YCHIOT

UWB ProTag2s

User Manual

Version 1.1

Wenzhou Yanchuang IOT Technology Co., Ltd
Add: Gaoke Rd, Chashan Higher Education Park, Ouhai, Wenzhou, Zhejiang, P.R.CHINA
Tel/Wechat: 15606880772
QQ：171932915
Online Store: https://atomdesign.taobao.com/

Content

1 YCHIOT UWB Kit and Accessories Instruction

1.1 UWB serials and suite

Project	Summary	Data
UWB Mini3 Development Board	The module adopts STM32F105RCT6 SCM as the main control chip. Read and write UWB DWM1000 module through SPI. The module Anchor and tag are integrated and switched by dip switch. In addition, it is an ideal reference for developing small tags, which has a coin size of the module.	• UWB Mini Hardware PDF Schematic Diagram. • Provide official data manuals.
UWB Mini3s Development Board	The module adopts STM32F103T8U6 SCM as the main control chip. Read and write UWB UWB DW1000 module through SPI. The communication distance is up to 80 meters.	• Support USB Virtual COM Port and provide PC demo. • Provide official data manuals and technical support.
UWB Mini3sPlus Development Board	The module adopts STM32F103T8U6 SCM as the main control chip. Read and write UWB UWB DW1000 module through SPI. The communication distance is up to 300 meters.	• Support USB Virtual COM Port and provide PC demo. • Provide official data manuals and technical support.
UWB ProTag	UWB ProTag uses STM32 MCU as the main control chip. The product integrates ceramic antennas and all radio frequency circuits, DW1000 peripheral circuits, lithium battery charging and discharging management circuits and clock circuits, and a built-in 250mAh rechargeable lithium battery. The module is based on the TWR algorithm, whose distance error is less than 10cm, and the location error is less than 15cm for locating the target, and the module supports the data transmission rate of up to 6.8Mbps. The module is very convenient to carry as a label, and the module supports AT instruction set through USB.	• Support USB Virtual COM Port and provide PC demo. • Provide official data manuals and technical support.
UWB Tag Handheld Development Board	UWB Tag handheld development board aims to achieve the UWB Mini 3 / Mini3s / Mini3s Plus module output data via the COM Port in accordance with a certain format for parsing. Combine with YCIOT exclusive Trilateration, it simplifies mathematical operations, and truly realizes the real-time calculation of ranging data on STM32F103C8T6 SCM (embedded system). And it also can display coordinate results X，Y，Z on OLED.	• Provide official data manuals and technical support. • Provide paid source code.

1.2 YCIOT UWB Series Module Specs Comparison

	Mini3	Mini3s	Mini3s Plus	Mini4	**ProTag2s**
Release time	2015.8.2	2016.10.2	2017.5.17	Upcoming	2018.5.17
Characteristics	Small size	Cost-effective	Long distance	Low power	charging, long distance
PCB size	30mm*23mm	46mm * 20mm	58mm*24mm	48mm*32mm	50mm*35mm
PCB material	Ordinary 2 Layer	4 Layer	4 Layer	4 Layer	4 Layer
Power supply port	USB	USB	USB	USB	USB
USB communication port	√	√	√	√	√
TTL COM Port	√	√	√	√	√
SWD interface	√	√	√	√	√
Control chip	STM32F105RBT6	STM32F103T8U6	STM32F103T8U6	STM32F103C8T6	STM32F103T8U6
Lithium-ion battery chip	×	×	×	√	√

controller					
Antenna	Ceramic plate antenna	External rod antenna	External rod antenna	Ceramic plate antenna	Ceramic plate antenna
Transmitting power	-45dbm/Mhz	-42dbm/Mhz	-22dbm/Mhz	-45dbm/Mhz	-30dbm/Mhz
Channel	CH2 / CH5	CH2 / CH5	CH2	CH2 / CH5	CH2
Effective coverage radius	30m	80m	300m	30m	300m
Ranging accuracy error	<10 cm	<10 cm	<10 cm	<10 cm	<10 cm
Positioning accuracy error	<15cm	<15 cm	<15 cm	<15 cm	<15 cm

1.3 UWB ProTag Instructions

1.3.1 UWB ProTag overview

UWB ProTag uses STM32 MCU as the main control chip. The product integrates ceramic antennas and all radio frequency circuits, DW1000 peripheral circuits, lithium battery charging and discharging management circuits and clock circuits, and a built-in 250mAh rechargeable lithium battery. The module is based on the TWR algorithm, whose distance error is less than 10cm, and the location error is less than 15cm for locating the target, and the module supports the data transmission rate of up to 6.8Mbps. The module is very convenient to carry as a label, and the module supports AT instruction set through USB.

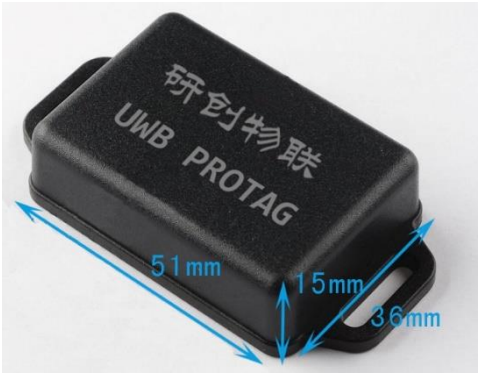


Figure 1.3.1 UWB ProTag instructions

1.3.2 UWB ProTag Support Signal Channel

Table 1.3.4 UWB IEEE802.15.4-2011 DWM1000 supports UWB channel

UWB Channel	Centre Frequency (MHz)	Band (MHz)	Bandwidth (MHz)
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*

Note: The maximum receiving bandwidth of DW1000 is about 900MHz.

1.4 Application Situation

According to the customer demands and the actual situations, and through a series of technical visits, UWB mini3 indoor positioning products have been applied in the following application scenarios: the airport hall, exhibition hall, library, warehouse, supermarket, underground parking and mine. Details:

- Intelligent suitcase and intelligent children's car;
- Factory container and cargo positioning;
- Help visitors find corresponding attractions and public facilities in the amusement park;
- Supermarket personnel positioning;
- Visitors can be more effective in understanding exhibits information and viewing exhibitions in the museum;
- Mine personnel positioning and monitor the working condition of entry-driving machine;

1.5 Advantages and disadvantages of mainstream LPS in global market

In recent years, some technology giants, including Google, Microsoft, apple and Broadcom, and some world-famous universities are studying indoor positioning technology. According to the global literature research and investigation, Bluetooth and radio frequency have been widely used in the office, family, factory and other scenes of indoor positioning. Advantages and disadvantages of mainstream indoor positioning technology in global market, as shown in the following table:

Table 1.5 Advantages and disadvantages of mainstream indoor positioning technology in global market

Indoor positioning technology	Advantage	Disadvantage
Ultrasonic positioning technology	High precision and simple structure	It is affected by multipath effect and NLOS propagation and requires a large amount of underlying hardware investment with high cost.
Bluetooth/ ibeacon	Small size, easy to integrate and popularize.	For complex space and environment, the stability of Bluetooth system is slightly worse, and it is disturbed easily by noise signal.
Radio Frequency Identification (RFID)	Small size and low cost.	It has a short distance, no communication capability, and it 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 it can provide accurate positioning.	It is affected by occlusion, metal and so on. The price is a little expensive, and now it is hard to mass production.
SLAM technology	It can create maps in a completely unknown environment with uncertain position of its own and use maps to locate and navigate autonomously.	The amount of image data is huge, and the equipment price is very expensive. It is suitable for research, not suitable for mass production.

1.6 Technical Terminology Glossary

Table 1.4 Technical Terminology Glossary abbreviations and meanings

Abbreviations	Full name	Meanings
ANCHOR		Anchor, also called Beacon anchor point. It refers to the node that obtains the position coordinates in advance.
DW1000		A chip produced by Decawave
DWM1000		A module produced by Decawave
PSR	Preamble symbol repetitions	Preamble symbol repetitions
RTLS	Real time position system	Real time position system
TAG	Tag	Tag
TOF	Time of flight	It mainly uses the signal between two asynchronous transceivers (or reflected surface) round-trip flight time to measure the distance between nodes.
TWR	Two-way ranging	Two asynchronous transceivers can obtain range values.
UWB	Ultra-wide band (UWB)	It is a carrier free communication technology. And it transmits data from nanosecond to picosecond non-sinusoidal narrow pulses.

2 Specification

2.1 Default Firmware version

The default firmware version is: 1.8.7.7. This version contains buzzer driving function and G-sensor driving.

2.2 Hardware Parameters

Table 2.2 UWB ProTag2s Hardware Parameters

Basic Parameter		Wireless Parameter	
PCB technology	4 Layer	Communication speed	110 kbit/s, 6.8 Mbit/s
Power supply port	micro-USB	Working frequency	3.5 GHz ~ 4.2 GHz
Communication port	micro-USB	Working channel	CH2
External crystal oscillator	8Mhz	Ranging	>150m（No shade）
Size	51mm * 36mm * 15mm	Ranging Error	Typical: ±10cm; General shade: ±30cm
Battery capacity	250mAH	G-Sensor	LIS3DH

2.3 IO Distribution

Table 1.3.3 ProTag Hardware IO Port Distribution

GPIOA	GPIO_Pin	Note	GPIOB	GPIO_Pin	Note
PA0	DW_RSTn		PB0	DW_WUP	
PA1	PGOOD	0: USB detect 1: no USB detect	PB1	ADC_VBAT	ADC x2 is battery voltage
PA2	CHG	0: charging 1: charging complete	PB2	BOOT1	
PA3	USB_EN	0: USB Disable 1: USB Enable	PB3	BQ_TD_EN	0: Charging Enable 1: Charging Disable
PA4	DW_NSS		PB4	INT	LIS3DH Interrupt
PA5	DW_SCK		PB5	DW_IRQN	
PA6	DW_MISO		PB6	LED1	Programable LED1
PA7	DW_MOSI		PB7	LED2	Programable LED2
PA8	DW_EXTON				
PA9	USART1 - TX	USART1-TXD			
PA10	USART1 – RX	USART1-RXD			
PA11,12	USB				
PA13	SWDIO	SWD Interface			
PA14	SWCLK	SWD Interface			

2.4 UWB ProTag2s Channel 2 Measured Spectrum

Connect the antenna of **ProTag2s** the spectrum analyzer FSL6 (Rhodes and Schwartz company), and the center frequency of channel 2 is 4GHz, and the maximum gain is -49.96dbm, as shown in the following figure

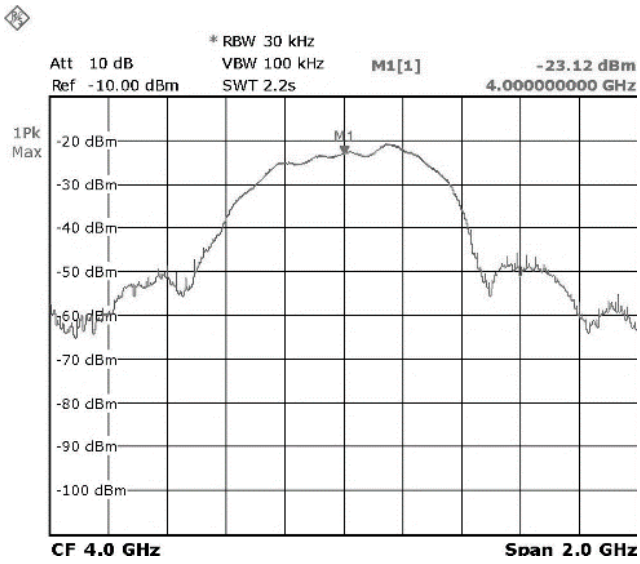


Figure 2.4 ProTag2s Emission power test

2.5 Hardware Interface Definition

For USB interface, obey the standard micro USB interface. Data reading and writing could be processed though USB cable. Tag could be charged though the USB interface.

For working indicator LED, it is controlled by IO PB7. When the LED flashing at 1Hz, it indicates that the Tag is working properly; When the LED flashing at 4Hz, it indicates that the label is waiting to be configured.

For Power On / Off button, in the state of the boot, press the key to turn off the Tag. While in the state of shutdown, press the key to let the tag power on.

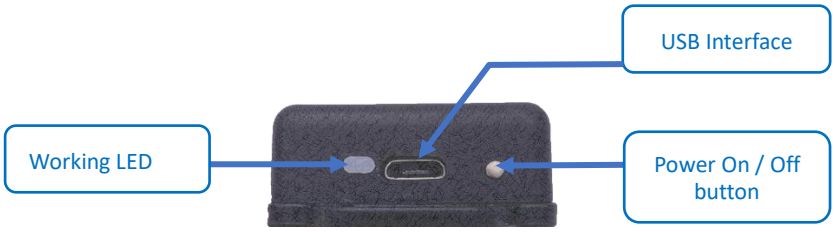


Figure 2.5 UWB ProTag2sHardware Interface Definition

3 Tech Support: Common Q&A

3.1 Principle

3.1.1 UWB ranging principle

TW-TOF (two way-time of flight): Each module can generate an independent time stamp from the start. The transmitter of the module A transmits the requested pulse signal on the time stamp of the Ta1. The module B sends a response signal at the Tb2 moment, which is received by the module A at its own time stamp Ta2.

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

3.1.2 UWB triangulation principle

1) Distance = speed of light * time difference / 2; XY plane and 3 circles can determine a point;
2) XYZ space and 4 circles can determine a space point;

3.2 Application

3.2.1 Compatibility

Answer: ProTag could be paired with Mini3 / Mini3s / Mini3sPlus which could be configured as anchor. Mini3sPlus is strongly recommended as anchor for its high performance.

3.2.2 Could the UWB signal range though the wall?

Answer: Paired with Mini3s Plus, ProTag can work under NLOS.

3.2.3 Installation Notes

- The UWB module should be at least 1m away from the wall, table, shelf, metal cabinet and other obstacles. Otherwise, the positioning data will be affected, and it causes the range results to be inaccurate.
- Try not to be shielded around the antenna. For standard measurement, the Anchor should be placed on the tripod and more than **1.5 meters** above the ground.
- When testing, please screw the antenna to ensure the performance of the module to the best.
- If you need to signal range through the wall, you can buy Mini3s Plus module. The module increases the RF power amplifier circuit, and the signal can be stable through the wall.

Figure 3.2.2 Anchor / Tag installation notes

4 UWB Positioning Suite Test Instructions

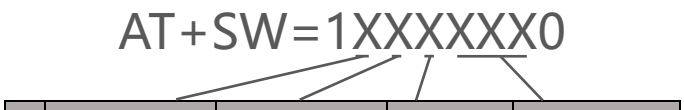
UWB positioning system is consisted of at least 4 UWB modules, 3 anchors and 1 tags. After that, tags and anchors can be purchased to extend the number of tag and system. The DEMO can support 4 anchors and 8 tags. But it doesn't mean that the system can only support 8 tags, it can support tens of thousands of tags through custom development.

4.1 ANCHOR and TAG Mode Configuration

The mode configuration has been set up at the factory. If there is no special case, it is unnecessary to change. Skip this step directly.

4.1.1 AT command

Connect the Mini3s to the computer through the USB line, open the com debugging assistant XCOM software, send the command, and add the return line at the end, such as:



	S2 (Data Rate)	S3(Frequency)	S4(Mode)	S5-7(Address)
1	6.8M	Channel 5	ANCHOR	Address
0	110K	Channel 2	TAG	[000-001]

4.1.2 Example

Example 1: Set the module to anchor, 110k transmission data rate, channel 2, address is NO.3, then send AT+SW=10010110.

Example 2: Set the module to tag, 6.8M transmission data rate, channel 5, address is NO.7, then send AT+SW=11101110.

Note: The address of the anchor is only 0/1/2/3, and more than 4 anchor are temporarily not supported. The default rate is 110k, channel 2. In a system, the anchor & tag transmission rate and frequency band should be consistent.

4.1.3 Default Module AT Commands

Table 4.1.3 Default Module Configuration Commands

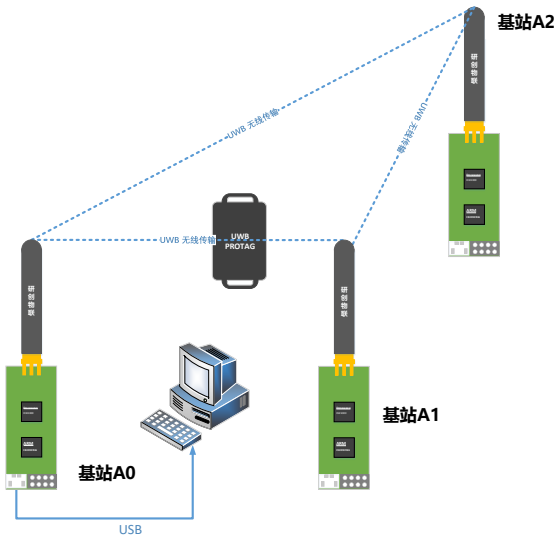
Module	Commands	Module	Commands	Module	Commands
Anchor A0	AT+SW=10010000	Tag T0	AT+SW=10000000	Tag T4	AT+SW=10001000
Anchor A1	AT+SW=10010010	Tag T1	AT+SW=10000010	Tag T5	AT+SW=10001010
Anchor A2	AT+SW=10010100	Tag T2	AT+SW=10000100	Tag T6	AT+SW=10001100
Anchor A3	AT+SW=10010110	Tag T3	AT+SW=10000110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

4.2 Method 1-Indoor Positioning (3 Anchors and 1 Tag)

1) Hardware platform construction.
2) Install Virtual COM Port driver. See Chapter 6.4.
3) Connect directly A0 Anchor and USB.
4) Open host software DecaRangeRTLS.exe. If there is an error like Figure 4.2.2, there may be several reasons:
   - Virtual com driver installation failure, the software can’ t find *COMx*;
   - USB is not connected on hardware. Micro-USB line does not support communication, otherwise use damaged micro-USB line.

   Note1: Most win7 users can't open the host. You can see the DecaRangeRTLS.exe daemon process. If you encounter this problem (unable to solve the problem at present), please try another computer.

   Note 2: Some high screen users (2k screen or 4K screen users) will encounter the problem of incomplete display of the host computer. You can adjust the separator to display.



5) All tag powered by power bank.
6) A1/A2 Anchor powered by power bank.

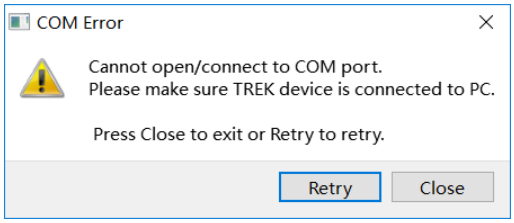
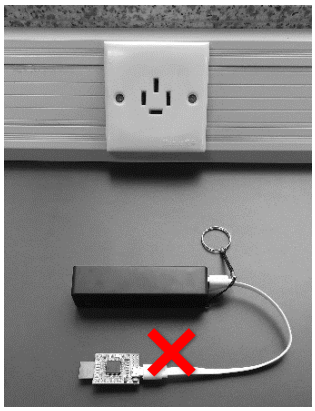


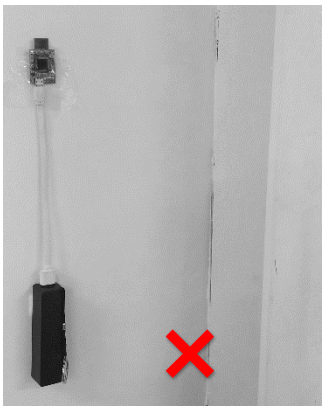
Figure 4.2.2 COM Error on PC client

7) Notes in product placement. The placement of Anchor and tag directly affect the ranging accuracy and positioning accuracy. Here are a few common errors:
   - Put the module near the metal. The antenna signal is directly absorbed by the metal, whether it is a built-in ceramic antenna or an external rod antenna.
   - Place the module on the desktop, stick the module to the wall and hold the antenna by hand, these acts will affect the beam of the UWB antenna and cause a certain multipath effect.

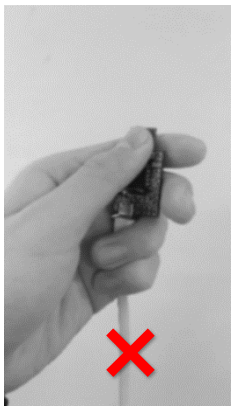
Put the module near the metal.



Put the module flat on the desktop.

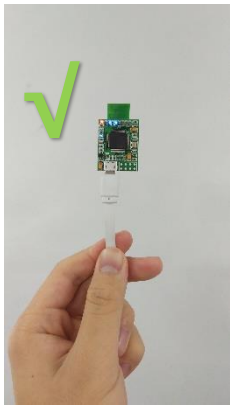


Stick the module on the wall.



Hold antenna by hand.

基站正确的安装方式如下图所示：



8) Operational software DecaRangeRTLS

- In the Settings, select the Tracking / Navigation Mode (Default check).
- Open host, when the distance data has started to beat in Tag / Anchor Tables, it shows that range finding has begun.
- In the upper left corner of the Anchor, select Anchor ID 0 / 1 / 2, and according to the actual situation of the Anchor placement, enter the Anchor XYZ relative coordinates. In general, we set A0 to (0,0,1.5), it shows the height of A0 is 1.5m. On the software, the default A0 A1 A2 is at the same height, so when placed, the 3 Anchors need to be at the same height.
- When the Anchor coordinates are set successfully, the coordinates can be solved (the solution of the real root of the equation), otherwise the coordinates of tag are not displayed.

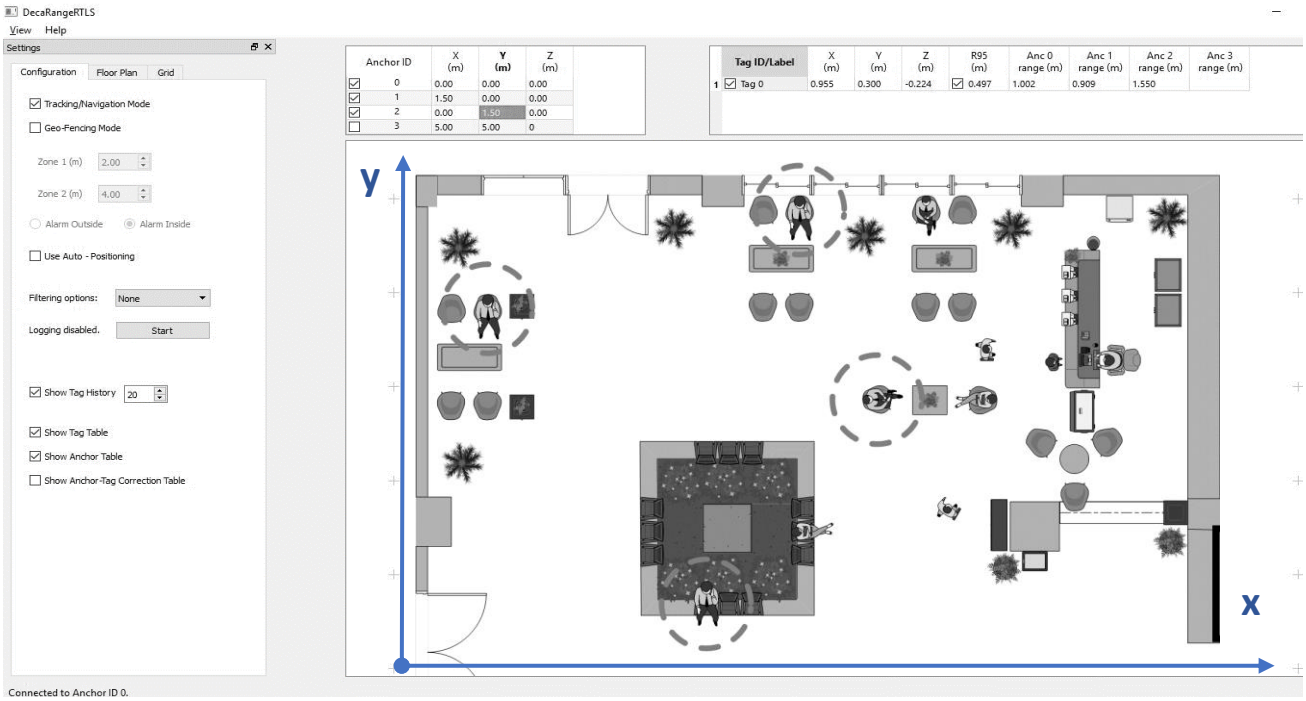


Figure 4.2.7 PC-RTLS demo software screenshot and use

9) It's better to have 4 Anchors to get a larger positioning system. To get a better Z axis accuracy, for the 4 Anchors, the height of the A3 is best to be 1 meter or 0.5 meters higher than the A0/A1/A2, and the A0/A1/A2 is in the same plane.

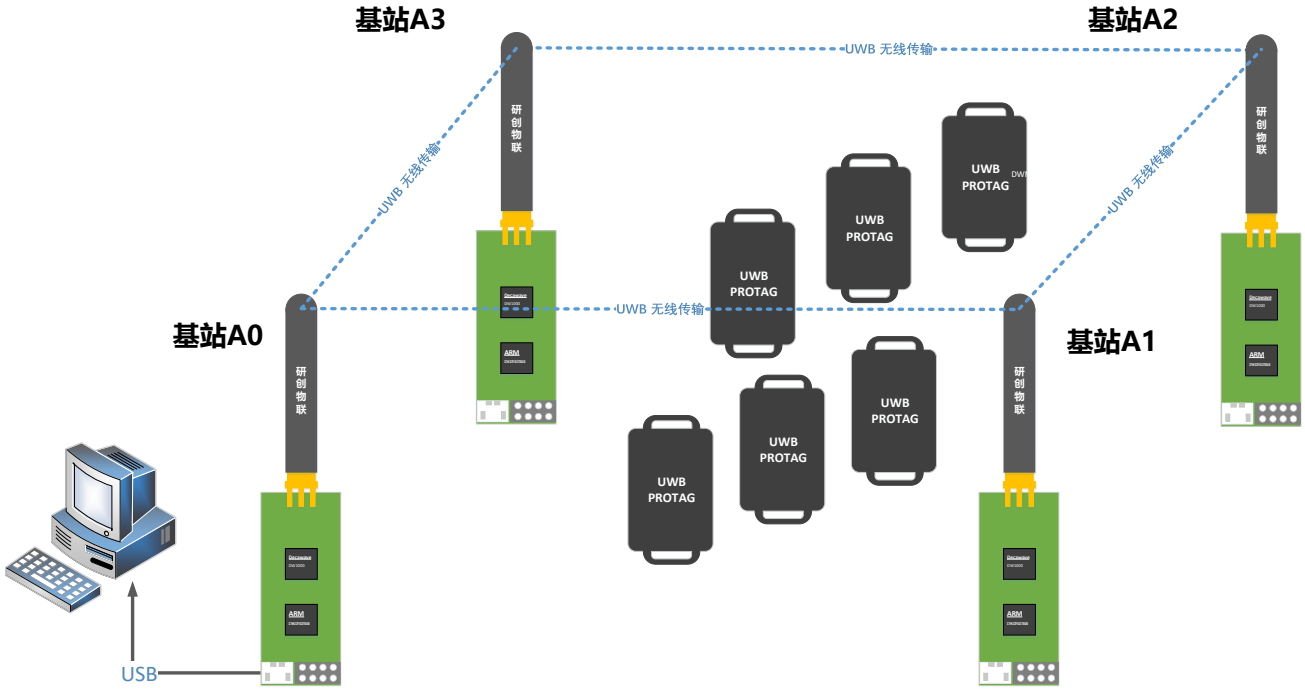


Figure 4.2.3 The schematic diagram of locating 4 stations + multi tag hardware platform

4.3 Method 2-GeoFencing Mode (1 Anchor and 3 Tags)

1) Hardware networking.
2) Install Virtual COM Port driver (the same as above).
3) A0 connects computers through USB (the same as above).
4) Open host software DecaRangeRTLS.exe (the same as above).
5) All tag powered by power bank.
   Note: If there are only 1 Tag (1 station, 1 Tag), you can also test them in this mode. Anchor A0 must exist.
6) Operational software: Set to Geo-Fencing Mode.

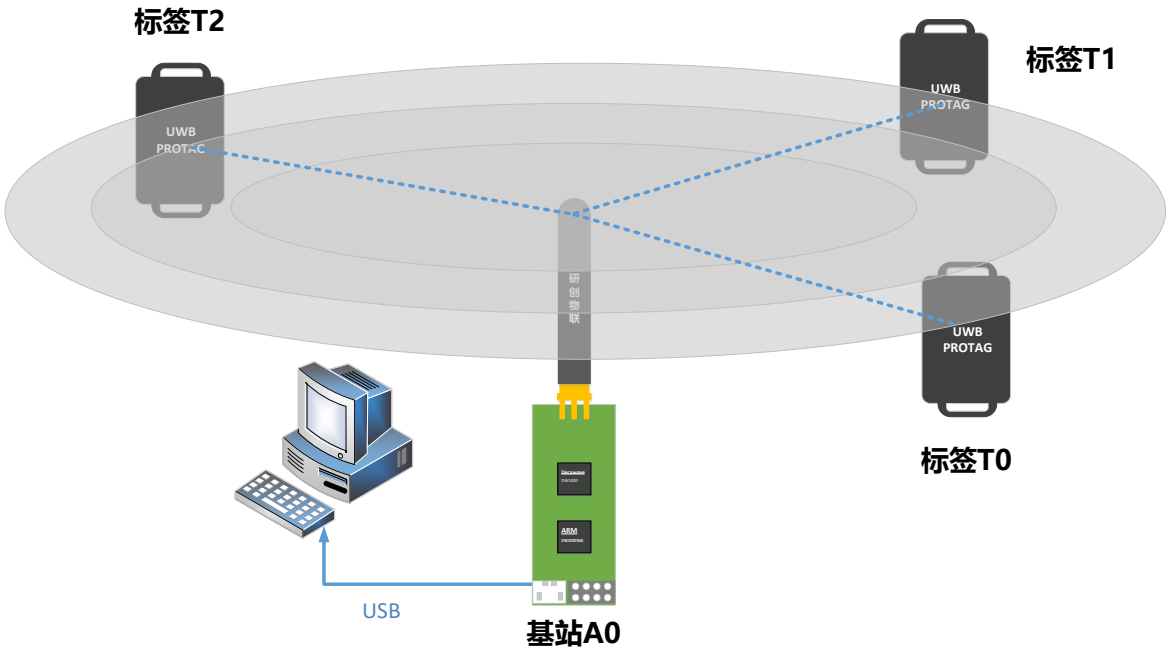
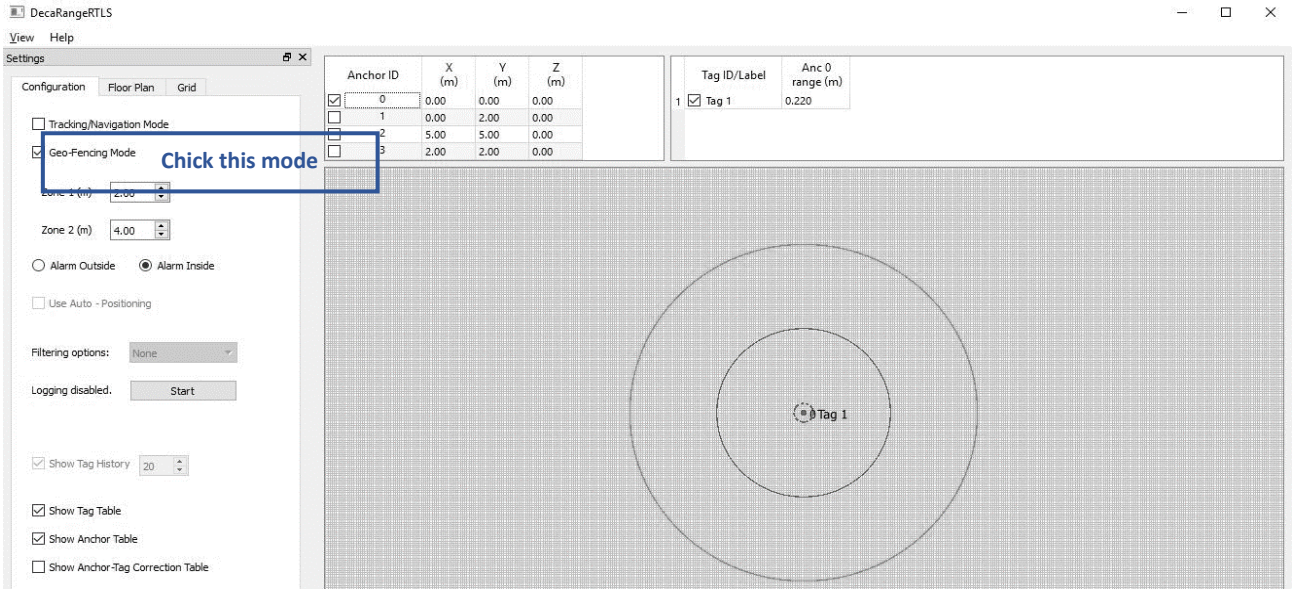


Figure 4.3 Geo-Fencing Mode Diagram


DecaRangeRTLS
View Help
Settings
Configuration
Floor Plan
Grid
Tracking/Navigation Mode
Geo-Fencing Mode
Chick this mode
Zone 2 (m)
4.00
Alarm Outside
Alarm Inside
Use Auto - Positioning
Filtering options:
None
Logging disabled.
Start
Show Tag History
20
Show Tag Table
Show Anchor Table
Show Anchor-Tag Correction Table
Anchor ID
X (m)
Y (m)
Z (m)
0 0.00 0.00 0.00
1 0.00 2.00 0.00
2 5.00 5.00 0.00
3 2.00 2.00 0.00
Tag ID/Label
Anc 0 range (m)
1 Tag 1 0.220
Tag 1

5 UWB Smart Link (Optional)

5.1 Data access solution of positioning system

UWB Smart Link networking suite development board aims to achieve the UWB Mini 3/ Mini3s/ Mini3s plus module into a remote server from the TOF Report Message com output data, then developers can realize remote management and monitoring of UWB positioning data. The development board is equipped with MXCHIP super WiFi module. Just through simple settings, you can achieve data access.

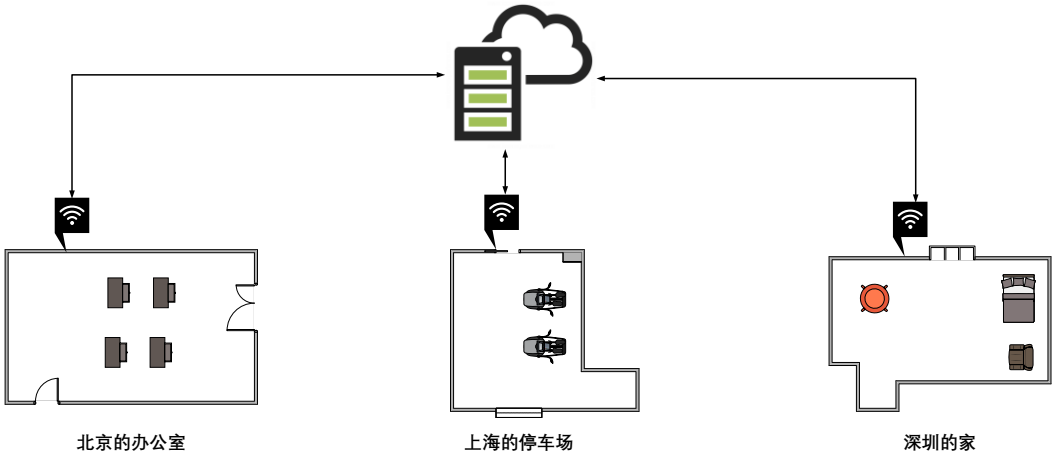
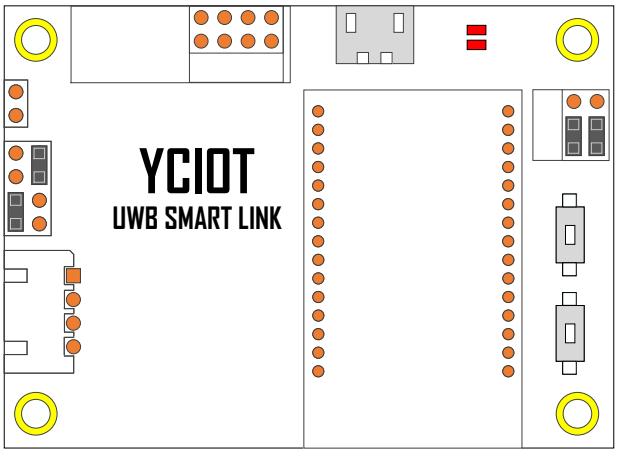


Figure 5.1 The diagram of positioning data access network

5.2 UWB Smart Link Overview

1) The left upper 2*4 port is compatible with the UWB ***UWB Mini 3/ Mini3s/ Mini3s plus*** module, plug and play. Please write the latest development firmware before using and use UWB module to output COM Port.
2) The WiFi module adopts MXCHIP EMW3162. It has high performance and low power consumption Cortex-M3 micro controller and 128KB RAM + 1MB Flash. The module can run the MiCO IOT operating system and support the Add-ons Development. Users can use MiCO TCP/IP protocol stack and some security encryption algorithms to achieve a variety of embedded Wi-Fi applications.
3) The USB chip for TTL is CH340. It is a USB bus adapter chip developed by WCH, and it can achieve USB com or USB to print port.



For more information, please refer to instruction manual <UWB Smart Link Instruction manual V1.3>.
Link: https://pan.baidu.com/s/1eSvGMRK. Password: gdp2

6 UWB Module Add-ons Development

6.1 EDA and Tools

Before the Add-ons Development, you need to install a series of software drivers to ensure the development of the basic conditions. The required installation software is already provided in pan.baidu.com.

Table 6.1.1 UWB Suite development software

Tool	Function
ST-LINK	ST-LINK is a development tool, which can simulate online and download STM8 and STM32. The function is more comprehensive than J-Llink.
KEIL-MDK5.20	It is the STM32 development platform. Keil software is widely used by more than 80% software and hardware engineers in China. If the major related to electronics, they all start learning from SCM and computer programming. However, if you learn the SCM, you must use Keil software. Mill technology, Emdoor electronic and EMBEST sale Keil and provide technical support services in domestic. Not only they are the ARM partner, but also are the leading embedded solutions providers in domestic.
DecaRangeRTLS.exe	Indoor positioning host. It supports positioning graphical port display and map import.
XCOM	Excellent COM debugging assistant software which is developed by ALIENTEK

6.2 Mini3s Firmware updating

6.2.1 Install the ST-LINK Driver

Open *en.stsw-link009.zip*, follow the installation process, click OK or Next, and then you have finished the ST-LINK driver installation. Insert the STLINK downloader and find its driver in the device manager.

Figure 6.2.1 STLINK download picture.

6.2.2 Hardware connection of STLINK and Mini 3s

If you need to upgrade or modify the firmware of UWB Mini3s, you need to STLINK for help. And the hardware connection is shown in the following figure:

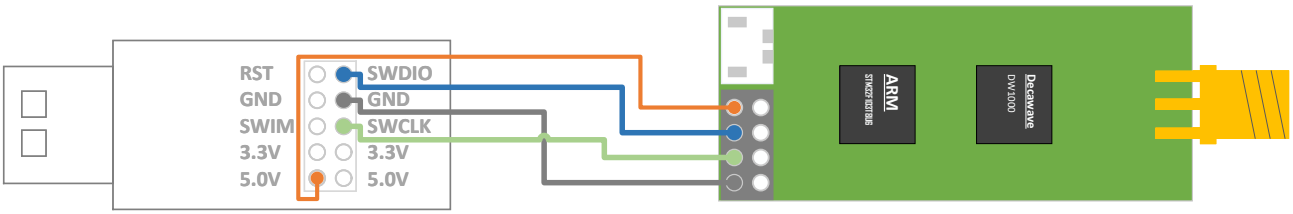


Figure 6.2.2 STLINK V2 downloader and Mini3s hardware wiring method

6.2.3 Installation of development environment Keil

Keil installation instructions are in the manual document aps003-keil installation instructions. You can use the built-in download function in Keil to download the program to the UWB module.

6.2.4 STLINK download settings

The update of UWB module program can also be realized by STLINK Utility software. STLINK Utility instructions website: http://blog.csdn.net/ybhuangfugui/article/details/52597133

6.3 Mini3s Output data via COM Port method

6.3.1 External COM Port device/RS232/485

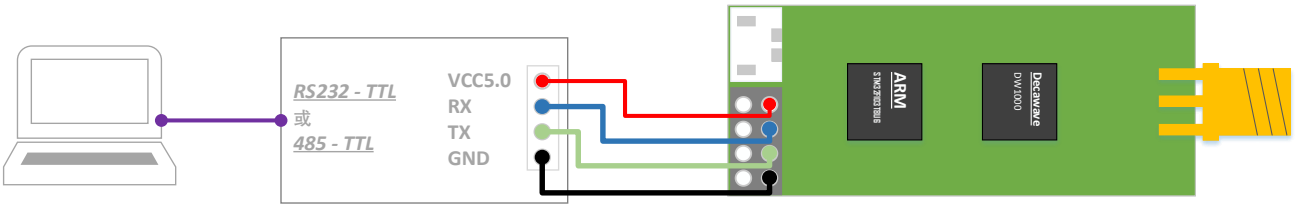


Figure 6.3.1.1 UWB Mini3s module and TTL-RS232 module or TTL-485 module connection

UWB mini3s external BLE 4.0 com Bluetooth module. It can check the data of Android mobile phone and apple mobile phone.

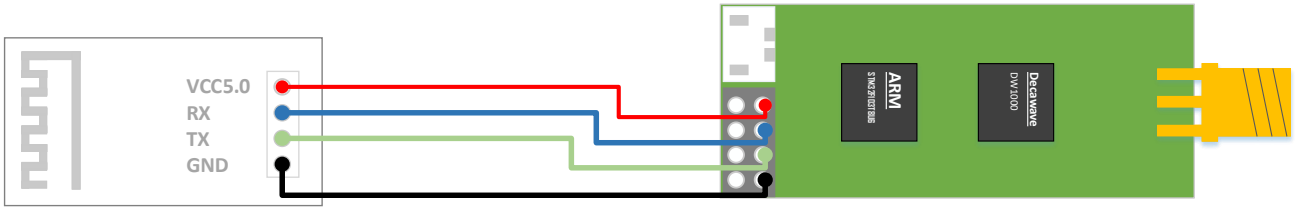


Figure 6.3.1.2 UWB Mini3s module and Bluetooth module connection

Raspberry Pi or Arduino is the TTL 5V development board. When they are connected to the UWB module, they need 27R~51R current-limiting resistance in series.

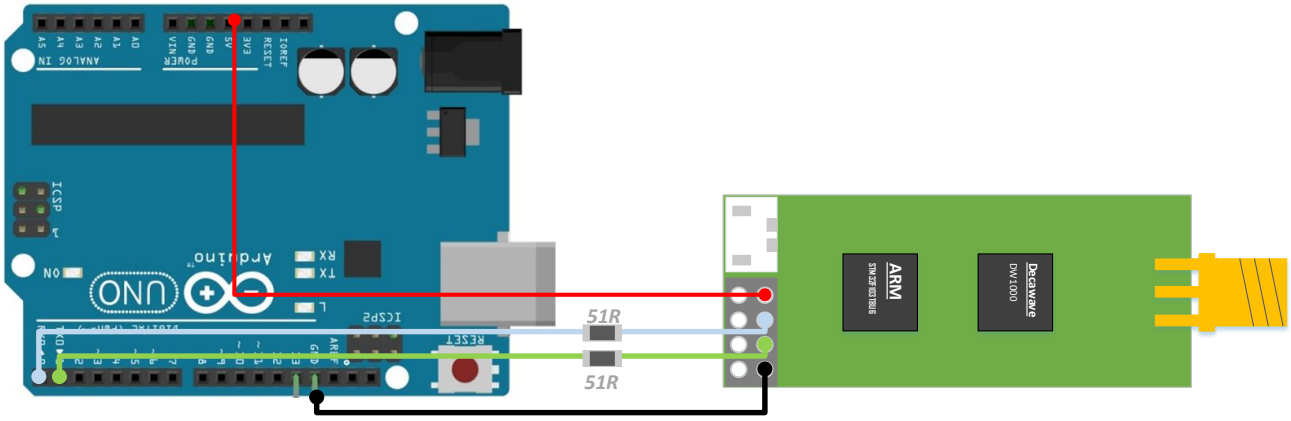


Figure 6.3.1.2 UWB Mini3s module and SCM (Arduino) connection

6.3.2 Check with COM Port assistant

Baud rate: 115200bps; Data bit: 8; Stop bit: 1; No parity bit. Follow the Figure 6.3.1 to connect. Open the XCOM com debugging assistant on the computer; you can see the TOF Report Message data stream.

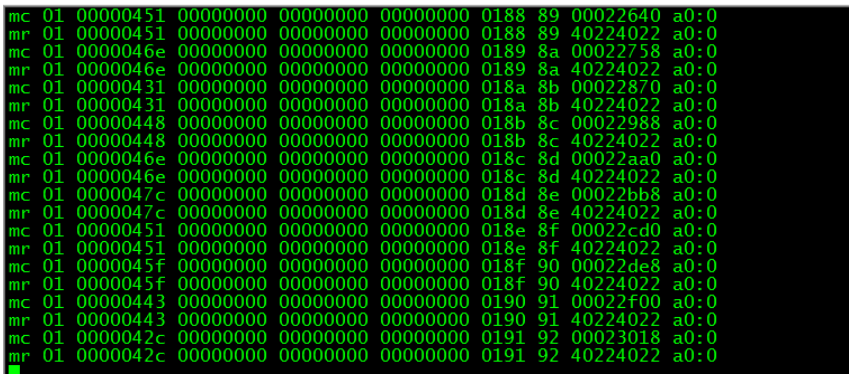


Figure 6.3.2 TOF Report Message data stream.

6.4 Output data via USB Virtual COM Port method

6.4.1 Install ST Virtual COM Port driver.

Virtual COM Port driver is issued by ST Company. Please select the version according to the operating system. Please try *VCP_V1.4.0_Setup.exe* for Win 7 users.

Table 6.4 Virtual COM Port driver support system

Operating system	Support
Windows 98 / ME / XP / Vista	Nonsupport
Win7 32-bit	Nonsupport
Win7 64-bit	Install VCP_V1.4.0_Setup.exe or VCP_V1.3.1_Setup.exe
Windows 8/8.1	Install VCP_V1.4.0_Setup.exe
Windows 10 (recommendation)	Install VCP_V1.4.0_Setup.exe

1) Open *VCP_V1.4.0_Setup.exe*, follow the installation instructions, select OK or NEXT, and finish the Virtual COM Port driver file copy and expansion. Note: This step is only completed file decompression.
2) Enter *C:\Program Files (x86)\STMicroelectronics\Software\Virtual comport driver\Win8*
3) 64-Bit system users need to find *dpinst_amd64.exe*, then to install it. 32-Bit system users need to find *dpinst_x86.exe*, then to install it.
4) After installation successfully, using USB line to connect A0 Anchor and computer. You can find *COMx in* My Computer-Property-Device Manager-COM and LPT. Now, the ST Virtual COM Port driver is installed. Please restart the computer after the driver is installed.

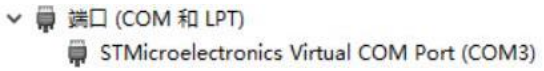


Figure 6.4.3 Find Virtual COM Port COM3 in Device Manager

5) Some win7 users may not be able to install the driver (Exclamation mark), because of the lack of USB Virtual COM Port file (Reason: the system installed with Ghost). The solutions are as follows, please contact the seller to get the patch package:
   - Copy *mdmcpq.inf* to *C:/windows/inf/*.
   - Copy *usbser.sys* to *C:/windows/system32/drivers/*.
   - Install the driver software *VCP_V1.3.1_Setup.exe* (Note: The number of win7 users need to install the V1.3.1 version).

- Then re-insert the USB line, and select Update Driver in the device manager port by right click.

6.4.2 Check with COM Port assistant

USB Virtual COM Port can adapt baud rate, data bits, stop bits and check bits. So, the above parameters without modification and selection, just click "open the COM Port" , you can the TOF Report Message data stream.

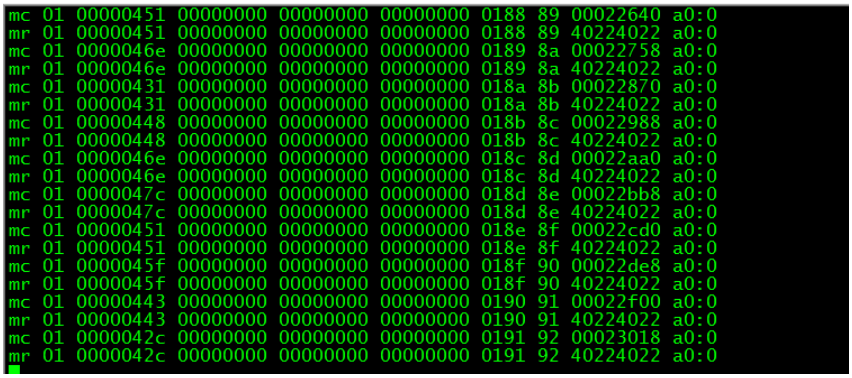


图 6.4.2 TOF Report Message 数据流

7 Message Protocol and Add-ons Development

7.1 RTLS host summary

This section describes the use of PC host. The host software uses *QT 5.7.0 MinGM* development, and the written language is C ++. Qt is a cross platform C++ graphical user port application development framework, which is developed by Trolltech in 1991. It not only can develop GUI programs, but also can develop non-GUI programs, such as console tools and servers. QT is an object-oriented framework, using special code generation extensions (called Meta object compilers) and some macros, which are easy to extend and allow component programming. Cross platform integrated development environment Qt Creator 3.1.0 officially released, and it implements full support for IOS. It added WinRT, Beautifier plug-in, abandoned without Python port GDB debugging support. What' s more, it integrates C/C++code module based on Clang and supports for Android to adjust. Thus, it can achieve the full support of the IOS, Android and WP.

Functions:

1) Connect with the *Virtual COM Port* of the UWB module.
2) Read TOF report message via the UWB module.
3) Anchor list, the Anchor can be set actual position in the list.
4) Tag list, it can display the tag distance from the Anchor, and the position of the tag (XYZ coordinate) in the tag list.
5) Map display, support custom import a PNG format map, and it can achieve zoom and coordinate fine-tuning.
6) Other parameter settings

7.2 RTLS Client

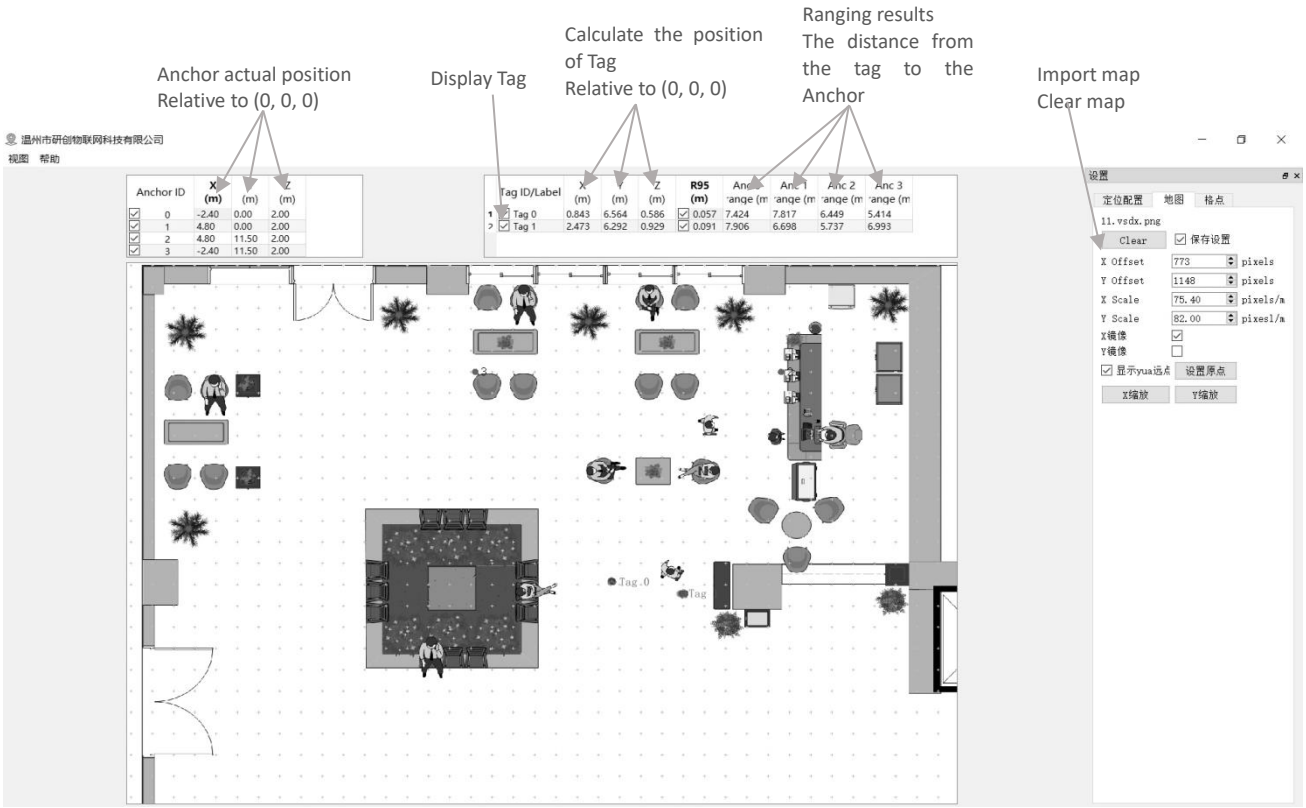


Figure 7.2 RTLS Client

7.2.1 Graphics

7.2.1.1 Tag and Anchor Tables

Tag Table includes Tag ID, ranging results and coordinates position.

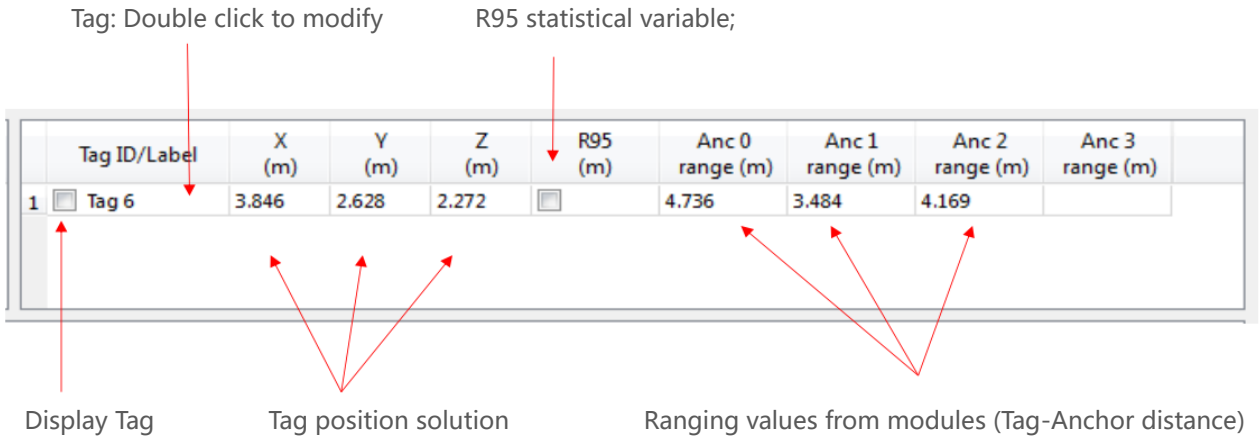


Figure 7.2.1.1 Tag Table

- R95 Statistical variable reference materials: https://baike.baidu.com/item/%E7%BD%AE%E4%BF%A1%E5%8C%BA%E9%97%B4/7442583?fr=aladdin
- Tag position solution is calculated according to the tag-Anchor distance. The concrete solution method is shown in section 7.5.

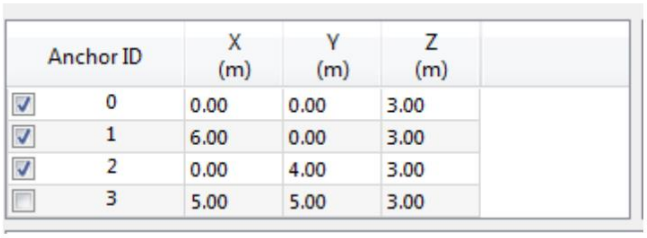


Figure 7.2.1.1.2 Anchor Table

Anchor Tables includes Anchor Anchor ID and position information of Anchor.

7.2.2 Status Bar

The lower left corner of the status bar displays the following contents:

- "DecaRangeRTLS Anchor/Tag ID Mode" - Open the software, and the COM Port connection is successful.
- "Connected to Anchor/Tag/Listener ID" - Tag / Anchor is connected and receives TOF data.
- "No position solution" - According to the distance data, the software can' t solve the coordinate.
- "Open error" - Software failed to open Virtual COM Port.

7.2.3 View Settings

It includes 3 tables: Configuration, floorplan and grid.

- Configuration Table

Name	Description

Tracking/Navigation Mode	Tracking/Navigation Mode
Geo-Fencing Mode	Ultra-range alarm mode
Zone1	Zone1
Zone2	Zone2
Alarm Outside/Inside	Alarm Outside/Inside
Show Tag History (N)	Show Tag History (N)
Show Tag Table	Show Tag Table
Show Anchor Table	Show Anchor Table
Auto Positioning	In this mode, the Anchor position does not need to set filter.
Filtering	Filtering
Logging	Logging

- Grid Table

Name	Description
Width (M)	Width (M)
Height (M)	Height (M)
Show	Show grid point

- Floor Plan tab

Name	Description
Open	Open a map and import the software.
X offset	Translation the map in pixels in the X direction.
Y offset	Translation the map in pixels in the Y direction.
X scale	Zoom the map in pixels in the X direction.
Y scale	Zoom the map in pixels in the Y direction.
Flip X	Take the X axis as the symmetry axis to mirror the image.
Flip Y	Take the Y axis as the symmetry axis to mirror the image.
show	Show origin
Set Origin	Set Origin
X Scale button	Click on this button produces a small tool for measuring distance on the map, then input actual distance, and set X scaling values.
Y Scale button	Click on this button produces a small tool for measuring distance on the map, then input actual distance, and set Y scaling values.

7.3 TOF Report Message

Open any COM debugging assistant, without setting baud rate and other parameters, you can observe the Anchor A0 through the USB Virtual COM Port to the PC end of the USB transmission data format is as follows:

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	Message ID is consisted of mr, mc, ma. mr represents the tag-Anchor distance (native data). mc represents the tag-Anchor distance (Optimize the corrected data for locating tag). ma represents the tag-Anchor distance (Optimize the corrected data for automatic positioning Anchor).
MASK	It represents RANGE0, RANGE1, RANGE2 and RANGE3 valid messages. For example: MASK=7 (0000 0111) indicates that RANGE0, RANGE1, RANGE2are valid.
RANGE0	If MID = mc or mr, it represents the distance from tag x to Anchor 0. Unit: mm.
RANGE1	If MID = mc or mr, it represents the distance from tag x to Anchor 1. Unit: mm. If MID = ma, it represents the distance from Anchor 0 to Anchor 1. Unit: mm.
RANGE2	If MID = mc or mr, it represents the distance from tag x to Anchor 2. Unit: mm. If MID = ma, it represents the distance from Anchor 0 to Anchor 2. Unit: mm.
RANGE3	If MID = mc or mr, it represents the distance from tag x to Anchor 3. Unit: mm. If MID = ma, it represents the distance from Anchor 1 to Anchor 2. Unit: mm.
NRANGES	unit raw range count value (continue to accumulate)
RSEQ	range sequence number count value (continue to accumulate)
DEBUG	If MID=ma, it represents the delay of the TX/RX antenna.
aT:A	T is Tag ID, A is 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 you use the host, click "Start", then it will produce *yyyymmdd_hhmmssRTLS_log.txt* format log files in the log folder, meanings are as follows:

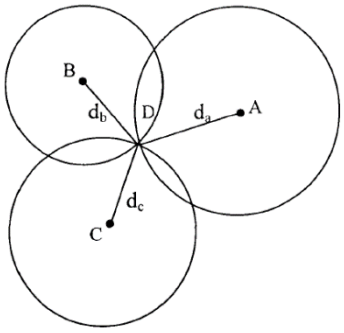
Table 7.4 log file corresponding to the meaning

Log content	Meanings
T:151734568:DecaRangeRTLS:LogFile:Ver. 2.10 TREK:Conf:Anchor0:1:Chan2	15:17, 34s; 568ms; Version: V2.10. Currently connected: 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, 34s,600ms, Anchor Position 0 (X, Y, Z)
T: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: Tag ID: Anchor ID: Reported Range: Corrected Range: Sequence# : Range Number

T:151734614:LE:0:2627:146:[0.743669,7.9919,-1.89245]:8794:9160:5687:4773	LE: Position Estimate: Tag ID: LE Count: Sequence #:[x,y,z]: Range to A0: Range to A1: Range to A2: Range to A3:
T:151734614:TS:0 avx:0.786397 avy:8.00351 avz:-1.93044 r95:0.0732666	TS: Tag Statistics: Tag ID: Average X: Average Y: Average Z:

7.5 Trilateration Principle and Calculation Method

7.5.1 Trilateration Theoretical Principle



Trilateration principle as shown on the right, with three nodes A, B, C as the center circle, coordinates respectively (X_a, Y_a), (X_b, Y_b), (X_c, Y_c), the three circles intersect at one point D, D is the intersection of mobile nodes. A, B, C are reference nodes. A, B, C and D respectively from the point of intersectiond_a, d_b, d_c. Suppose the intersection point D coordinates are (X, Y).

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

The coordinates of the intersection point D can be obtained by the 7.5.1:

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

The disadvantage of Trilateration: Because each node of the hardware and power consumption is not the same, the measured distance is not the ideal value, which leads to the three rounds above not just at a point. In fact, it is certainly the intersect in a small area, so by this method the calculated (X, Y) are recommended the error. Therefore, it is necessary to estimate the relative ideal position by a certain algorithm, as the optimal solution of the current mobile node coordinates.

7.5.2 Trilateration Function

In the trilateration.cpp file, the function implemented by GetPosition(): The coordinates of the incoming Anchor (unit: m) and the distance from each Anchor to the tag (unit: mm). Calculate the Best Solution of Tag (unit: m).
Because the measured distance is not the ideal value, which leads to the three rounds above not just at a point, so when the Anchor A0/A1/A2 at work, from the mathematical point of view, there will be 2 solutions; when the A0/A1/A2/A3 at work, there must be an optimal solution. A3 is used the auxiliary Anchor. After the Trilateration is completed by A0/A1/A2, two solutions are obtained, and the nearest solution from the A3 sphere is taken as the optimal solution.
Note: trilateration.cpp file is the PC client source code. 4 Anchors and 4 tags or more are provided for free.

7.5.3 Lower accuracy on Z axis than X and Y?

As shown in figure A0/A1/A2 are three Anchors, T0 is the tag, L_{A0T0} L_{A1T0} L_{A2T0} represents the distance from each Anchor to the tag. In the case of accurate range finding, the tag coordinates of the solution should be at T0. But the actual measurements L_{A0T0} L_{A1T0} L_{A2T0} may be too large, the position of the calculation is in T0′ . Because the A0/A1/A2 in the x o y plane, the ranging error will accumulate to the Z axis and causes jitter of Z axis data.

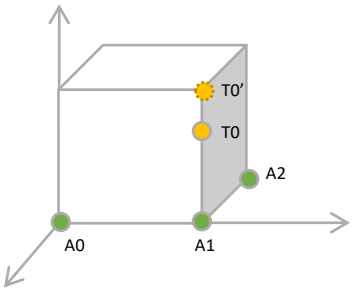


Figure 7.5.3 Z axis data error

8 UWB Product Development

8.1 Data Calibration Method

Some customers response that UWB module measurement value is always greater than the actual distance; and some users response that UWB module measured value is smaller than the actual distance. What' s wrong with it? Because the scene and the environment are different, they are affected by latitude and longitude, air quality, environmental obstacle, altitude and so on. So, in the process of product, you must calibrate the module.

In general, the calibration only needs to be carried out once in the field and the correction coefficient is obtained through the ranging of 1 Anchor and 1 Tag, which does not need to be calibrated by each Anchor and Tag.

Use Microsoft 2016 Excel software to data fitting and generate the fitting formula. There are a lot of the fitting formulas; the simplest is the linear equation.

UWB测量距离	实际距离（米尺测量）
1390.00	1000.00
2550.00	2000.00
3540.00	3000.00
4660.00	4000.00
5570.00	5000.00
6780.00	6000.00
7670.00	7000.00
8620.00	8000.00
9750.00	9000.00
10750.00	10000.00
11740.00	11000.00
12770.00	12000.00
13650.00	13000.00
14650.00	14000.00
15780.00	15000.00
16750.00	16000.00
17650.00	17000.00
18660.00	18000.00
19780.00	19000.00
20460.00	20000.00
21550.00	21000.00
22600.00	22000.00
23600.00	23000.00
24610.00	24000.00
25660.00	25000.00
26800.00	26000.00

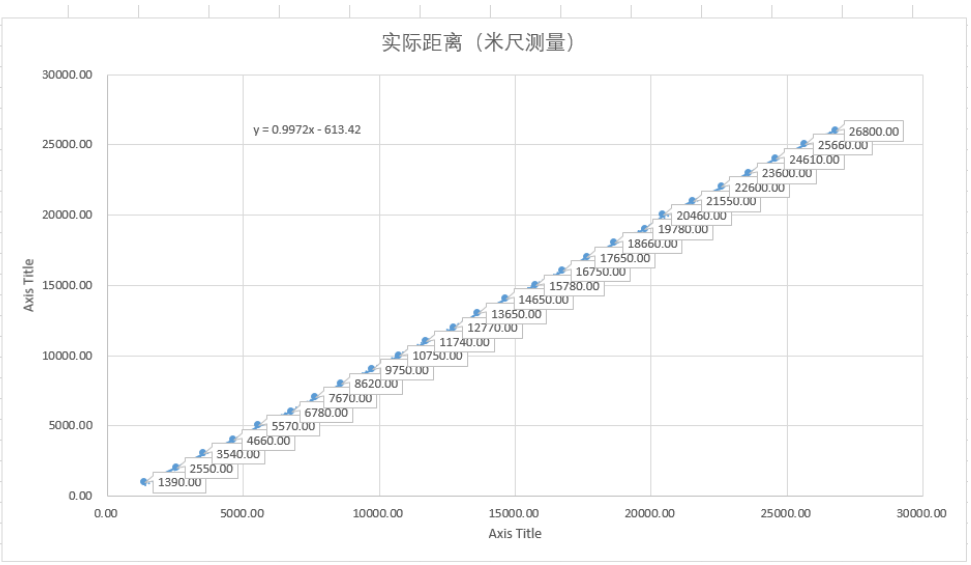


Figure 8.1 Calibration EXCEL form

The A-T distance values stored on these four variables: instancegetidist_mm(0), instancegetidist_mm(1), instancegetidist_mm(2), instancegetidist_mm(3). Each distance needs to be substituted into the calculated calibration formula. In the main.c function, the original program:

```
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);
```

We can revise it:

```
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 with the computer, without downloading each module. Through data correction, the distance value measured by UWB module has very high accuracy.

8.2 Method for further improving ranging refresh rate

If there is only 1 tag used, the refresh rate of the ranging can be improved as follows: in *instance.h file,*

- Modify the *ANCTOANCTWR (Anchor-Anchor ranging) to 0.*
- Modify the *MAX_TAG_LIST_SIZE* to 1.
- Modify the *MAX_ANCHOR_LIST_SIZE* to 1.

In main.c sfCongfig_t sfConfig[4] structure array

- and Mode 1/2/3/4, modify the number of slots to 2.

8.3 Method for improving positioning refresh rate

If there are only 4 tags and 3 Anchors used, the refresh rate of the ranging can be improved as follows: in instance.h file,

- Modify the *ANCTOANCTWR (Anchor-Anchor ranging) to 0.*
- Modify the *MAX_TAG_LIST_SIZE* to 4.
- Modify the *MAX_ANCHOR_LIST_SIZE* to 3.

In *main.c*, modify the sfCongfig_t sfConfig[4] structure array

```
sfConfig_t sfConfig[4] =
{
    //mode 1 - S1: 2 off, 3 off
    {
        (28),   //ms -
        (4),    //thus 4 slots
        (4*28), //superframe period
        (4*28), //poll sleep delay
        (20000)
    },
    //mode 2 - S1: 2 on, 3 off
    {
        (10),   // slot period ms
        (4),    // number of slots
        (4*10), // superframe period (40 ms - gives 25 Hz)
        (4*10), // poll sleep delay (tag sleep time, usually = superframe period)
        (2500)
    },
    //mode 3 - S1: 2 off, 3 on
    {
        (28),    // slot period ms
        (4),     // thus 4 slots - thus 112ms superframe means 8.9 Hz location rate
        (4*28),  // superframe period
        (4*28),  // poll sleep delay
        (20000)
    },
    //mode 4 - S1: 2 on, 3 on
    {
        (10),   // slot period ms
        (4),    // thus 4 slots  - thus 40 ms superframe means 25 Hz location rate
        (4*10), // superframe period (40 ms - gives 25 Hz)
        (4*10), // poll sleep (tag sleep time, usually = superframe period)
        (2500)  // this is the Poll to Final delay - 2ms
    }
};
```

8.4 Blocking influence of indoor UWB positioning

The main points are as follows:

1) Solid wall: A block of solid wall will make the UWB signal attenuation 60-70%, positioning accuracy error rise about 30 centimeters. Two or more than two blocks of solid wall occlusion will make the UWB can’ t locate.
2) Steel plate: The absorption of UWB pulse signal by steel is very serious, which will make UWB unable to locate.

3) Glass: Glass occlusion has a great influence on the positioning accuracy of UWB.
4) Wood or cardboard: The thickness of 10 centimeters of wood or cardboard on the UWB positioning accuracy does not have much impact in general.
5) Poles or trees: The poles or trees occlusion need to look at the distance from the Anchor and tag, whether the relative distance between trees or poles and Anchors or tags are short. For example, the Anchor and positioning tag distance is 50 meters, poles or trees just in the middle of the two: 25 meters, this shelter will not have a big impact. If the distance from the Anchor or tag is very close, less than 1 meters, the impact will be great.

9 Ordering Information

WeChat: 15606880772

Taobao purchase Address: https://ychiot.taobao.com/

Company website: http://www.ychiot.com/

10 Document Management Information Table

Subject	UWB ProTag User Manual
Version	V1.1
Reference documentation	dw1000-datasheet-v2.08 dwm1000-datasheet-v1.3 evk1000_user_manual_v1.11 trek1000_user_manual_v1.04
Date	2018/4/5
Creator	Lynn
Latest release date	2019/5/1

Modifier	Date	Document change record
Lynn	2019/5/1	Hardware V1.1 Product Instruction Manual