHORS) TO 1;

In the *main.c function, in the array of sfConfig\_t sfConfig[4]* structs,

- In Mode 1/2/3/4, change the number of slots to 2;

## 8.3 Ways to further increase the location refresh rate

If only 4 tags and 3 anchors are used, you can increase the refresh rate of ranging *in the instance.h file in the following ways:*

- Change ANCTOANCTWR (Anchor-Anchor Ranging) to 0;
- Change MAX\_TAG\_LIST\_SIZE (maximum number of tags) to 4;
- CHANGE MAX\_ANCHOR\_LIST\_SIZE (MAXIMUM NUMBER OF ANCHORS) TO 3;

In the *main.c function, modify the array of structs of the sfConfig\_t sfConfig[4]* to: ,

```

1.  sfConfig_t sfConfig[4] =
2.  {
3.      //mode 1 - S1: 2 off, 3 off
4.      {
5.          (28) - Suck
6.          (4),    //thus 4 slots
7.          (4*28), //superframe period
8.          (4*28), //poll sleep delay
9.          (20000)
10.     },
11.     //mode 2 - S1: 2 on, 3 off
12.     {
13.         (10),    // slot period ms
14.         (4),     // number of slots
15.         (4*10),  // superframe period (40 ms - gives 25 Hz)
16.         (4*10),  // poll sleep delay (tag sleep time, usually = superframe period)
17.         (2500)
18.     },
19.     //mode 3 - S1: 2 off, 3 on
20.     {
21.         (28),    // slot period ms
22.         (4),     // thus 4 slots - thus 112ms superframe means 8.9 Hz location rate
23.         (4*28),  // superframe period
24.         (4*28),  // poll sleep delay
25.         (20000)
26.     },
27.     //mode 4 - S1: 2 on, 3 on
28.     {
29.         (10),    // slot period ms
30.         (4),     // thus 4 slots - thus 40 ms superframe means 25 Hz location rate
31.         (4*10),  // superframe period (40 ms - gives 25 Hz)
32.         (4*10),  // poll sleep (tag sleep time, usually = superframe period)
33.         (2500)   // this is the Poll to Final delay - 2ms
34.     }
35. };

```

## 8.4 The impact of occlusion on indoor positioning UWB

The impact of occlusion on UWB positioning can be divided into the following scenarios:

- 1) Solid wall: This kind of occlusion of a solid wall will make the UWB signal attenuation 60-70% and the positioning accuracy error increase by about 30 cm.
- 2) Steel plate: Steel absorbs UWB pulse signals very badly, which will make UWB unable to locate.

- 3) Glass: Glass occlusion has a great impact on the positioning accuracy of UWB.
- 4) Wood or cardboard: Generally, wood or cardboard with a thickness of about 10 cm does not have much impact on the positioning accuracy of UWB.
- 5) Telephone poles or trees: When the poles or written shields are blocked, it is necessary to see the distance between them from the anchor or the Tag, and whether the relative distance between the anchor and the Tag is very small, for example, the distance between the anchor and the positioning Tag is 50 meters, and the pole or tree is just in the middle of the two, 25 meters, this kind of shielding has no great impact, such as the distance from the anchor or the Tag is very close to less than 1 meter, the impact is great.

## 9 AT instruction set

### 9.1 AT+SW Command (8 Tags and below)

The AT+SW command supports a kit of 4 anchors for N tags ( $N \leq 8$ ).

#### 9.1.1 How it's set up

Connect the module to the computer through a USB cable, open the serial port debugging assistant XCOM software, send a command, and [add a car entry to the end to wrap the line](#), such as:

AT+SW=1XXXXXX0

	S2 (rate).	S3 (frequency band).	S4 (mode).	S5-7 (address).
1	6.8M	Channel 5	ANCHOR	address
0	110K	Channel 2	DAY	[000-001]

#### 9.1.2 illustrate

Example 1: If the module is set as a anchor, with a transmission rate of 110k, channel 2, and the address is 3, then AT+SW=10010110 should be sent

Example 2: If the module is set to a Tag, 6.8M transmission rate, channel 5, and address 7, then AT+SW=11101110 should be sent

Note: The address of the anchor can only be 0/1/2/3, and more than 4 anchors are not supported for the time being; the default rate is 110K, channel 2, and the transmission rate and frequency band of the anchor and tag should be consistent in one system.

#### 9.1.3 The module is configured by default

**Table 9.1.3 Default configuration commands for AT+SW modules**

module	directives	module	directives	module	directives
Anchor A0	AT+SW=10010000	Tag T0	AT+SW=10000000	Tag T4	AT+SW=10001000
Anchor A1	AT+SW=10010010	Tag T1	AT+SW=10000010	Tag T5	AT+SW=10001010
Anchor A2	AT+SW=10010100	Tag T2	AT+SW=10000100	Tag T6	AT+SW=10001100
Anchor A3	AT+SW=10010110	Tag T3	AT+SW=10000110	Tag T7	AT+SW=10001110

## 9.2 AT+QSET Commands (9 tags and above)

Customers with firmware version 1.8.4 or later and who purchase more than 8 tags can get a kit that supports 4 anchor N-tags ( $N \geq 9$ ) with AT+QSET commands.

Table 9.2AT-Instruction Set

The PC initiates the command	type	meaning	The UWB module answers
AT+VIEW?	Query commands	Print the version information	Return version information
AT+INF?	Query commands	Print the UWB configuration information	Returns the configuration information
AT+SLEP	Control commands	The module goes into sleep for 5 seconds and wakes up automatically	OK+SLEP
AT+TEST	Control commands	Manufacturer spectrum test	OK+TEST
AT+STAR	Control commands	The module restarts	OK+STAR
AT+RSET	Control commands	Module Flash erase, and restart	OK+REST
AT+QSET=xx-xxx	Control commands	Quickly set the transmission rate, frequency band, mode and ID (see below)	OK+QSET=xx-xxx

Note: All commands must end with a carriage return.

### 9.2.1 How it's set up

ID bit, can be set to 00~31

If it is a anchor, the ID cannot be greater than 3

Mode bit, which can be set to A or T

AT+QSET=F2-T11

Rate bit, which can be set to F or S  
F means 6 .8M and S means 110K

Band bits, which can be set to 2 or 5  
2 indicates band 2 and 5 indicates band 5

### 9.2.2 illustrate

Example 1: If the module is set as a anchor, with a transmission rate of 110k, channel 2, and the address is 13, then AT+QSET=S2-A13 should be sent

Example 2: Set the module to a Tag, 6 .8M transmission rate, channel 5, address is 31, then



AT+QSET=F5-T31 should be sent

Note: The address of the anchor can only be 0/1/2/3, and more than 4 anchors are not supported for the time being; the default rate is 110K, channel 2, and the transmission rate and frequency band of the anchor and tag should be consistent in one system.

### 9.2.3 The module is configured by default

**Table 9.2.3 Default configuration commands for AT+SW modules**

module	directives	module	directives	module	directives
Anchor A0	AT+QSET=S2-A0	Tag T0	AT+QSET=S2-T0	Tag T4	AT+QSET=S2-T4
Anchor A1	AT+QSET=S2-A1	Tag T1	AT+QSET=S2-T1	Tag T5	AT+QSET=S2-T5
Anchor A2	AT+QSET=S2-A2	Tag T2	AT+QSET=S2-T2	Tag T6	AT+QSET=S2-T6
Anchor A3	AT+QSET=S2-A3	Tag T3	AT+QSET=S2-T3	Tag T7	AT+QSET=S2-T7

## 10 Document Management Information Sheet

Subject	YCHIOT UWB Mini3sPlus User Manual
Version	V1.5
Reference documents	dw1000-datasheet-v2.08 dwm1000-datasheet-v1.3 evk1000_user_manual_v1.11 trek1000_user_manual_v1.04
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Lynn	2017/5/17	V1.0 Released
Foresters	2017/10/20	V1.1 revise Chapter 4 and rearrange it; Section 8.2 has been modified to further improve the method for measuring the refresh rate of ranging liters
Foresters	2018/4/6	V1.2 Hardware V12. Correct some clerical errors
Foresters	2018/6/1	V1.3 Corrected errors in Chapter 1.3.3 IO Allocation Table Add Chapter 9 [AT Instruction Set]
Foresters	2019/4/4	V1.4 Corrected some error
Foresters	2023/12/01	V1.5 Corrected some error