



YCHIOT UWB KIT

Mini4sPlus User Manual

Version 1.3 (2023.12.01)

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1 Introduction to YCHIOT positioning development kits and accessories

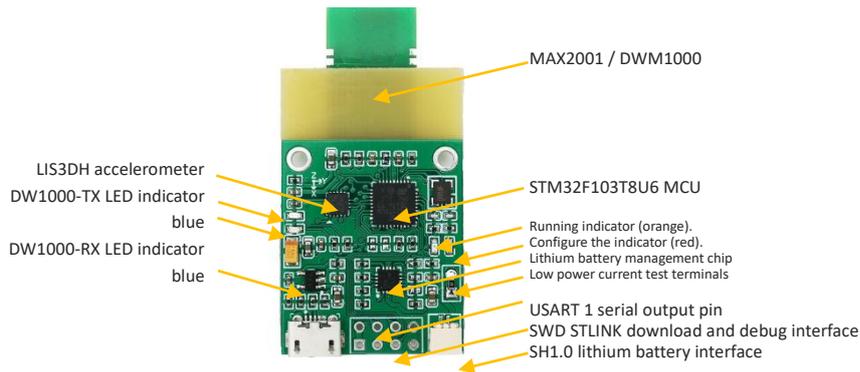
1.1 Research and creation of UWB series products

UWB low-power module MAX2001-CA  立即购买		<ul style="list-style-type: none"> Based on DW1000 design 频段: 3.7G-4.2G High power long distance Compatible with DWM1000 packages 支持 TOF/TDOA 	Mini4sp-C2-CA  立即购买		<ul style="list-style-type: none"> Equipped with a MAX2001 module STM32F103T8U6 主控 Lithium battery charging management With accelerometer AT instruction set configuration Provide the schematic diagram of the base plate Provide example program development manuals
UWB high-power module MAX2001-SMA  立即购买			Mini4sp-C2-SMA  立即购买		
UWB high-power module MAX2001-IPEX  立即购买			Mini4sp-C2-IPEX  立即购买		
UWB high-power module MAX5007-CA  立即购买		<ul style="list-style-type: none"> Based on DW1000 design 频段: 6.0G-7.0G High power long distance Compatible with DWM1000 packages 支持 TOF/TDOA 	Mini4sp-C5-CA  立即购买		<ul style="list-style-type: none"> Equipped with MAX5007 module STM32F103T8U6 主控 Lithium battery charging management With accelerometer AT instruction set configuration Provide the schematic diagram of the base plate Provide example program development manuals
UWB high-power module MAX5007-SMA  立即购买			Mini4sp-C5-SMA  立即购买		
UWB high-power module MAX5007-IPEX  立即购买			Mini4sp-C5-IPEX  立即购买		

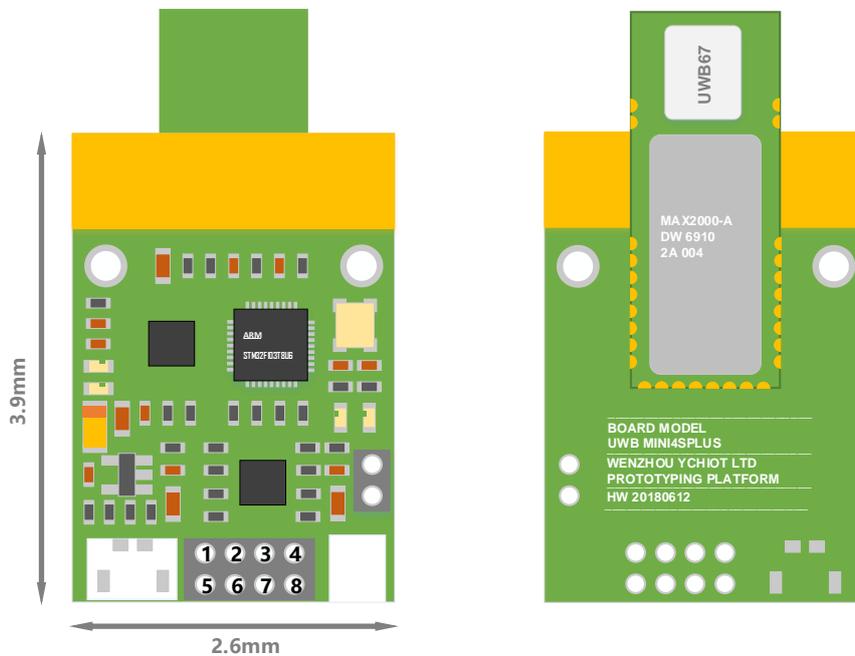
1.2 Module Introduction

1.2.1 overview

UWB Mini4sPlus adopts the architecture of "base plate + module". The base board adopts STM32F103T8U6 single-chip microcomputer as the main control chip, and the peripheral circuits include: power module, LED indication module, lithium battery management module, LIS3DH acceleration sensor, etc. Mini4sPlus is equipped with a self-made MAX2001 module (with PA/LNA) for better performance. The Mini4sPlus can be used as both a anchor and a tag that can be switched via USB commands.



1.3 Definition of the external interface



Pin Numer	Item	Pin direction	Description
1, 5	VCC5.0	input	The module power supply is positively referenced, and the voltage range is 3.7V~5.2V
2	TXD	output	TTL serial output, connected to an external RXD pin
3	RXD	input	TTL serial input, connected to an external TXD pin
4, 8	GND	input	Modular ground
6	SWDIO	-	SWD download interface
7	SWCLK	-	SWD download interface

2 Main parameters

2.1 Factory program firmware

Factory program version number: 1.8.7.6. The program has been added with an accelerometer driver.

2.2 Hardware parameters

Table 13.2 UWB Mini4sPlus hardware parameters

Basic parameters		Wireless parameters	
PCB process	4-layer board - epoxy	Communication rate	110 kbit/s, 850 kbit/s, 6.8 Mbit/s
Power supply interface	micro-USB(5.0V) / Binding post	Operating frequency	Mini4sPlus-C2: 3.7GHz ~ 4.2 GHz Mini4sPlus-C5: 6.2GHz ~ 6.7 GHz
Communication interface	micro-USB(5.0V) / 串 □(3.3V TTL)	Work channel	Mini4sPlus-C2: Channel 2 Mini4sPlus-C5: Channel 5
Download the interface	SWD (VCC SDIO SCK GND)	Transmit power	-23dBm/Mhz
Main controller	STM32F103T8U6 (36pin)	Maximum package length	1023 bytes
External crystal oscillator	8Mhz	Communication distance	500m (unobstructed) @ SMA antenna 110K
PCB size	47mm *26mm	Data jitter	Typical ± 10 cm, general shield ± 30 cm

2.3 Hardware I/O assignments at a glance

Table 2.3 Hardware I/O port assignment of YCHIOT series UWB products

	Mini3s	Mini3s Plus	Protag 2s	Mini4sPlus	Pin remarks
PA0	DW_RSTn	DW_RSTn	DW_RSTn	DW_RSTn	
PA1	-	-	PGOOD	PGOOD	0: USB has power input and charging 1: No USB access
PA2	-	-	CHG	CHG	0: The battery is not fully charged 1: The battery is fully charged
PA3	-	USB-EN	USB	USB-EN	
PA4	DW_NSS	DW_NSS	DW_NSS	DW_NSS	
PA5	DW_SCK	DW_SCK	DW_SCK	DW_SCK	LIS3DH – SPI 接口
PA6	DW_MISO	DW_MISO	DW_MISO	DW_MISO	LIS3DH – SPI 接口

PA7	DW_MOSI	DW_MOSI	DW_MOSI	DW_MOSI	LIS3DH – SPI 接口
PA8	DW_EXTON	DW_EXTON	DW_EXTON	DW_EXTON	
PA9	USART1_TX	USART1_TX	USART1_TX	USART1_TX	Serial port 1-TXD
PA10	USART1_RX	USART1_RX	USART1_RX	USART1_RX	Serial port 1-RXD
PA11	USB-DM	USB-DM	USB-DM	USB-DM	USB interface
PA12	USB-DP	USB-DP	USB-DP	USB-DP	USB interface
PA13	SWDIO	SWDIO	SWDIO	SWDIO	SWD interface
PA14	SWCLK	SWCLK	SWCLK	SWCLK	SWD interface
PA15	-	-	LIS_CS	LIS_CS	Accelerometer chip selection
PB0	DW_WUP	DW_WUP	DW_WUP	DW_WUP	
PB1	-	-	ADC_VBAT	ADC_VBAT	The ADC value x2 is the lithium battery voltage
PB2	BOOT1	BOOT1	Buzzer	BOOT1	
PB3	-	-	BQ_TD_EN	BQ_TD_EN	0: Charging enabled 1: Charging incapacitated
PB4	-	-	INT	INT	LIS3DH interrupts the foot 0: Power off the DW1000 1: Power on the DW1000
PB5	DW_IRQN	DW_IRQN	DW_IRQN	DW_IRQN	
PB6	LED1	LED1	LED1	LED1	Normally controllable LEDs
PB7	-	-	LED2	LED2	Normally controllable LEDs

2.4 Measured spectrum

Connecting the antenna of the development board to the spectrum analyzer FSL-6 (Rohde & Schwarz), the Channel 2 center frequency of the Mini4 is measured to be 4 GHz and the maximum gain is -49.96 dbm, and the Channel 2 center frequency of the Mini4sPlus is 4 GHz and the maximum gain is -23.12 dbm, as shown in the figure below.

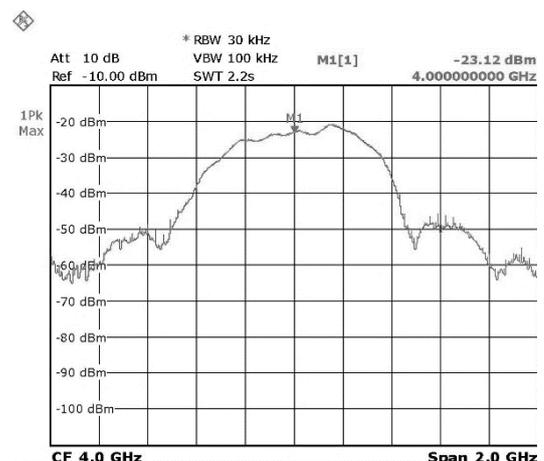
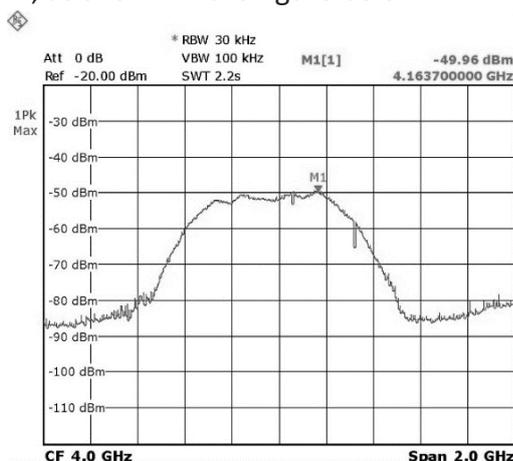


Figure 2.4.1 UWB Mini4 transmit power test Figure 2.4.2 UWB Mini4sPlus transmit power test

2.5 What occasions can YCHIOT UWB products be used?

According to the needs provided by customers and the actual application situation, after a series of technical return visits, UWB 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;

2.6 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 technology	Strong penetration, low power consumption, good anti-multipath effect, high security, low system complexity, and can provide accurate positioning accuracy.	It will have a certain impact when encountering shelters, metals, etc., 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.
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3 Q&A on frequently asked 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 use

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 a high-power module, which adds an RF power amplifier circuit to ensure that the signal stably passes through the wall;

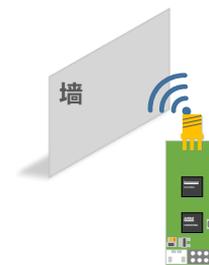


Figure 3.2.2 Anchor Tags Installation precautions

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 in ranging

- 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 Mini4sPlus Positioning Kit Test Instructions

The YCHIOT UWB positioning system consists of at least four UWB modules, that is, 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 Mode configuration

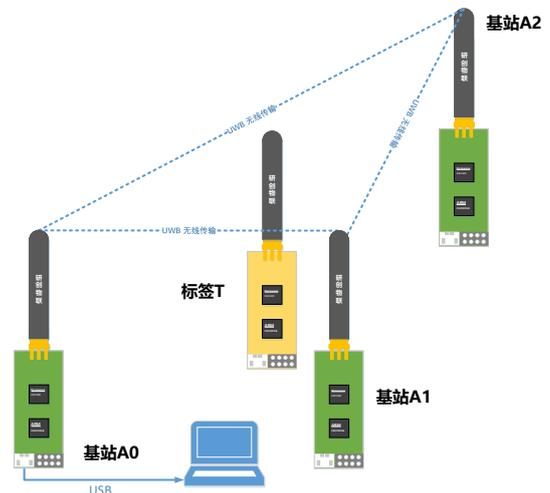
The mode configuration has been set at the factory, if there are no special circumstances, there is no need to change, the module can be tested at hand, and [this step can be skipped](#).

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 Positioning test: 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;

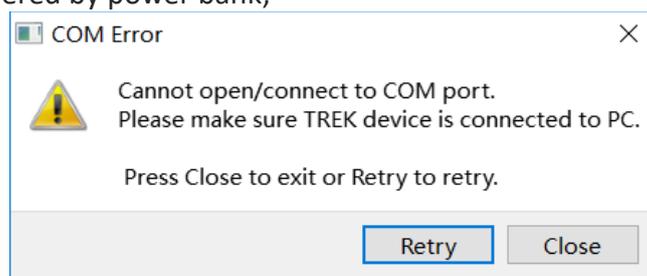
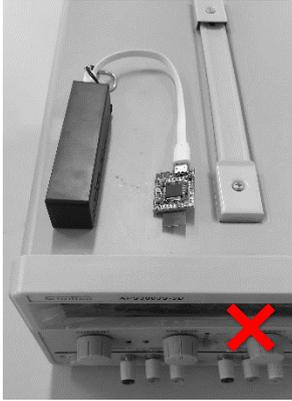


Figure 4.2.2 The host computer cannot communicate

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:

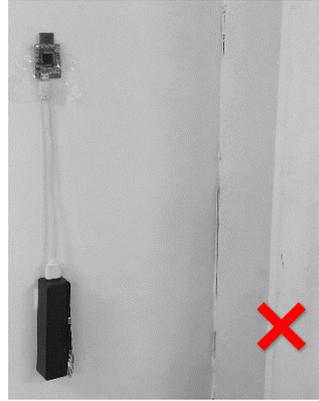
- Place the module near the metal. Whether it is a built-in ceramic antenna or an external rod antenna, the antenna signal will be directly absorbed by the metal when it encounters it
- Placing the module flat on the table, sticking the module to the wall, and holding the antenna in your hand will affect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

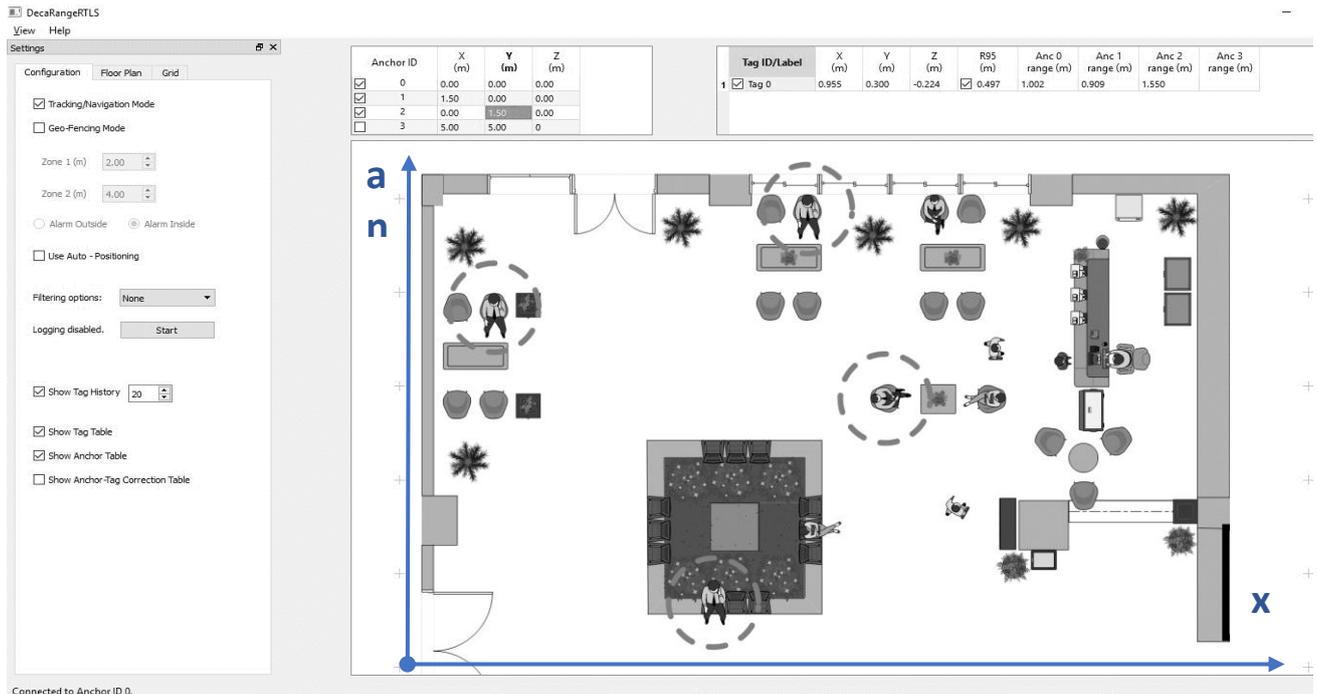


Figure 4.2.7 Screenshot and use of PC-RTLS presentation software

4.3 Positioning test: 4 anchors + multi-Tag test

- 1) 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.
- 2) The procedure is the same as in Section 4.2.

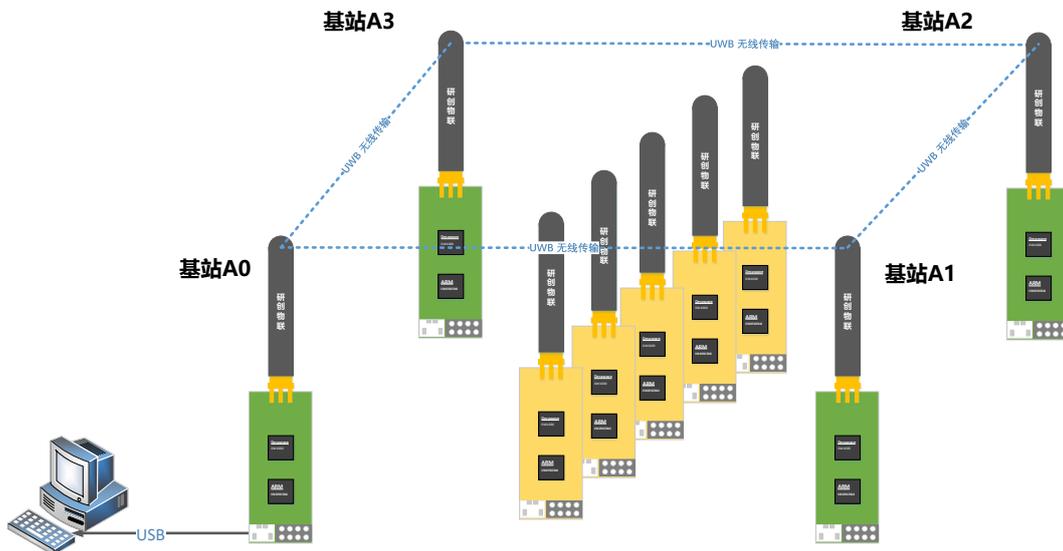


Figure 4.3.1 Schematic diagram of positioning 4 anchor + multi-Tag hardware platform

4.4 Ranging test: 1 anchor + 3 tag test

- 1) PC operation software: Set to Geo-Fencing Mode
- 2) Hardware networking: 1 anchor Mini3sPlus, 3 tags ProTag2s
- 3) Install the virtual serial port driver (same as above);
- 4) A0 Connect to a computer via USB (same as above);
- 5) Open the host computer software DecaRangeRTLS .exe (ibid.).
- 6) 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.

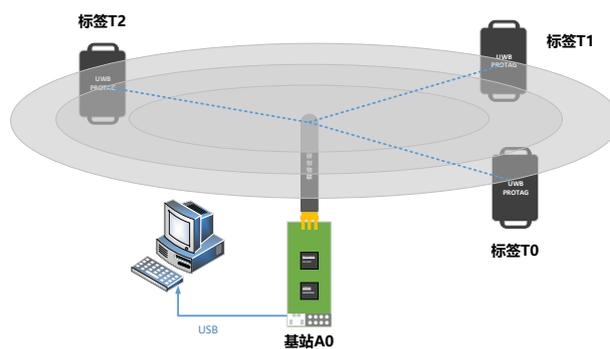


Figure 4.4 Schematic diagram of the hardware platform of 1 anchor + 3 tag for over-range alarm

5 Introduction to the data access solution of YCHIOT positioning system

5.1 overview

The solution aims to transmit the TOF Report Message data output by the UWB tag module from the serial port to the remote server, so as to realize the remote management and monitoring of the UWB positioning data by developers. Using the manned USR-WIFI232-B2 WIFI/Ethernet module, the data can be connected to the network through simple settings.

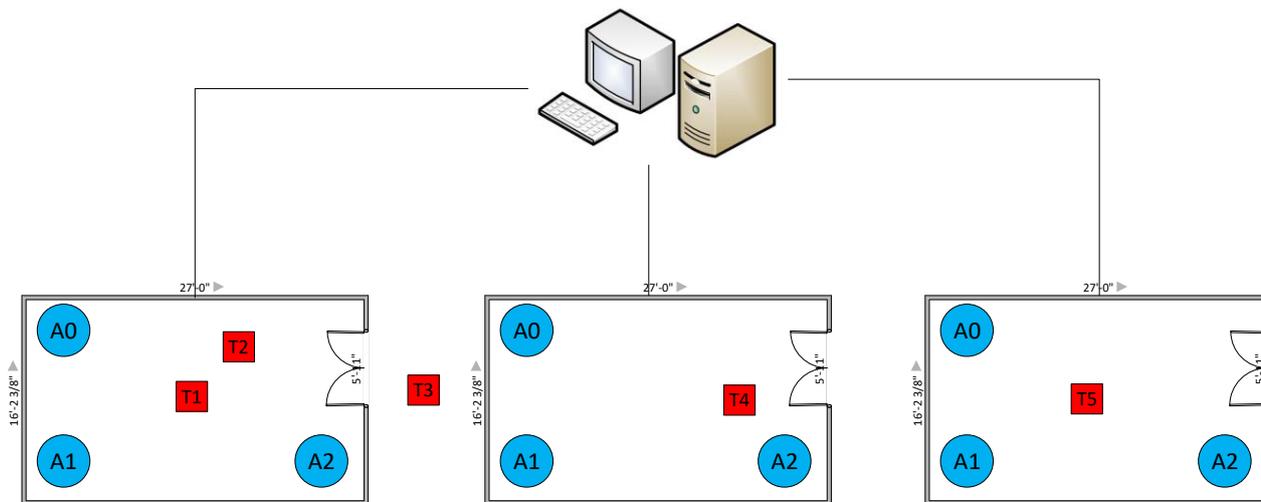


Figure 5.1 Positioning data sensing IoT general framework diagram

The method of regional division is adopted, and 3 anchors are placed in each relatively independent area, and the anchor signals between regions and regions can cover each other. When a tag enters an area, the anchor in that area will automatically recognize it, collect information through A0, and connect to the network via WIFI or Ethernet (see Figure 5.2). The advantages of this scheme are: at the technical level, the anchor in each room carries out wireless communication, and the connection between each room and the computer (server) needs to be connected with wires, and the wiring is relatively simple.

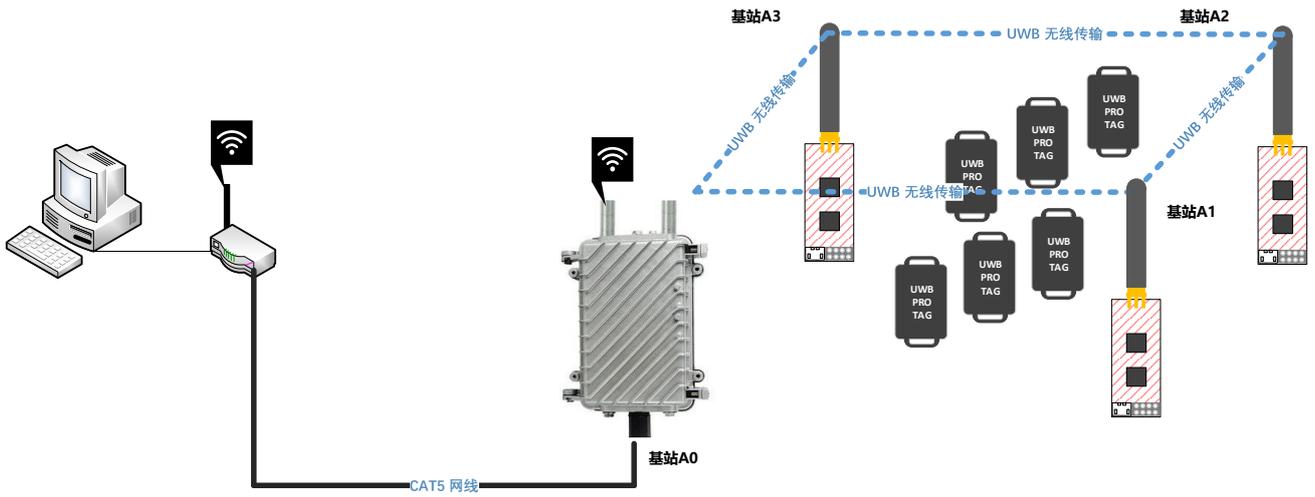


Figure 5.2 UWB positioning architecture for a single region

6 Secondary development of modules

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 Firmware updates

For details, please refer to the manual APS003-UWB module firmware update.

6.3 The method of outputting data from a serial port

6.3.1 External serial port equipment/RS232/485, etc

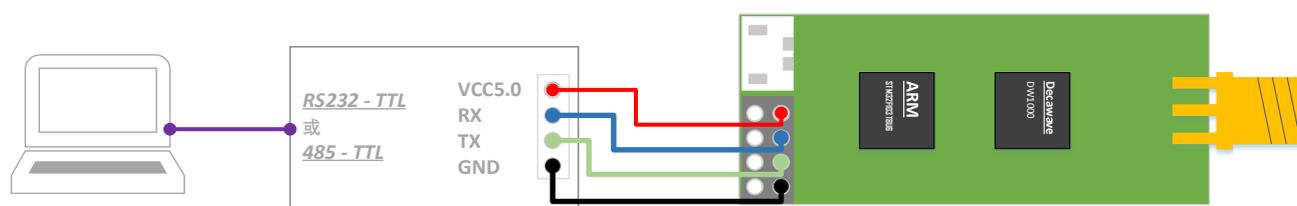


Figure 63.1.1 The module is connected with the TTL to RS232 module or TTL to 485 module

The module is connected to the BLE 4.0 serial port Bluetooth module, which can realize the data viewing of Android mobile phones and Apple mobile phones.

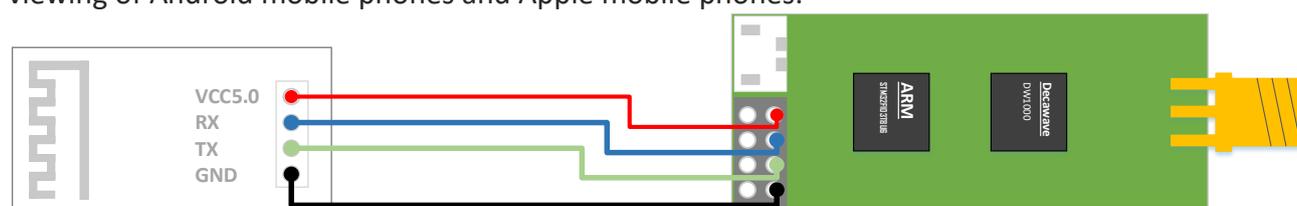


Figure 63.1.2 The module is connected to the Bluetooth module

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.

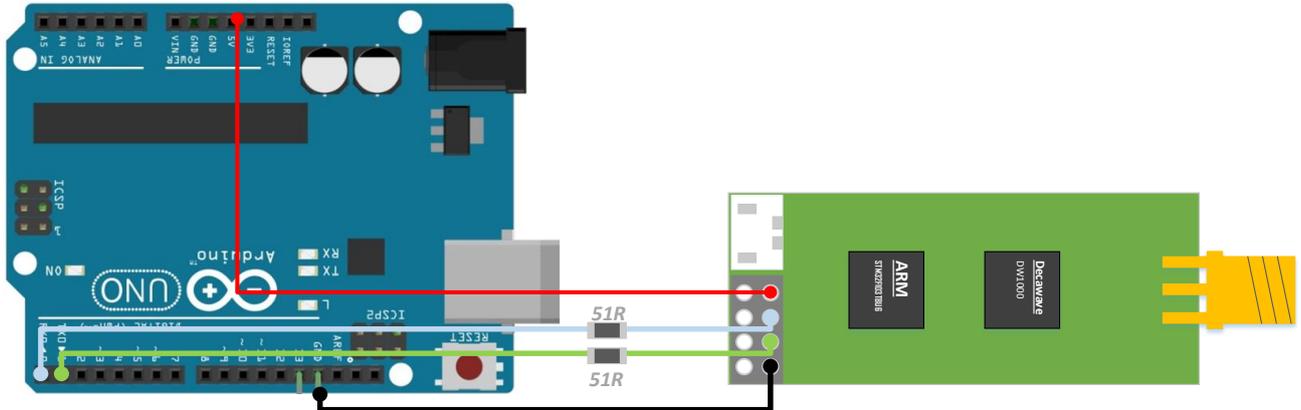


Figure 63.1.3 The module is connected to a single-chip microcomputer (Arduino).

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.

```
>> COPYRIGHT 2018 YCHIOT
>> SW-VER:1.8.6-20180713
>> HW-VER:066eff56-52517178-67214033
>> Start Number:536873875
>> Switch:aace
>> UWB Rate:6.81M
>> UWB Channel:2
>> UWB Mode:Tag 7
mc 02 00000000 00000bb2 00000000 00000000 0001 7d 00005e11 t7:0
mr 02 00000000 00000afe 00000000 00000000 0001 7d 40224022 t7:0
mg x= -0.307g,y= 0.712g,z= -0.468g
mc 03 000019c9 00000b5d 00000000 00000000 0003 7e 00005e43 t7:0
mr 03 0000195b 00000aa9 00000000 00000000 0003 7e 40224022 t7:0
mg x= -0.364g,y= 0.494g,z= -0.401g
mc 02 00000000 00000b1c 00000000 00000000 0004 81 00005ed9 t7:0
mr 02 00000000 00000a68 00000000 00000000 0004 81 40224022 t7:0
mg x= -0.493g,y= 0.606g,z= -0.444g
mc 02 00000000 00000adf 00000000 00000000 0005 82 00005f0b t7:0
mr 02 00000000 00000a2b 00000000 00000000 0005 82 40224022 t7:0
mg x= -0.463g,y= 0.608g,z= -0.521g
mc 02 00000000 00000a73 00000000 00000000 0006 84 00005f6f t7:0
mr 02 00000000 000009bf 00000000 00000000 0006 84 40224022 t7:0
```

Figure 6.3.2 TOF Report Message Data Flow

6.4 The method of exporting 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 select the version by operating system. Win7 users, please try VCP_V1.4.0_Setup.exe first.

Table 6.4 Supported systems for virtual serial port drivers

operating system	Support
Windows 98 / ME / XP / Vista	Not supported
Win7 32-bit system	Not supported
Win7 64-bit system	安装 VCP_V1.4.0_Setup.exe 或 VCP_V1.3.1_Setup.exe

Windows 8/8.1	安装 VCP_V1.4.0_Setup.exe
Windows 10 (推荐)	安装 VCP_V1.4.0_Setup.exe

- 1) Open the VCP_V1.4.0_Setup .exe, follow the installation process, click OK or NEXT, and complete the copy and expansion of the virtual serial port driver file.
- 2) 进入如下目录 , *C:\Program Files (x86)\STMicroelectronics\Software\Virtual comport driver\Win8*
- 3) If the computer is a 64-bit system, find the dpinst_amd64 .exe and install it, and if the computer is a 32-bit system, find the dpinst_x86 .exe and install it
- 4) Prompt: The installation is successful, connect the A0 anchor with the computer with a USB cable, my computer >> properties >> in the device manager, in the "Ports (COM and LPT)" column, you can see COMx. At this point, the ST virtual serial port driver is installed. After the driver is installed, restart your computer.

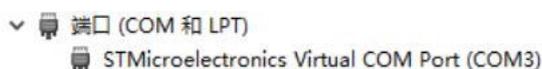


Figure 6.43 Virtual serial port COM3 was found in Device Manager

- 5) Some Win7 users will not be able to install the driver (the driver appears an exclamation mark), which is caused by the missing file of the USB virtual serial port (reason: the system is installed using Ghost, etc.). The solution is as follows, please contact the seller to obtain the patch package:
 - Copy mdmcpq.inf to *C:/windows/inf/*
 - 将 usbser.sys 复制到 *C:/windows/system32/drivers/*里面去;
 - Install the driver software *VCP_V13.1_Setup.exe* ;(Note: This part of the Win7 user needs to install V1.3.1).
 - Then plug the USB cable back in and right-click on the Device Manager interface to update the driver.

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", and the TOF Report Message data stream can be observed (the acceleration signal can only be seen at the Tag end).

```
>> COPYRIGHT 2018 YCHIOT
>> SW-VER:1.8.6-20180713
>> HW-VER:066eff56-52517178-67214033
>> Start Number:536873875
>> Switch:aace
>> UWB Rate:6.81M
>> UWB Channel:2
>> UWB Mode:Tag 7
mc 02 00000000 00000bb2 00000000 00000000 0001 7d 00005e11 t7:0
mr 02 00000000 00000afe 00000000 00000000 0001 7d 40224022 t7:0
mg x= -0.307g,y= 0.712g,z= -0.468g
mc 03 000019c9 00000b5d 00000000 00000000 0003 7e 00005e43 t7:0
mr 03 0000195b 00000aa9 00000000 00000000 0003 7e 40224022 t7:0
mg x= -0.364g,y= 0.494g,z= -0.401g
mc 02 00000000 00000b1c 00000000 00000000 0004 81 00005ed9 t7:0
mr 02 00000000 00000a68 00000000 00000000 0004 81 40224022 t7:0
mg x= -0.493g,y= 0.606g,z= -0.444g
mc 02 00000000 00000adf 00000000 00000000 0005 82 00005f0b t7:0
mr 02 00000000 00000a2b 00000000 00000000 0005 82 40224022 t7:0
mg x= -0.463g,y= 0.608g,z= -0.521g
mc 02 00000000 00000a73 00000000 00000000 0006 84 00005f6f t7:0
mr 02 00000000 000009bf 00000000 00000000 0006 84 40224022 t7:0
```

Figure 6.4.2 TOF Report Message Data Flow

7 PC upper computer communication data format and secondary development

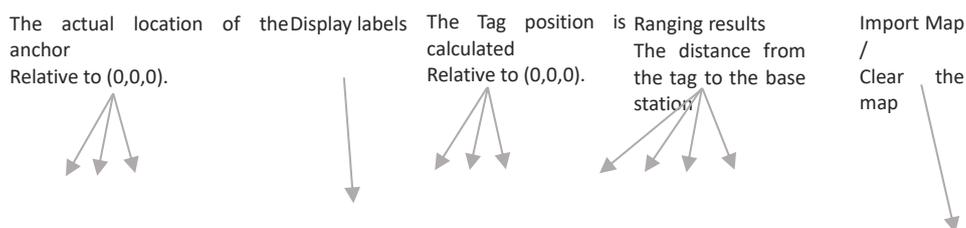
7.1 Introduction to the real-time positioning system upper computer

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 Real-time positioning system host computer interface



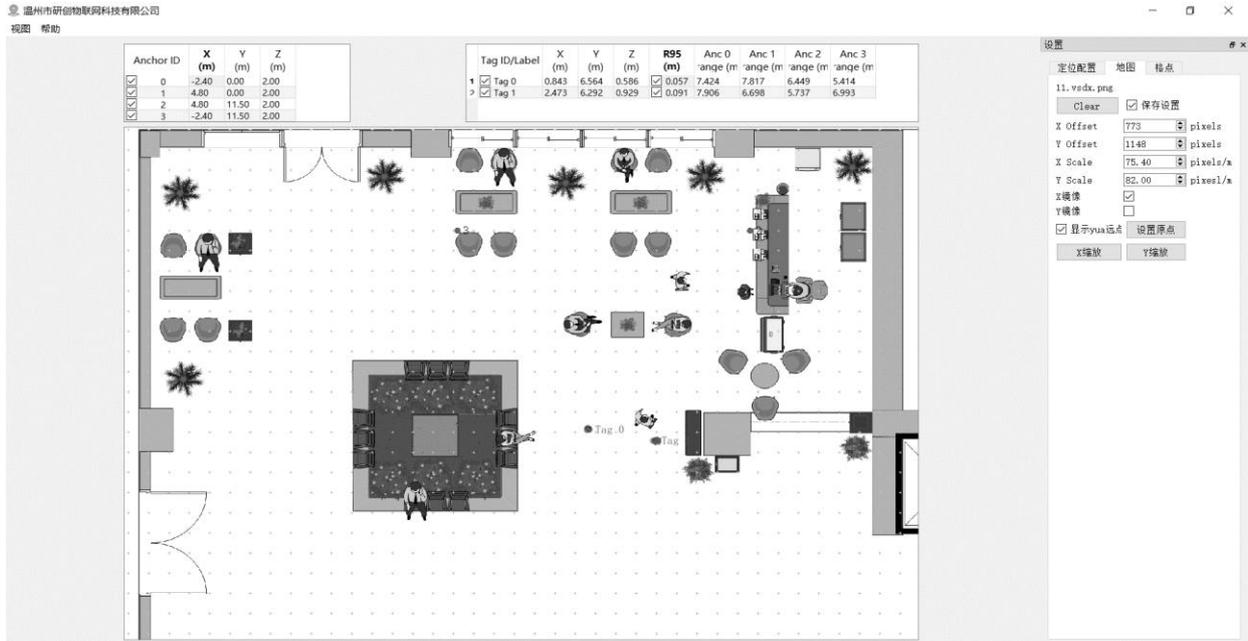


Figure 7.2 RTLS host computer interface

7.2.1 Positioning system 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 Table 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 Data Frame 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.A 07 000000000 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:*

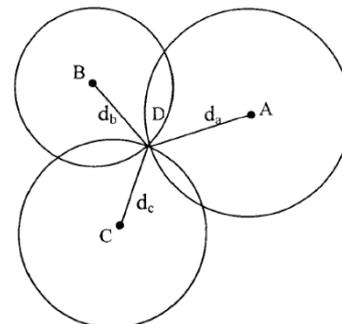
Table 7.4 Definitions of log files

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 The principle and calculation method of trilateration

7.5.1 Theoretical basis of trilateral positioning method

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 $((X_a, Y_a), (X_b, Y_b), (X_c, Y_c), d_a, d_b, d_c, X, Y)$.

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

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 The implementation process of the trilateral positioning method

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.

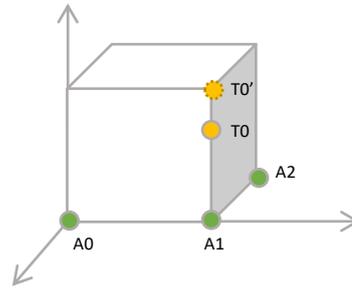


Figure 7.5.3 Schematic diagram of Z-axis data error

8 UWB product development

8.1 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.

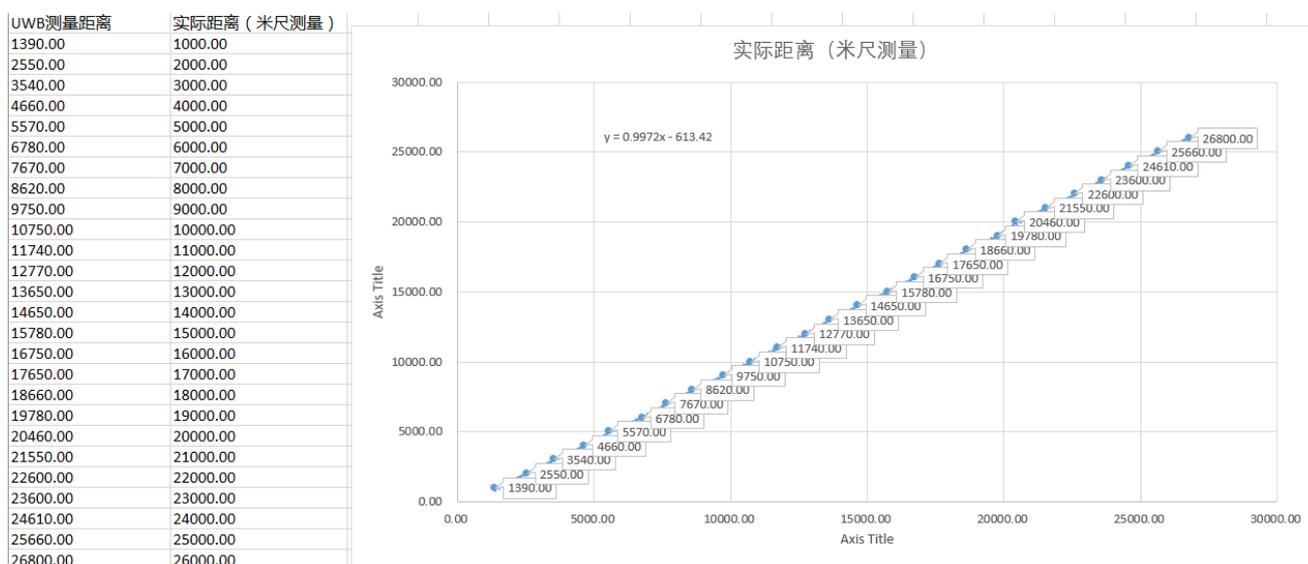


Figure 8.1 Mini4sPlus calibration EXCEL table

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≤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≥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 base station, the ID cannot be greater than 3

Mode bit, which can be set to A or T

A represents the base station and T represents the label

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 Mini4sPlus User Manual
Version	V1.3
Reference documents	dw1000-datasheet-v2.08 dwm1000-datasheet-v1.3 evk1000_user_manual_v1.11 trek1000_user_manual_v1.04
Creation time	2018/7/14
Founder	Lynn
Latest release date	2023/12/01

Modifier	Date	Document change history
Lynn	2018/7/14	V1.0 is released
Lynn	2019/2/1	V1.1 is released
Lynn	2019/4/4	V1.2 is released
Lynn	2023/12/01	V1.3 is released