YCHIOT

UWB Mini 3s

User Manual

Version 1.4

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1.1 UWB Mini 3s 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 base station 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 Smart Link-WiFi Development Board	UWB Smart Link -WiFi networking suite development board aims to achieve the UWB Mini 3 or UWB Nano X1 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.	• Provide official data manuals and technical support.
UWB Tag Handheld Development Board	UWB Tag handheld development board aims to achieve the UWB Mini 3 module or UWB Nano X1 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 module	Mini3s module	Mini3s Plus module	Mini4 module
Release time	2015.8.2	2016.10.2	2017.5.17	Upcoming
Characteristics	Small size	Cost-effective	Long distance	Low power consumption tag
PCB size	30mm*23mm	46mm * 20mm	58mm*24mm	48mm*32mm
PCB material	Ordinary 2 laminate	High frequency 4 laminate	High frequency 4 laminate	High frequency 4 laminate
Power supply port	USB/ Positive and negative terminal	USB/ Positive and negative terminal	USB/ Positive and negative terminal	USB/ Positive and negative terminal
USB communication port	√	√	√	√
TTL COM Port	√	√	√	√
SWD download and debug port	√	√	√	√
Control chip	STM32F105RBT6	STM32F103T8U6	STM32F103T8U6	STM32F103C8T6
Ten axis sensors	×	×	×	√
Lithium-ion battery chip controller	×	×	×	√
Antenna	Ceramic plate antenna	External rod antenna	External rod antenna	Ceramic plate antenna
Transmitting power	-45dbm/Mhz	-42dbm/Mhz	-22dbm/Mhz	-45dbm/Mhz
Channel	CH2/CH5	CH2/CH5	CH2	CH2/CH5
Stable and effective coverage radius	30M	80M	300M	30M
Ranging accuracy error	<10cm	<10cm	<10cm	<10cm
Positioning accuracy error	<15cm	<15cm	<15cm	<15cm

1.3 UWB Mini 3s Module Instructions

1.3.1 UWB Mini 3s Brief Summary

UWB Mini 3s module adopts STM32F103T8U6 SCM as the main control chip. Peripheral circuit includes DW1000 chip, power module, LED indicator module, reset circuit and so on. The module can be used either as a base station or as a tag, and it can be switched through the USB instruction.

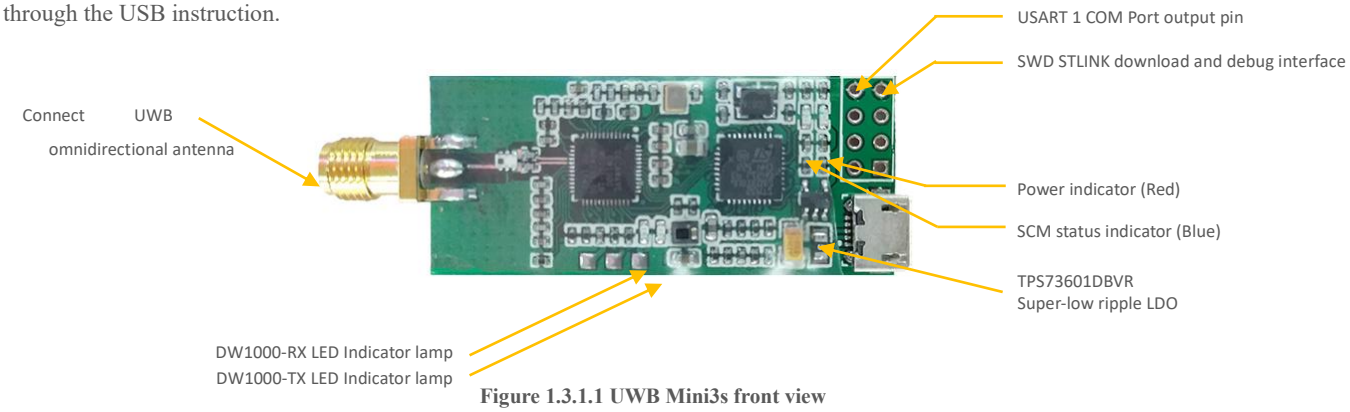

Figure 1.3.1.1 UWB Mini3s front view

1.3.2 UWB Mini 3 Hardware Parameter

Table 1.3.2 UWB Mini 3s Hardware Parameter

Basic Parameter		Wireless Parameter	
PCB technology	4 laminates- Epoxy resin	Communication speed	110 kbit/s, 850 kbit/s, 6.8 Mbit/s
Power supply port	micro-USB(5.0V)/Terminal	Working frequency	3.5 GHz ~ 6.5 GHz
Communication port	micro-USB(5.0V)/Com (3.3V TTL)	Working channel	6
Download port	SWD (VCC SDIO SCK GND)	Transmitting power	-35dbm/MHZ ~ -62dbm/MHZ Programmable
Controller	STM32F103T8U6(64pin)	Maximum packet length	1023 bytes
External crystal oscillator	8Mhz	Communication distance	80M (No shade)
PCB Size	46mm * 20mm	Data jitter	Typical: ±10cm; General shade: ±30cm

1.3.3 UWB Mini GPIO Pin Distribution

Table 1.3.3 UWB Mini 3s Hardware IO Port Distribution

GPIOA	GPIO Pin	GPIOB	GPIO_Pin
PA0	DW_RSTn	PB0	DW_WUP
PA1,2,3	-	PB1	-
PA4	DW_NSS	PB2	BOOT1
PA5	DW_SCK	PB3,4	-
PA6	DW_MISO	PB5	DW_IRQN
PA7	DW_MOSI	PB6,7,8,9	-
PA8	-	PB10-15	-
PA9,10,	USART1		
PA11,12	USB		
PA13,14	SWD		

1.3.4 UWB Mini 3 Support Signal Channel

UWB transmitted power is smaller than WiFi, no personal injury. From the DW1000 datasheet, only channel 5 and channel 7 are available on the current supported channel in China.

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*
5	6489.6	6240 – 6739.2	499.2
7	6489.6	5980.3 – 6998.9	1081.6*

Note: The maximum receiving bandwidth of DWM1000 is about 900MHz.

1.3.5 UWB Mini 3s Channel 2 Measured Spectrum

Connect the antenna of UWB Mini 3S to 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:

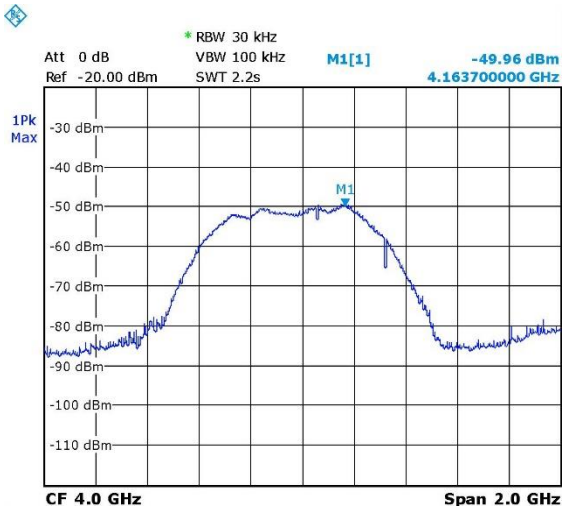

Figure 1.3.5 UWB Mini 3 Emission power test

1.4 Technical Terminology Glossary

Table 1.4 Technical Terminology Glossary abbreviations and meanings

Abbreviations	Full name	Meanings
ANCHOR		Base station, 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 YCIOT UWB Customers

2.1 Global universities of using YCIOT UWB suite

1) MIT
2) California Institute of Technology
3) Columbia University
4) Cornell University
5) National University of Singapore
6) Australian National University
7) HKUST
8) Hong Kong University
9) NTU
10) 한국과학기술원, KAIST
11) おおさかだいがく, Osaka University
12) 國立臺灣大學
13) Université de Montréal
14) University of Macau
15) Hanoi University, Vietnam

1) 北京大学
2) 中国人民大学
3) 清华大学
4) 北京交通大学
5) 北京工业大学
6) 北京航空航天大学
7) 北京理工大学
8) 北京科技大学
9) 北京化工大学
10) 北京邮电大学
11) 中国农业大学
12) 北京林业大学
13) 北京师范大学
14) 北京外国语大学
15) 中国传媒大学
16) 中央财经大学
17) 华北电力大学
18) 中国矿业大学
19) 中国石油大学
20) 南开大学
21) 天津大学
22) 河北工业大学
23) 太原理工大学
24) 内蒙古大学
25) 辽宁大学
26) 大连理工大学
27) 东北大学
28) 大连海事大学
29) 吉林大学
30) 哈尔滨工业大学
31) 哈尔滨工程大学
32) 东北农业大学
33) 东北林业大学
34) 复旦大学
35) 同济大学
36) 上海交通大学
37) 华东理工大学
38) 东华大学华东师范大学
39) 南京大学
40) 苏州大学
41) 东南大学
42) 南京航空航天大学
43) 南京理工大学
44) 中国矿业大学
45) 江南大学
46) 浙江大学
47) 安徽大学
48) 中国科学技术大学
49) 合肥工业大学
50) 厦门大学
51) 山东大学
52) 中国海洋大学
53) 中国石油大学（华东）
54) 郑州大学
55) 武汉大学
56) 华中科技大学
57) 武汉理工大学
58) 湖南大学
59) 国防科学技术大学
60) 中山大学
61) 暨南大学
62) 华南理工大学

63) 广西大学
64) 四川大学
65) 西南交通大学
66) 电子科技大学
67) 四川农业大学
68) 西南财经大学
69) 西安交通大学
70) 西北工业大学
71) 西安电子科技大学
72) 兰州大学

2.2 Industries of using YCIOT UWB suite

1) 北京####软件工程技术有限公司
2) 北京中加##科技有限公司
3) 北京##鹏勇光电技术有限公司
4) 北京##信息技术有限公司
5) 北京##灵域网络科技有限公司
6) 北京浩思##信息咨询有限公司
7) 北京##有限公司
8) 北京##智控科技有限公司
9) 北京##恒远科技有限公司
10) 北京##线信息技术有限公司
11) 北京知##技有限公司
12) 北京天##创科技有限公司
13) 北京智##汽车科技有限公司
14) 北京##体系科技股份有限公司
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22) 中##数据存储科技（北京）有限公司
23) 金蝶##（中国）有限公司
24) Intel Corporation
25) 北京##易物联网技术有限公司
26) 华清##(北京)信息技术有限公司
27) 京##科技集团股份有限公司
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31) 上海##港口设备有限公司
32) 上海##文化传播有限公司
33) 上海##通信科技发展有限公司
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35) 上海##精密机械加工有限公司
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37) 上海##物联网科技有限公司
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40) 上海##实业有限公司
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44) 深圳市##莫夫科技股份有限公司
45) 深圳市##和科技发展有限公司
46) 深圳市##科技有限公司
47) 深圳市##科技有限公司
48) 深圳##智数科技有限公司
49) 深圳市元##科技股份有限公司
50) 深圳市##数码科技有限公司
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77) ##金服(杭州)网络技术有限公司
78) 南京力##息科技有限公司
79) 南京云##数据科技股份有限公司
80) 南京申##智能科技有限公司
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82) 南京##实业有限公司
83) ##交通运输部国家能源局##水利科学研究院
84) ##电(苏州)综合能源有限公司
85) 江苏##科技软件技术有限公司
86) 苏州##格智能科技有限公司
87) ##智能科技(江苏)有限公司
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110) 重庆##建建筑科技有限公司
111) 内蒙##野昕光信息技术有限公司
112) 恒##达科技有限公司
113) 常熟市浙大####研究中心

Note: Some enterprise clients involve confidentiality agreement. Not open for the moment.

2.3 UWB Mini3 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;

2.4 Advantages and disadvantages of mainstream indoor positioning technology 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 2.4 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.

3 Tech Support: Common Q&A

3.1 Principle

3.1.1 UWB range measurement 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 T_{a1}. The module B sends a response signal at the T_{b2} moment, which is received by the module A at its own time stamp T_{a2}.

It can calculate the flight time of the pulse signal between two modules to determine the flight distance S.

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

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 Through-wall range measurement

Answer: If it passes through the wall, it might cause signal separation and lead to range failure. This is determined by the principle of UWB positioning. Small obstacles, such as tables, chairs, etc., do not have much impact on positioning accuracy.

3.2.2 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 base station 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 Base station tag installation notes

3.2.3 Radiation of station heated when using

Answer: It is a normal heating phenomenon when used. But it will not burn the module. Please be assured use.

3.2.4 Customization of the mini map in the host

Answer: It can be customized. It supports PNG format import, which can be drawn with Microsoft Office Visio.

3.2.5 The causes of TOF and TDOF errors

1) Signal impairment. The ranging data of indoor positioning is assumed to be measured in the range of sight distance. If it is in non-line of sight situations, e.g. there is an obstacle in the middle or through reflection, it will lead to longer reception time, and thus the distance will be larger.
2) Base station coordinates error. The coordinates of the tag are relative to the Anchor coordinates of the base station. If the coordinates of the base station are wrong, then our positioning data will not make any sense.
3) Clock synchronization error. Each base station has a slight gap in its clock, but if the gap is 1ns, there will be an error of 30 centimeters. So, if we can synchronize all the base stations in the system, the positioning accuracy can be further improved.

3.2.6 UWB Learning Websites and Materials

1) <Wireless Positioning System>, Publishing House of Electronics Industry (PHEI), Jiuzhen Liang.
2) DWM1000 Hardware vendor: http://www.decawave.com/
3) Kickstarter Crowd funding project: https://www.pozyx.io/
4) Indoor positioning map: https://navigine.com/and https://github.com/Navigine/

3.2.7 CoIDE Learning Websites and Materials

1) COIDE Application in STM32 SCM: http://www.cnblogs.com/shuolang/p/5322031.html
2) CoIDE manual: http://wenku.baidu.com/view/d7d8118989eb172dec63b744.html?from=search
3) CoIDE Web: www.coocox.org/

4 UWB MINI 3s Positioning Suite Test Instructions

UWB Mini 3s positioning system is consisted of at least 4 UWB Mini 3s modules, 3 stations and 1 tags. After that, tags and base stations can be purchased to extend the number of tag and system. The DEMO can support 4 stations 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 does not need to change. The module can be tested at hand, and it can skip this step directly.

4.1.1 Settings

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:

AT+SW=1XXXXXX0

	S2 (speed)	S3 (frequency channel)	S4 (mode)	S5-7 (address)
1	6.8M	Channel 5	ANCHOR	Address
0	110K	Channel 2	TAG	[000-001]

4.1.2 Demonstrations

Demonstration 1: Set the module to base station, 110k transmission rate, channel 2, address is NO.3, then send AT+SW=10010110.
Demonstration 2: Set the module to tag, 6.8M transmission rate, channel 5, address is NO.7, then send AT+SW=11101110.
Note: The address of the base station is only 0/1/2/3, and more than 4 base stations are temporarily not supported. The default rate is 110k, channel 2. In a system, the base station & tag transmission rate and frequency band should be consistent.

4.1.3 Default Module Configuration Commands

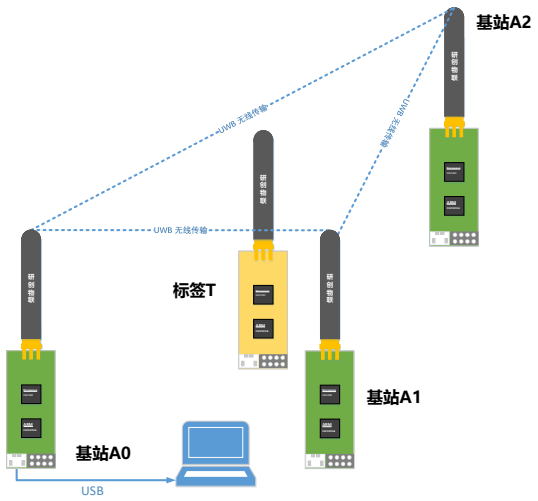
Table 4.1.3 Default Module Configuration Commands

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

4.2 Method 1 –Indoor Positioning (3 Stations and 1 Tag Test)

1) Hardware platform construction.
2) Install Virtual COM Port driver. See Chapter 6.4.
3) Connect directly A0 base station 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 base station powered by power bank.



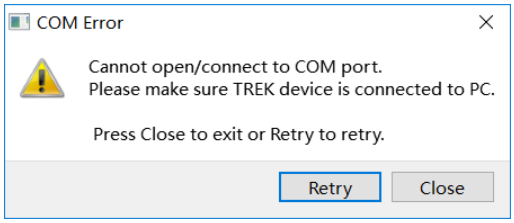
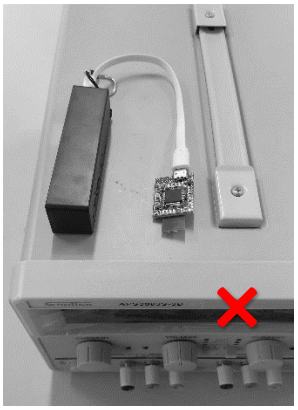


Figure 4.2.2 Host can't communicate

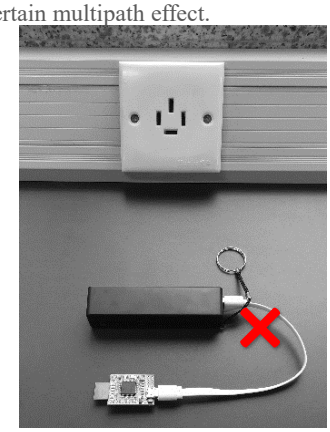
7) Notes in product placement

The placement of base station and tag directly affect the ranging accuracy and positioning accuracy. Here are a few common errors:

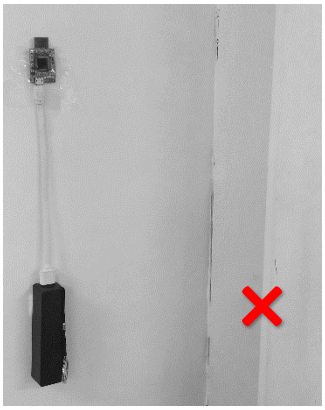
- Put the module near the metal. The antenna signal is directly absorbed by the metal, whether it is a built-in ceramic antenna or an external rod antenna.
- Place the module on the desktop, stick the module to the wall and hold the antenna by hand, these acts will affect the beam of the UWB antenna and cause a certain multipath effect.



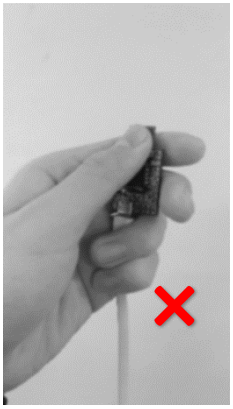
Put the module near the metal.



Put the module flat on the desktop.

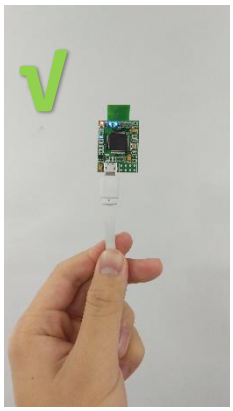


Stick the module on the wall.



Hold antenna by hand.

The correct installation method is shown as follows:



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 base station, select Anchor ID 0 / 1 / 2, and according to the actual situation of the base station placement, enter the base station 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 base stations need to be at the same height.
- When the base station 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.

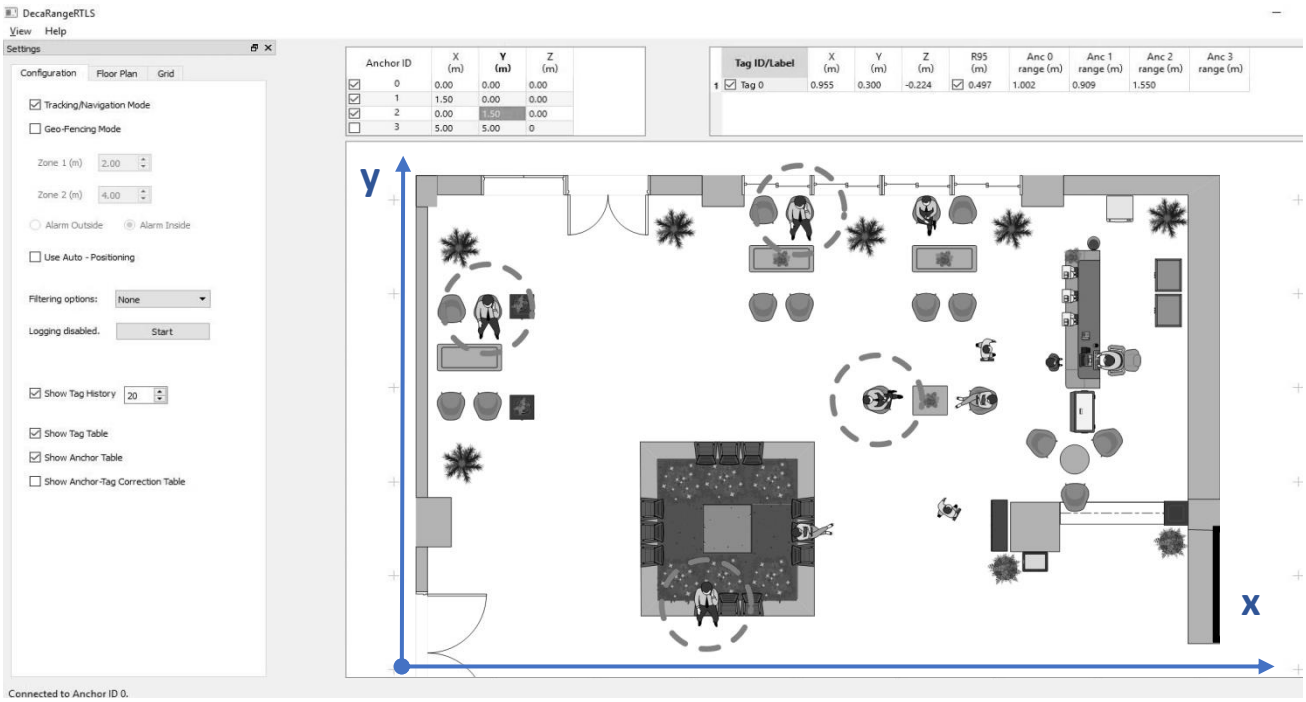


Figure 4.2.7 PC-RTLS demo software screenshot and use

9) It's better to have 4 base stations to get a larger positioning system. To get a better Z axis accuracy, for the 4 base stations, 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.

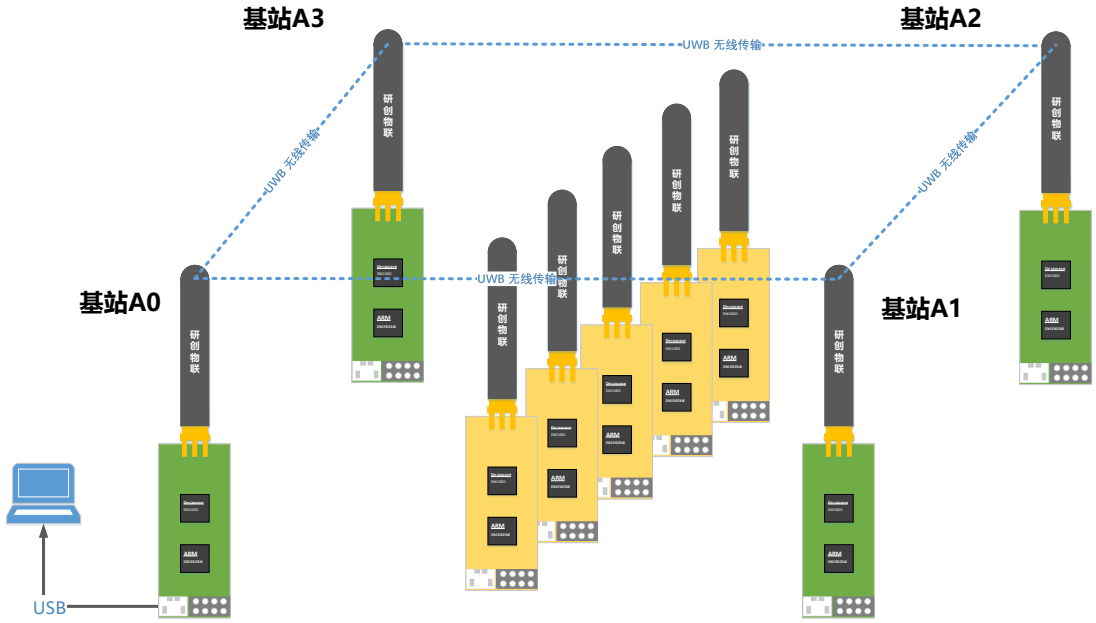


Figure 4.2.3 The schematic diagram of locating 4 stations + multi tag hardware platform

4.3 Method 2 –Ultra Range Alarm (1 Station and 3 Tags Test)

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. Base station A0 must exist.

6) Operational software: Set to Geo-Fencing Mode.

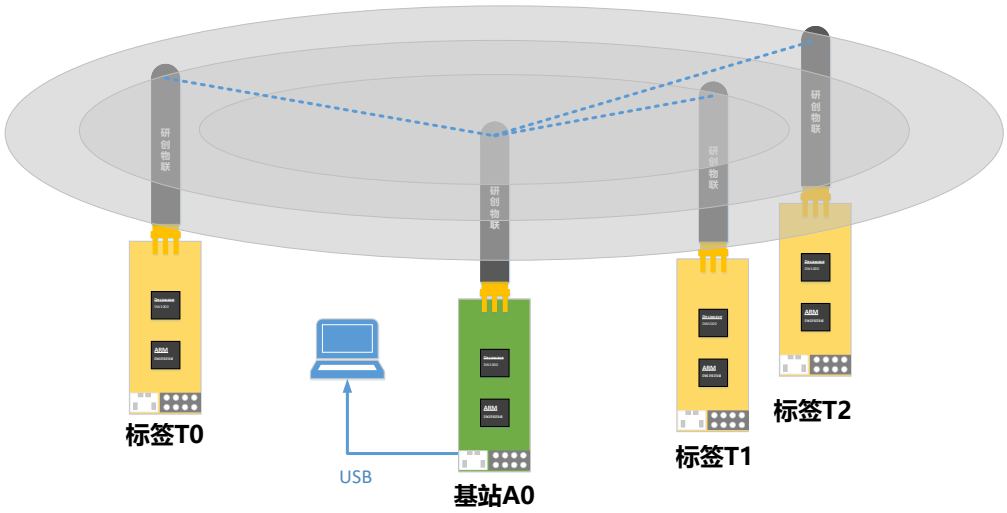
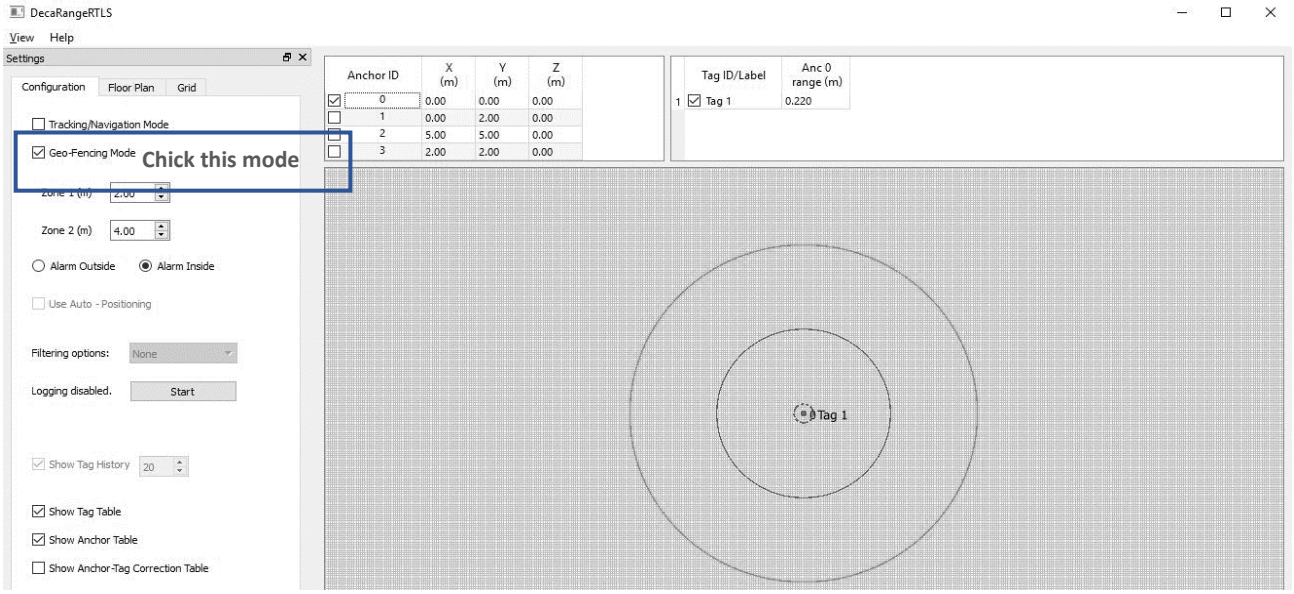


Figure 4.3 the schematic diagram of ultra-range alarm (1 station and 3 tags) hardware platform



5 UWB MINI 3s Networking Suite 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.

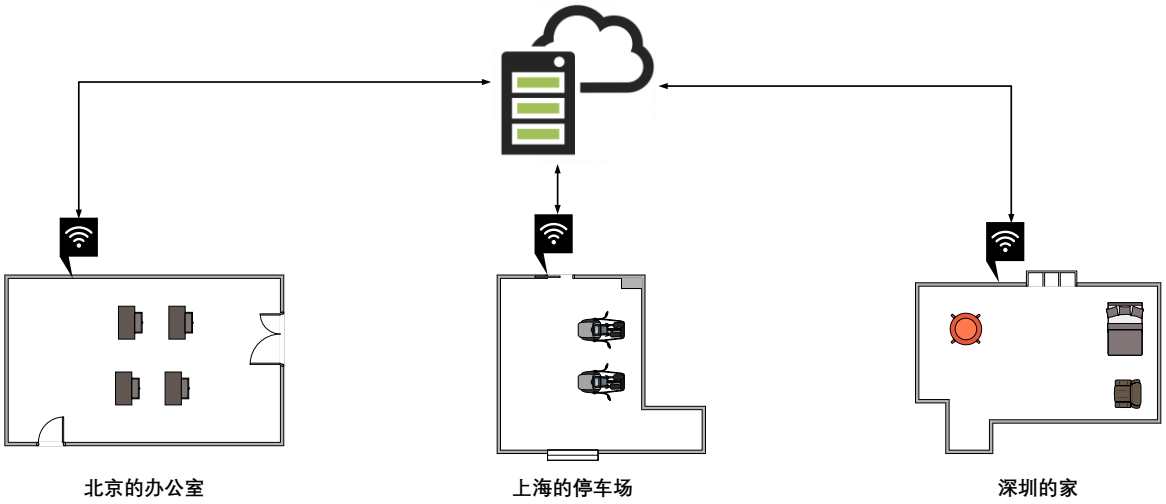
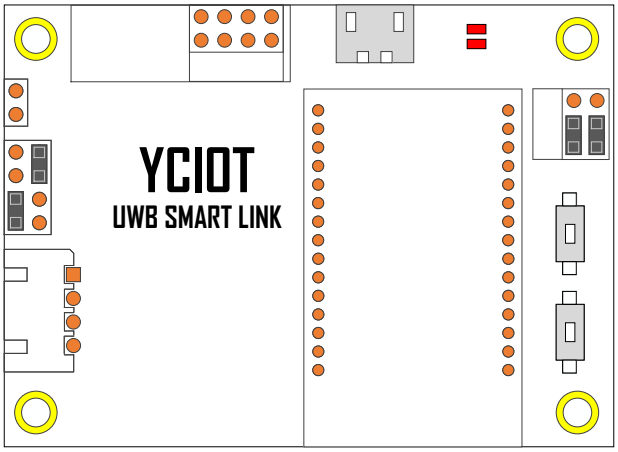


Figure 5.1 The schematic diagram of positioning data access network

5.2 Networking Suite UWB Smart Link Hardware Module Brief Summary

1) The left upper 2*4 port is compatible with the UWB *UWB Mini 3/ Mini3s/ Mini3s plus* module (Coming Soon), 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 Mini 3s Module Add-ons Development

6.1 Development environment 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 Mini 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 STM.

6.2 Mini3s Firmware updating

6.2.1 Install the ST-LINK program and burn the downloader 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:

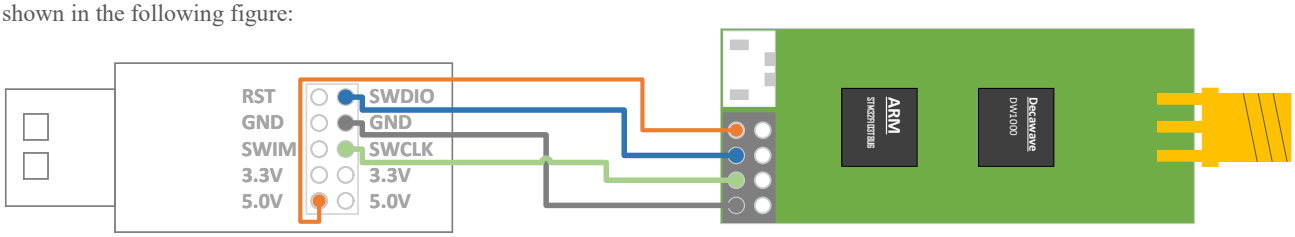


Figure 6.2.2 STLINK V2 downloader and Mini3s hardware wiring method

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

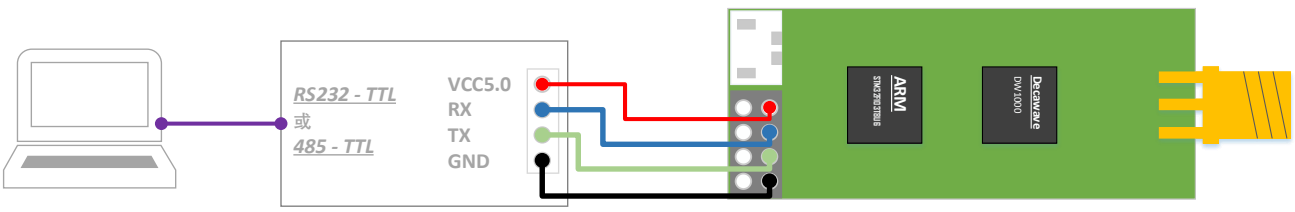


Figure 6.3.1.1 UWB Mini3s module and TTL-RS232 module or TTL-485 module connection

e. It can check the data of Android mobile phone and apple mobile phone.

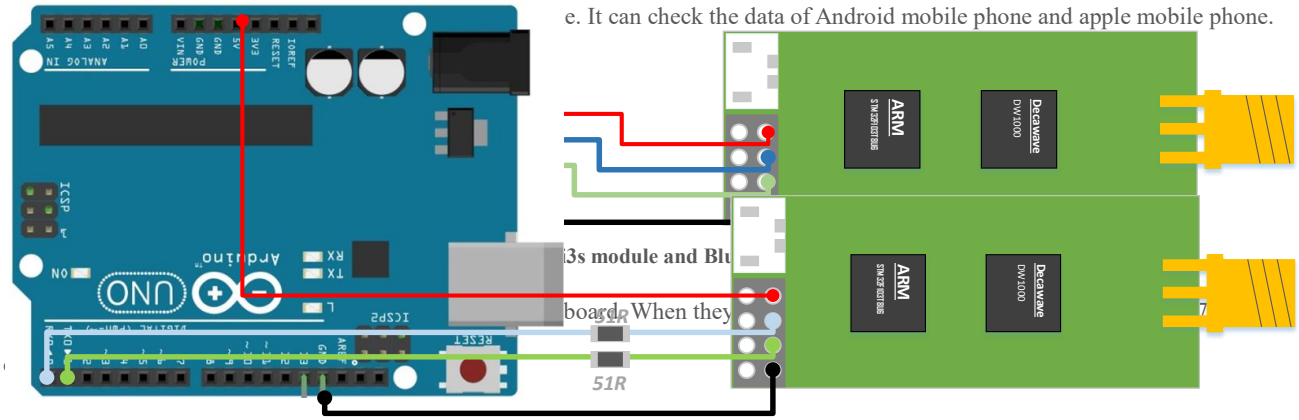


Figure 6.3.1.2 UWB Mini3s module and SCM (Arduino) connection

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.

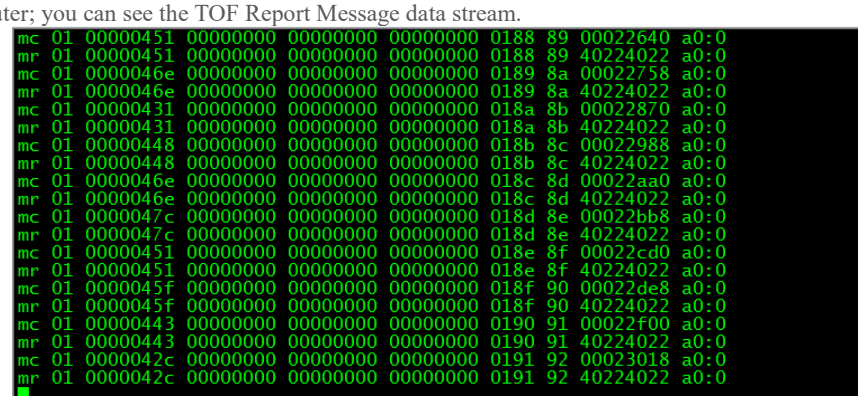


Figure 6.3.2 TOF Report Message data stream.

6.4 Mini3s 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 base station 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.

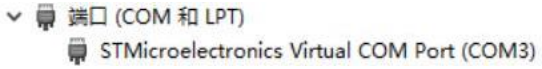


Figure 6.4.3 Find Virtual COM Port COM3 in Device Manager

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.

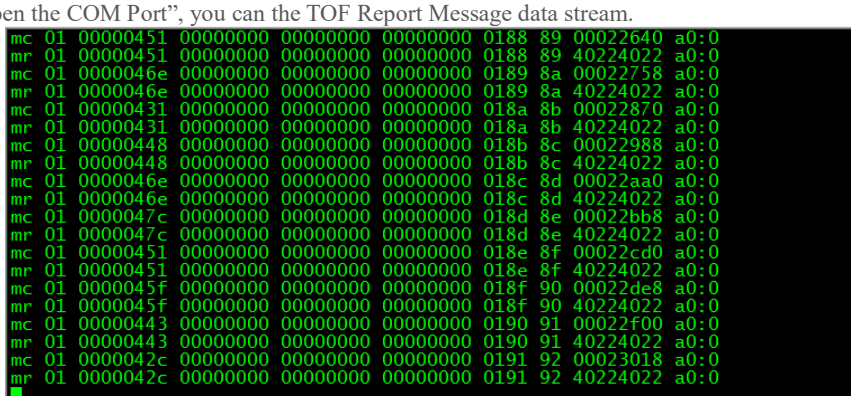


Figure 6.4.2 TOF Report Message Stream.

7 PC Host Communication Data Format 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) Base station list, the base station can be set actual position in the list.
4) Tag list, it can display the tag distance from the base station, 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 host port

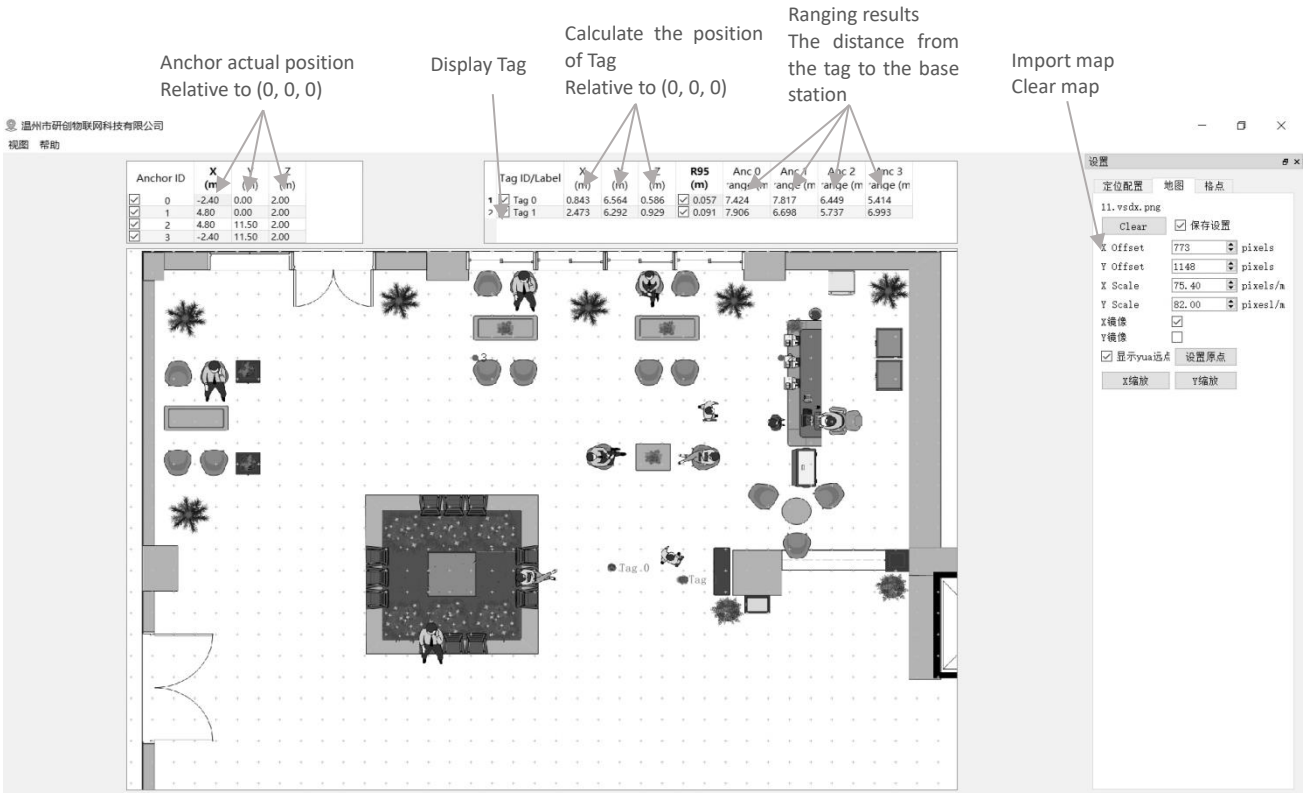


Figure 7.2 RTLS host port

7.2.1 Graphics

7.2.1.1 Tag and Anchor Tables

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

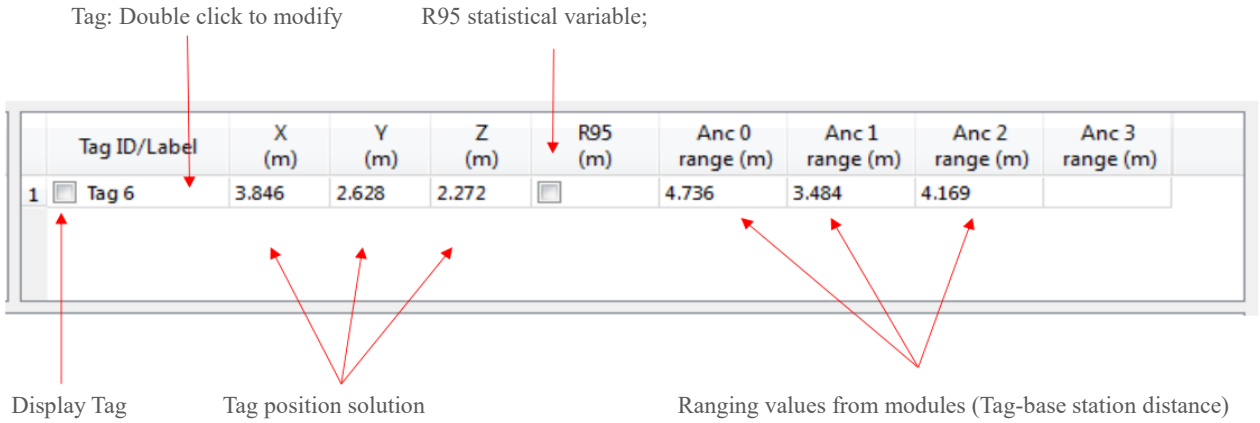


Figure 7.2.1.1.1 Tag Table

- 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-base station distance. The concrete solution method is shown in section 7.5.

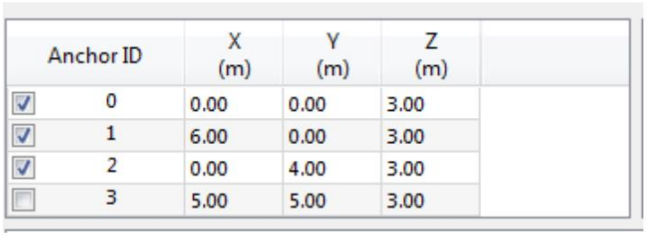


Figure 7.2.1.1.2 Anchor Table

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

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 / base station 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 base station 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 base station 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-base station distance (native data). mc represents the tag-base station distance (Optimize the corrected data for locating tag). ma represents the tag-base station distance (Optimize the corrected data for automatic positioning base station).
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 base station 0. Unit: mm.
RANGE1	If MID = mc or mr, it represents the distance from tag x to base station 1. Unit: mm. If MID = ma, it represents the distance from base station 0 to base station 1. Unit: mm.
RANGE2	If MID = mc or mr, it represents the distance from tag x to base station 2. Unit: mm. If MID = ma, it represents the distance from base station 0 to base station 2. Unit: mm.
RANGE3	If MID = mc or mr, it represents the distance from tag x to base station 3. Unit: mm. If MID = ma, it represents the distance from base station 1 to base station 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 Base station 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

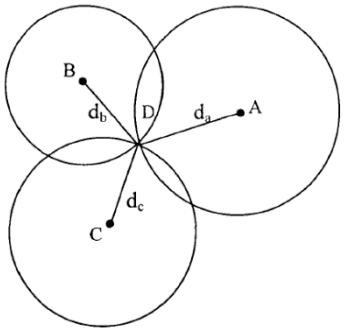
Log content	Meanings
T:151734568:DecaRangeRTLS:LogFile:Ver. 2.10 TREK:Conf:Anchor0:1:Chan2	15:17, 34s; 568ms; Version: V2.10. Currently connected: A0, 6.8M; Channel 2
T:151734600:AP:0:-2.4:0:0 T:151734600:AP:1:4.8:0:0	15:17, 34s,600ms, Anchor Position 0 (X, Y, Z)

T:151734600:AP:2:4.8:11.5:0 T:151734600:AP:3:-2.4:11.5:0	
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 intersection d_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 base station (unit: m) and the distance from each base station 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 base station 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 base station. 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 base stations 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 base stations, T0 is the tag, L_{A0T0} L_{A1T0} L_{A2T0} represents the distance from each base station 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.

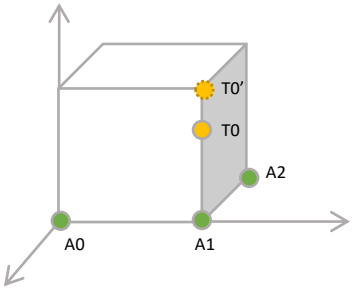


Figure 7.5.3 Z axis data error

8 UWB Product Development

8.1 Mini3s 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

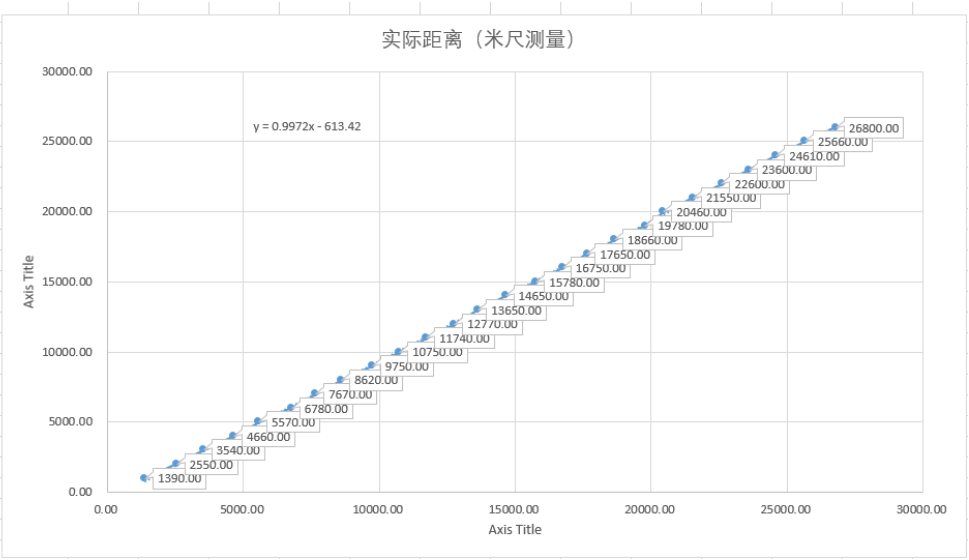


Figure 8.1 Mini3 calibration EXCEL form

The ranging values exist 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 (base station-base station 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 further improving positioning refresh rate

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

- Modify the *ANCTOANCTWR (base station-base station 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 position 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 position 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 base station and tag, whether the relative distance between trees or poles and base stations or tags are short. For example, the base station 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 base station or tag is very close, less than 1 meters, the impact will be great.

9 Document Management Information Table

Subject	UWB Mini 3s document.txt
Version	V1.4
Reference documentation	dw1000-datasheet-v2.08 dwm1000-datasheet-v1.3 evk1000_user_manual_v1.11 trek1000_user_manual_v1.04
Date	2017.5.17
Creator	Lynn
Latest release date	2017/10/20

Modifier	Date	Document change record
Lynn	2017.5.17	Hardware V1.0 Product Instruction Manual
Lynn	2017/6/11	V1.1 Product Instruction Manual
Lynn	2017/7/25	V1.2 Modify clerical error
Lynn	2017/8/20	V1.3 The sixth chapter is rearranged
Lynn	2017/10/20	V1.4 Modify and rearrange the fourth chapter. Modify section 8.2, and further improve the method of ranging and refresh rate.