YCHIOT UWB Development Board

Mini4

User Guide

Version 1.2

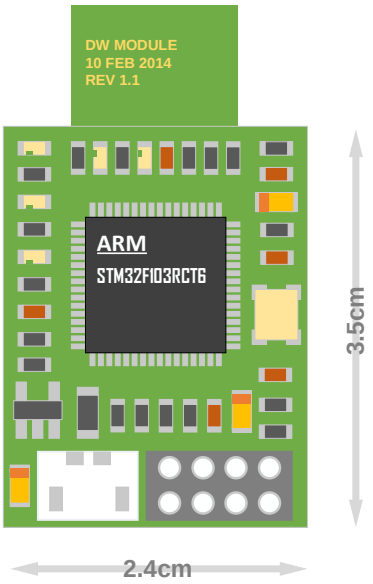
Content

1 研创物联定位开发套件简介

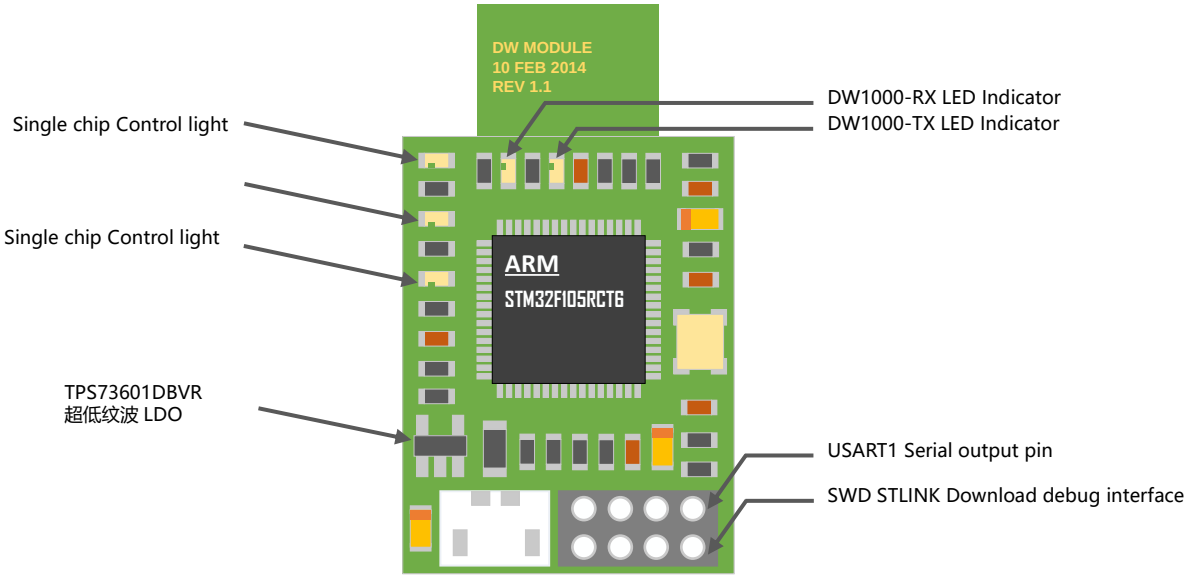
1.1 UWB Mini 4 Module Introduction

1.1.1 UWB Mini 4 Module Summary

The UWB Mini 4 adopts STM32F103RCT6 as the main control chip. The peripheral circuit includes: DWM1000 module, battery module, LED indicator, reset circuit, etc.



Picture 1.3.1.1 UWB Mini4 Front View **Picture 1.3.1.2 UWB Mini4 Back View**



1.1.2 UWB Mini 4 Hardware parameter

Table 1.3.2 UWB Mini4 Hardware parameter

Basic Parameter		Wireless Parameter	
PCB technology	4-ply board - Epoxy resin	Communication Rate	110 kbit/s, 850 kbit/s, 6.8 Mbit/s
Power supply interface	micro-USB(5.0V) / Terminal	Working Frequency	3.5 GHz ~ 6.5 GHz (Refer to chapter 1.3.2)
communication interface	micro-USB(5.0V) / Serial port (3.3V TTL)	Work channel	6 (Refer to Chapter 1.3.2)
Download Interface	SWD (VCC SDIO SCK GND)	Transmitting power	-35dbm/MHZ ~ -62dbm/MHZ Controllable
Main controller	STM32F103RCT6(64pin)	Maximum pack length	1023 Byte
External crystal oscillator	8Mhz	Communication distance	Mini4-CA, 30-meter; Mini4-SMA 80-meter
PCB Size	35mm * 24mm	Data jitter	Normal ±10cm, Normal occlusion± 30cm

1.1.3 UWB Mini 4 Support frequency band

The transmitting power of UWB is smaller than that of WiFi, so there should be harmless to human. It can be seen from dw1000 datasheet that only channel 5 and channel 7 are available in China.

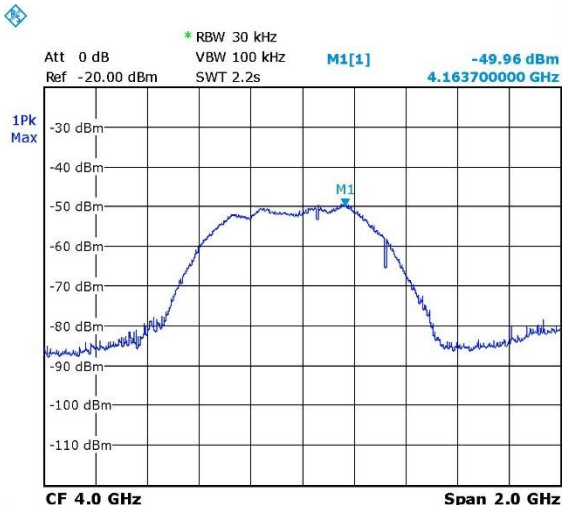
Table 1.3.3 UWB IEEE802.15.4-2011 DWM1000 Supported UWB Channel

UWB 信道 UWB Channel	中心频率 (MHz) Centre Frequency	频段 (MHz) Band	带宽 (MHz) Bandwidth
1	3494.4	3244.8 – 3744	499.2
2	3993.6	3744 – 4243.2	499.2
3	4492.8	4243.2 – 4742.4	499.2
4	3993.6	3328 – 4659.2	1331.2*
5	6489.6	6240 – 6739.2	499.2
7	6489.6	5980.3 – 6998.9	1081.6*

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

1.1.4 UWB Mini 4 Channel 2 Measured spectrum

Connectting the antenna of UWB Mini 4 to FSL6 (Rod and Schwartz brand). The center frequency of channel 2 is 4GHz and the maximum gain is - 49.96dbm, as shown in the figure below.



Picture 1.3.3 UWB Mini 4 Transmission power test

1.2 Glossary

Table 1.4 Abbreviations of technical terms

Abbreviations	Full terms	Explanation
ANCHOR		Anchor, also known as beacon anchor, refers to the node that obtains the position coordinates in advance by other means
DW1000		Chip type of company Decawave
DWM1000		Module type of company Decawave
IC	integrated circuit	Chip
PHY	physical layer	Physical layer
PSR	preamble symbol repetitions	Leading symbol repeat
RTLS	real time location system	Real time location System
TAG		Tag
TDOA	time difference of arrival	TDOA location is a method of

		using time difference to locate. The distance of the signal source can be determined by measuring the time of the signal arriving at the monitoring station.
TOA	time of arrival	TOA location is a method that directly uses the arrival time of signal to locate.
TOF	time of flight	TOF, Time-of-flight ranging method, which mainly uses the time of flight between two asynchronous transceivers (or reflected surface) to measure the distance between nodes.
TX	transmit	Transmission
TWR	two-way ranging	Two way ranging method, that is, two asynchronous transceivers can get the ranging value.
UWB	ultra-wide band	UWB (ultra wideband) is a carrier free communication technology, which uses nano-second to pico-second non-sinusoidal narrow pulse to transmit data.

2 研创 UWB 实际项目应用情况

2.1 UWB Mini4 能用在哪些场合?

根据客户提供的需求以及实际应用情况，经过一系列的技术回访， UWB Mini4 室内定位的产品已经在如下应用场景应用：如机场大厅、展厅、仓库、超市、图书馆、地下停车场、矿井等环境。具体情境如下:

- 智能行李箱、智能儿童车;
- 工厂集装箱、货物定位;
- 在游乐场帮助游客找相应的景点与公共设施;
- 超市人员定位;
- 在博物馆里更有效地帮助访客了解展品信息和观看展览;
- 矿井人员定位、掘进机工作情况;

2.2 国内外主流室内定位技术的优缺点?

近几年来，包括谷歌、微软、苹果、博通等在内的一些科技巨头，还有一些世界有名的大学都在研究室内定位技术。根据国内外文献的研究与调查，蓝牙、无线射频等，在办公室、家庭、工厂等场景的室内定位得到了广泛应用。国内外主流室内定位技术优缺点如下表所示:

表 2.2 国内外主流室内定位技术优缺点

室内定位技术	优点	缺点
超声波定位技术	精度较高，结构简单。	受多径效应和非视距传播影响很大，同时需要大量的底层硬件设施投资，成本太高。
蓝牙定位技术/ ibeacon	设备体积小、易于集成，容易推广普及。	对于复杂的空间环境，蓝牙系统的稳定性稍差，受噪声信号干扰大。
射频识别技术	标识的体积比较小，造价比较低。	作用距离近，不具有通信能力，而且不便于整合到其他系统之中。
UWB 超带宽技术	穿透力强、功耗低、抗多径效果好、安全性高、系统复杂度低、能提供精确定位精度。	遇到遮挡物、金属等会有一定影响，价格略贵，离大规模生产仍有一段距离。
SLAM 技术	在自身位置不确定的条件下，在完全未知环境中创建地图，同时利用地图进行自主定位和导航。	图像数据量巨大，设备价格非常贵，适合研究，不适合量产。

3 FAQs

3.1 Principle

3.1.1 What is the ranging principle of UWB?

TW-TOF (two way-time of flight) Each module will generate an independent timestamp from the start. The transmitter of module a transmits a request pulse signal at T_{a1} of its time stamp, and module B transmits a response pulse signal at T_{b2} , which is received by module A at T_{a2} of its time stamp. Once, the flight time of the pulse signal between the two modules can be calculated to determine the flight distance S.

$$S=Cx[(T_{a2}-T_{a1})-(T_{b2}-T_{b1})](C \text{ for lightspeed})$$

3.1.2 What is the location principle of UWB?

1) Location = Lightspeed * time diff / 2; XY surface, 3 circles, can define a node;
2) XYZ dimension, 4 circles, can define a node;

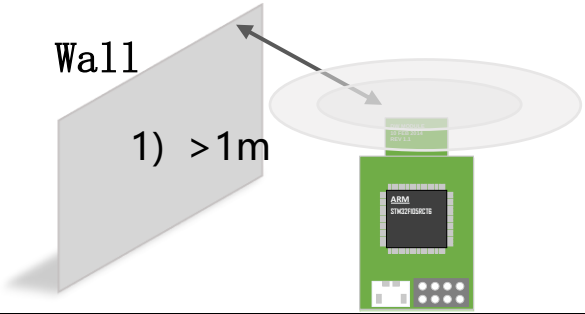
3.2 Applications

3.2.1 Is the module capable of distance measurement through the wall?

Answer: Through the wall will cause signal isolation, resulting in ranging failure. This is determined by the principle of UWB positioning. Small obstacles, such as tables and chairs, have little influence on the positioning accuracy.

3.2.2 Is there anything to pay attention to when installing this module?

The module shall be kept at least 1m away from the wall, table and other obstacles. Otherwise, the positioning data will be inaccurate. Try not to be covered around the antenna. The base station is best placed on a tripod, more than 2 meters above the ground.



Picture 3.2.2 Notes on installation of anchor and tag

3.2.3 Why does the base station get hot when it is in use?

Answer: There will generate heat, which is normal. But it won't burn the module, please continue to use.

3.2.4 Can the mini map of PC be customized?

Answer: Can be customized, support PNG format import, can be drawn with Microsoft Office Visio.

3.3 Development

3.3.1 Why does this module recommend USB virtual serial port output?

Answer: The baud rate of the serial port is generally 115200bps. The A0 anchor will receive all the distance values of "anchor-tag" and "anchor-anchor". The positioning data will be updated at least 20 times in one second. With the increase of the number of tags, the amount of data is huge. Through calculation, the serial port 115200bps = 14400 byte / S = 14KB / s, but USB can reach the maximum 4MB / s. In conclusion, virtual serial port is selected. Of course, when the number of tags is small, you can use the serial port to output data. This module provides USART1 output.

3.3.2 What are the main error from TOF or TDOF ranging?

1) Signal loss. The distance measurement information of indoor positioning is assumed to be the distance measured in the case of line of sight. If there is a non line of sight, such as an obstacle in the middle or arriving through reflection, the receiving time will be longer, and the measured distance will be larger.
2) Anchor coordinate error. The coordinates of tag are relative to the anchor coordinates of the anchor. If the coordinates of the anchor are wrong, then our positioning data is meaningless.
3) Clock synchronization error. Each anchor will have a slight difference in its clock, but if the difference is within 1ns, there will be an error of 30cm, so if we can

synchronize the time of all anchors in the system, we can further improve the positioning accuracy.

3.3.3 UWB Reference matterials?

1) 《无线定位系统》，电子工业出版社，梁久祯
2) DWM1000 Hardware supplier：http://www.decawave.com/
3) Kickstarter Crowdfunding projects：https://www.pozyx.io/
4) Indoor positioning map：https://navigine.com/ ; https://github.com/Navigine/

4 UWB MINI4 Positioning kit test instructions

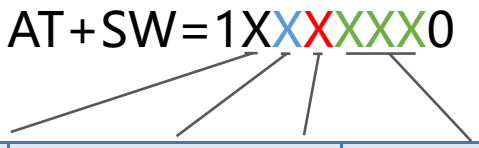
The UWB positioning system consists of at least four parts, namely three Anchors and one tag. The anchor can be Mini4 series development board and finished anchor ProAnc, and the tag can be ProTag or ProCard series tag. After that, you can purchase tags and base stations to expand the number and tags of the system. The number of base stations and tags that can be supported depends on the firmware version purchased.

4.1 Anchor AT Command Config and Setting

The default configuration has been written in the factory and does not need to be modified. If necessary, please refer to:

4.1.1 Setting-ups

Connect the module to the computer through the USB cable, open the XCOM software, send the command, and hit "Enter" at the end:



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

4.1.2 Examples

Example 1: Set the module as base station, 110k transmission rate, channel 2, address 3, then it should be sent: AT+SW=10010110

Example 2: Set the module to label, 6.8m transmission rate, channel 5, address 7, then it should be sent AT+SW=11101110

Note: The address of the anchor can only be 0/1/2/3, and it is not supported for more than 4 anchors temporarily; the default rate is 110k and channel 2. In a set of systems, the transmission rate and frequency band of anchor and tag should be consistent.

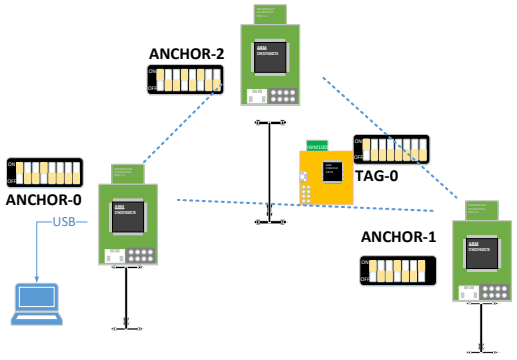
4.1.3 Module Default Command

Table 9.1.3AT+SW Module Default Command

Module	Command	Module	Command	Module	Command
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

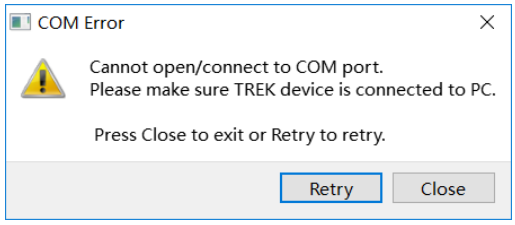
4.2 3 Anchor+1 Tag Test（Application 1——Indoor Positioning)

1) Networking of hardware platform
2) Install virtual serial port driver VCP 1.4.0. Refer to the operation video of WeChat link. (Link)
3) A0 Anchor and USB connection;
4) Open the upper computer software DecaRangeRTLS.exe If it appears as shown in Figure 4.2.2, there may be the following reasons:
   - The installation of virtual serial port driver failed, and the software could not find *COMx*;
   - The USB on the hardware is not connected; the micro-USB cable does not support communication or uses the damaged micro USB cable;



Picture 4.2.1 RTLS 3Acnhor +1 Tag View

Note 1: Most win7 users can't open the upper computer, however, they can see DecaRangeRTLS.exe Background process, encountered the problem (currently unable to solve the problem), please try another computer;



Picture 4.2.2 上位机无法通讯

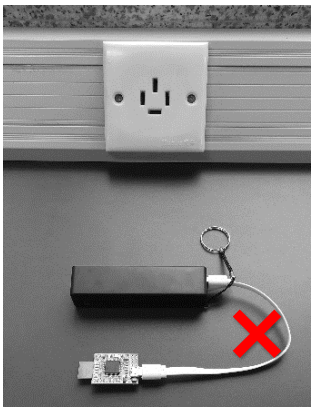
Note 2: Some split screen users (2K screen or 4K screen users) will have the problem of incomplete display of upper computer text, which can be displayed

by adjusting the separator;

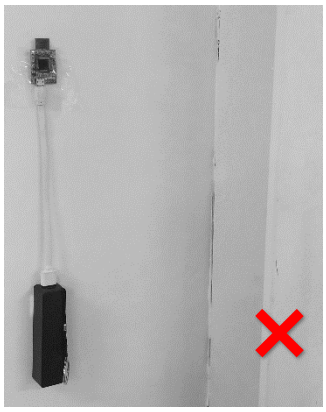
5) All tags can be powered by power bank;
6) A1/A2 Anchor can be powered by power bank;
7) Precautions for product placement

The positioning accuracy is directly affected by the placement of anchor and tag. Here are some common mistakes:

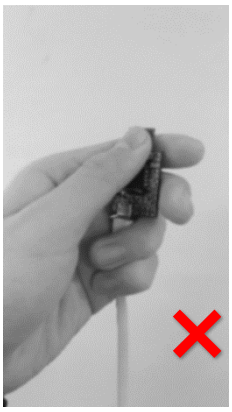
Place the module near the metal



Lay the module flat

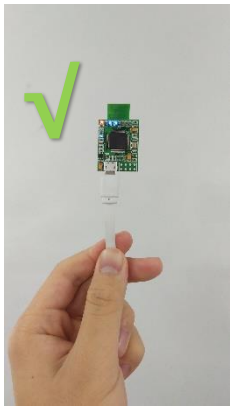


Stick the module to the wall



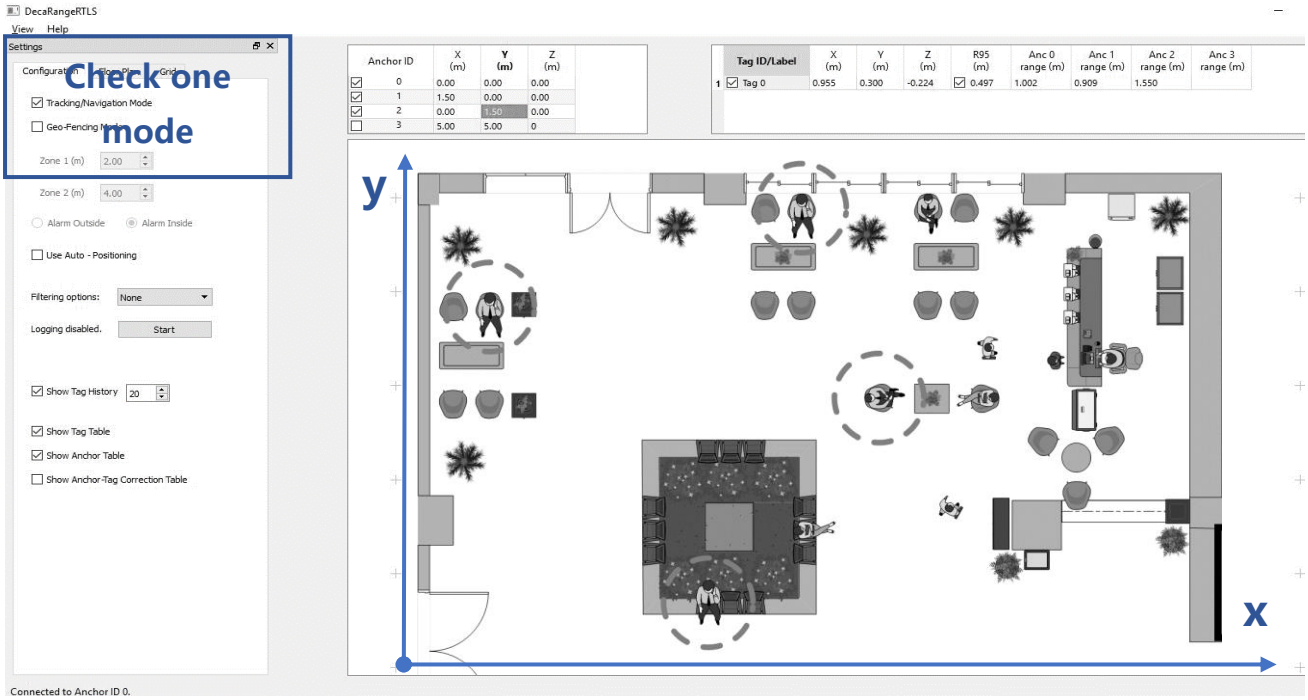
Hand Hold the antenna

The correct installation method is shown in the figure below:

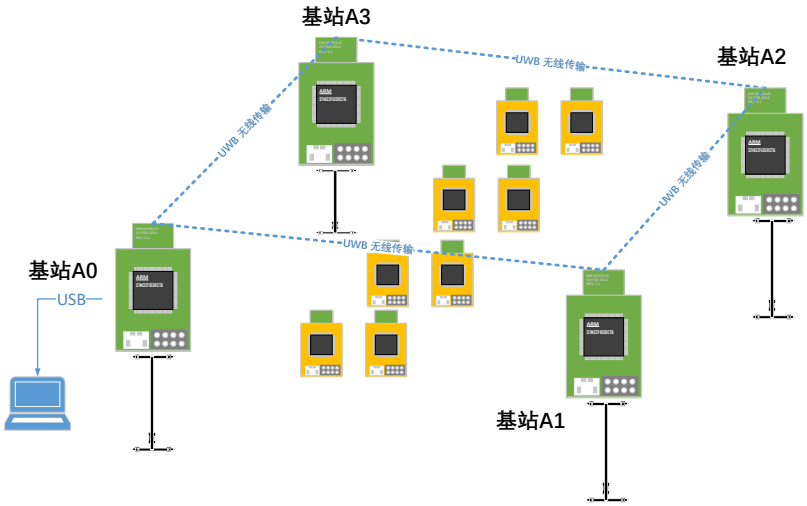


1) Operating software

Set the relative position of three anchors (must be consistent with the actual location!) Please check 0, 1, 2	**Automatically find a tag And calculate X / Y / Z**	**Tag distance Anchor Distance**



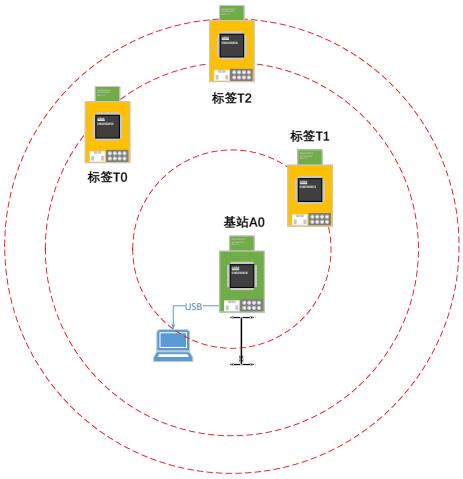
2) In order to obtain a larger positioning system, it is best to need four base stations.



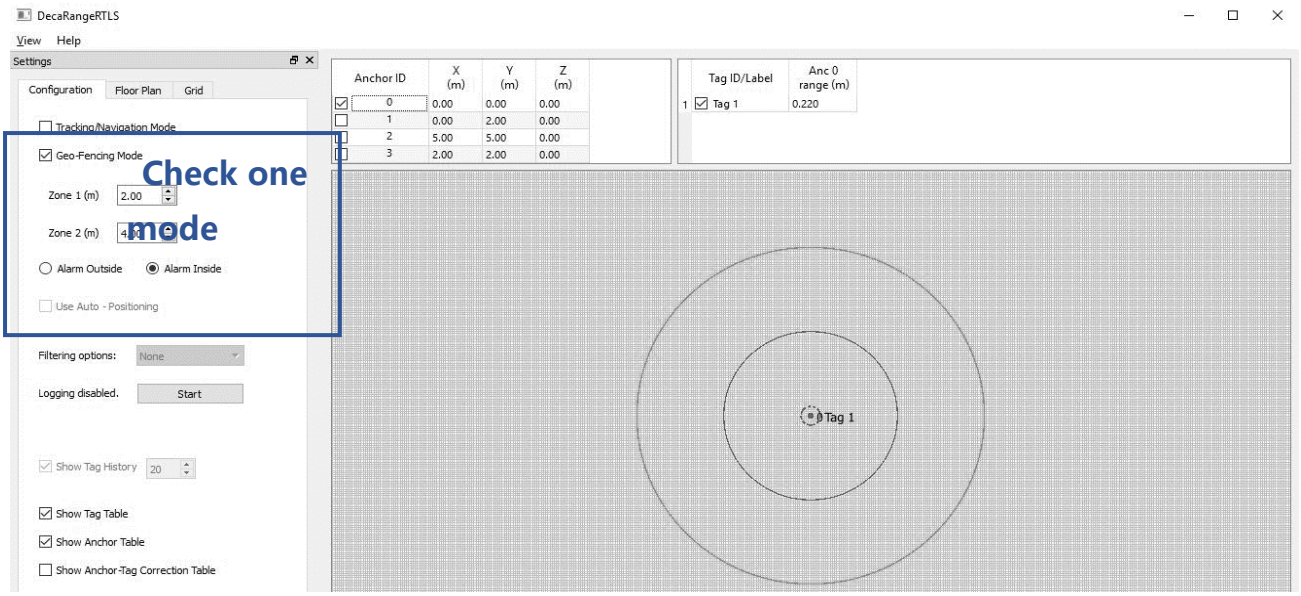
Picture 4.2.3 Positioning 4 Anchor + Multi-Tag View

4.3 1 Anchor+3 Tag（Application 2——Out of range alarm)

1) Networking of hardware platform
2) Install virtual serial port driver VCP 1.4.0. Refer to the operation video of WeChat link. (Link)
3) A0 Anchor and USB connection；
4) Open the upper computer software DecaRangeRTLS.exe
5) All tags can be powered by power bank；
6) Note：If there is only one tag (1 anchor, 1 tag), the test can also be carried out in this mode, but the whole system can only run if there is a anchor A0. This will not be repeated below.
7) Operating system：Setting to Geo-Fencing Mode



Picture 4.3 Out of range alarm 1 Anchor+3 Tag View

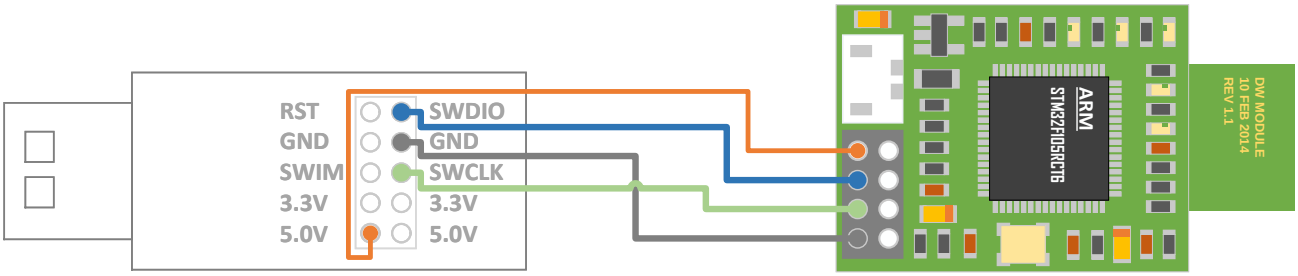


5 UWB MINI4 Module secondary development

5.1 Mini4 Firmware Update

5.1.1 STLINK and Mini 4 Hardware connection

If you need to upgrade or modify the UWB Mini4, you need to use stlink to update it. The hardware connection is shown in the following figure.



Picture 5.1 STLINK V2 and Mini4 Connection

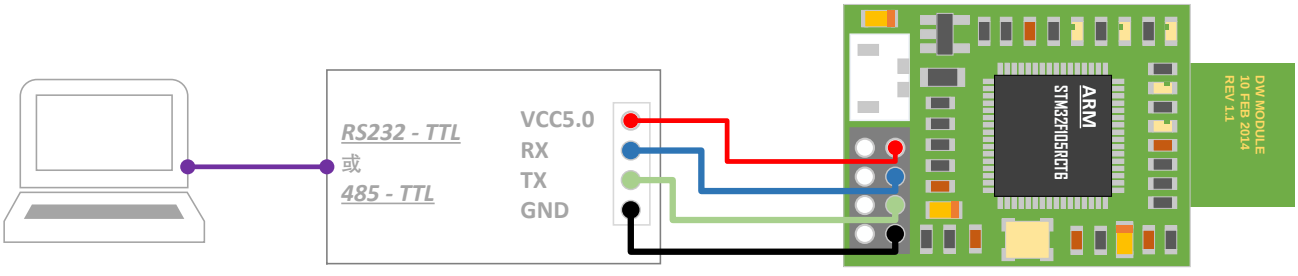
5.1.2 STLINK Setting

Please refer to **ap12-UWBPRO_YCHIOT_ Device firmware upgrade**, and related operation videos in this folder.

5.2 Method of Mini4 enabling serial port to output data

5.2.1 External serial port equipment/RS232/485, etc.

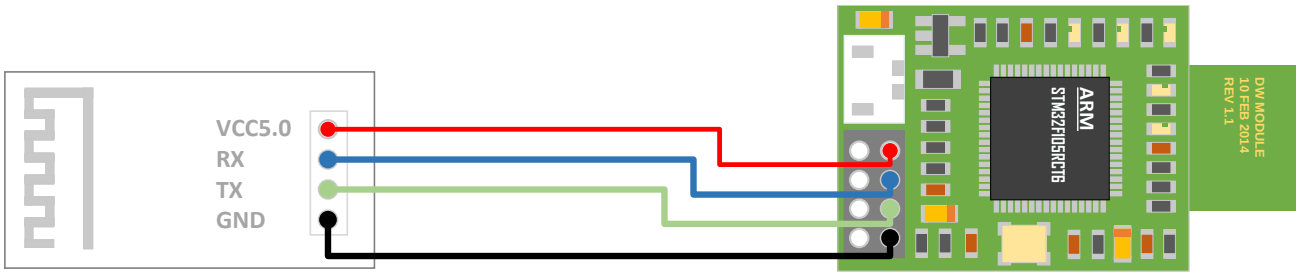
Set baud rate 115200bps, data bit 8, stop bit 1, no check bit. Connect according to Figure 5.2 and open XCOM serial port debugging assistant on the computer side to observe TOF report message data flow.



Picture 5.2 UWB Mini 4 Module and TTL-RS232 Module/TTL-485 Module

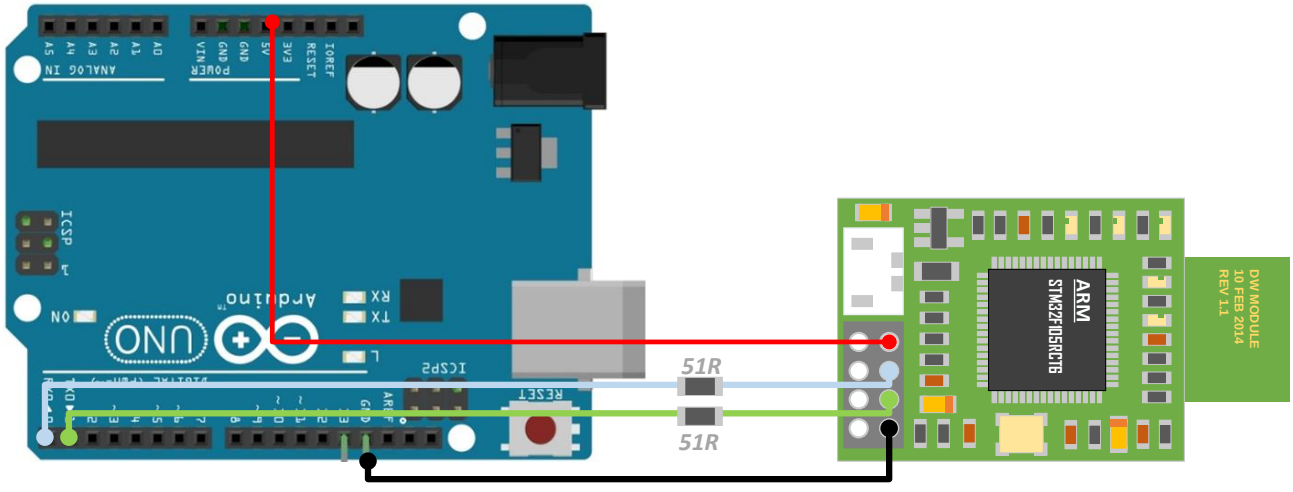
```
mc 01 00000451 00000000 00000000 00000000 0188 89 00022640 a0:0
mr 01 00000451 00000000 00000000 00000000 0188 89 40224022 a0:0
mc 01 0000046e 00000000 00000000 00000000 0189 8a 00022758 a0:0
mr 01 0000046e 00000000 00000000 00000000 0189 8a 40224022 a0:0
mc 01 00000431 00000000 00000000 00000000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

UWB MINI 4 connected with ble 4.0 serial port Bluetooth module, which can realize the data viewing of Android mobile phone and apple mobile phone



Picture 6.7.2 UWB Mini 4 Module to BLE Bluetooth

Raspberry pie or Arduino is a development board with TTL level of 5V. When connecting with UWB module, **27R ~ 51r current limiting resistor should be connected in series.**

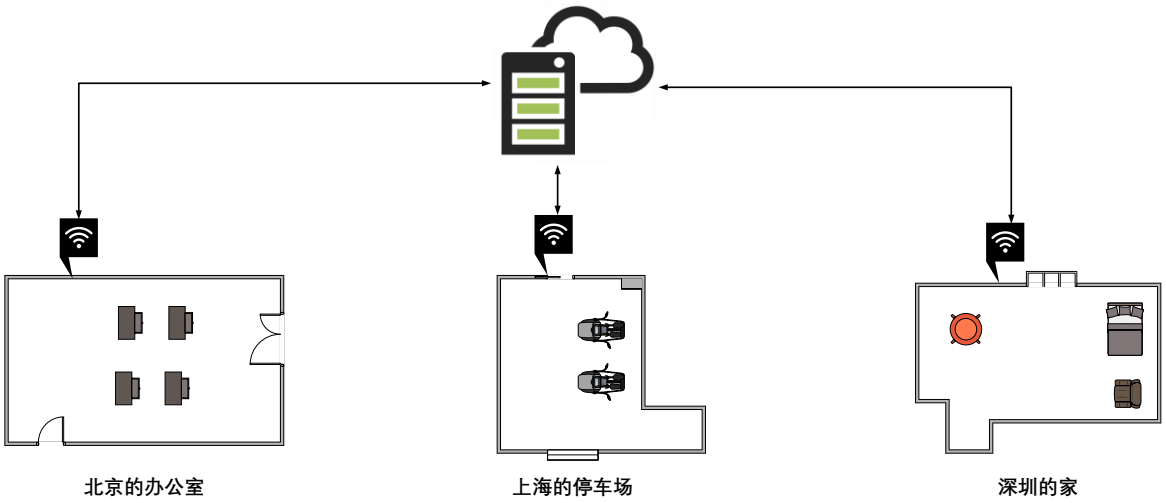


Picture 6.7.3 UWB Mini 4 Module to Arduino

5.3 Anchor output data network solution

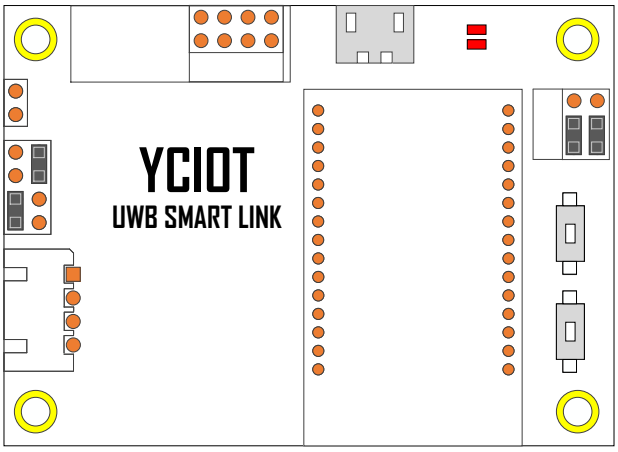
The development board of **UWB smart link networking kit** is designed to transfer the TOF report message data from the serial port of UWB MINI 4 module to the

remote server, and realize the remote management and monitoring of UWB positioning data by developers. The development board is equipped with the super WiFi module of MXCHIP. Through simple settings, data can be connected to the network.



Picture 5.3 Networking view

1) Top left corner 2*4Header is compatible to UWB Mini 4, by direct plug-in;
2) The WiFi module adopts mxchip EMW3162. Built in Cortex-M3 microcontroller with high performance and low power consumption, 128KB ram + 1MB flash. The module runs mico Internet of things operating system and supports secondary development. Users can use mico's TCP / IP protocol stack and various security encryption algorithms to realize various embedded Wi Fi applications;
3) CH340 is used as TTL to USB chip. It is a USB bus transfer chip developed by Jiangsu Qinheng company (WCH), which realizes USB to serial port or USB to print port;



4) More information please refer to 《UWB Smart Link User Guide V1.2》.
5) Link: https://pan.baidu.com/s/1eSvGMRK 密码:gdp2

6 Communication data format and secondary development of RTLS

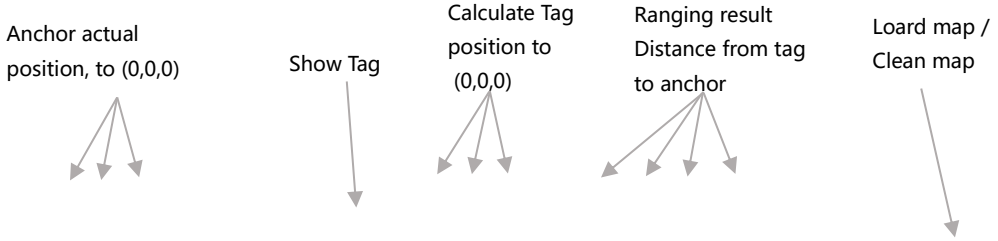
6.1 RTLS Introduction

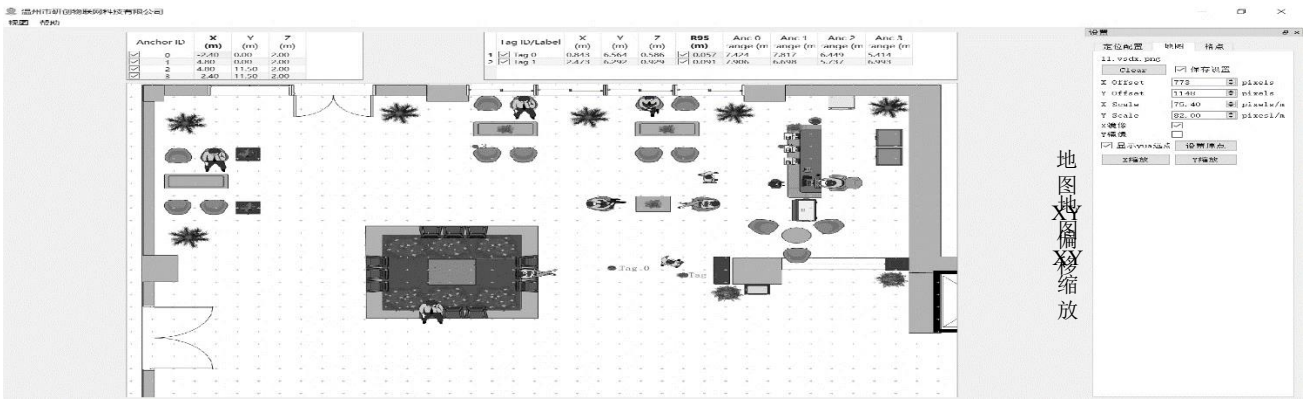
This chapter introduces the use of PC. The upper computer software is developed with *QT 5.7.0 MinGM* and written in C + +. QT is a cross platform C + + GUI application development framework developed by QIQU technology in 1991. It can be used to develop GUI programs as well as non GUI programs, such as console tools and servers. QT is an object-oriented framework, which uses special code generation extensions (called meta object compiler) and some macros. It is easy to extend and allows component programming. In April 2014, QT creator 3.1.0, a cross platform integrated development environment, was officially released, realizing full support for IOS, adding WinRT, beautifier and other plug-ins, abandoning GDB debugging support without Python interface, integrating C / C + + code module based on Clang, and adjusting Android support. Thus, IOS, Android and WP are fully supported.

The main functions of the Upper computer are：

1) Establish connection with *Virtual COM Port* of UWB module;
2) Read TOF report message from UWB module;
3) Anchor list, in which the actual placement position of the anchor can be set;
4) Tag list, which can display the distance from the tag to the base station and the location of the tag (XYZ coordinate);
5) Map display, support custom import a PNG format map, can realize zoom and coordinate fine-tuning;
6) Other parameter settings;

6.2 RTLS Upper computer interface



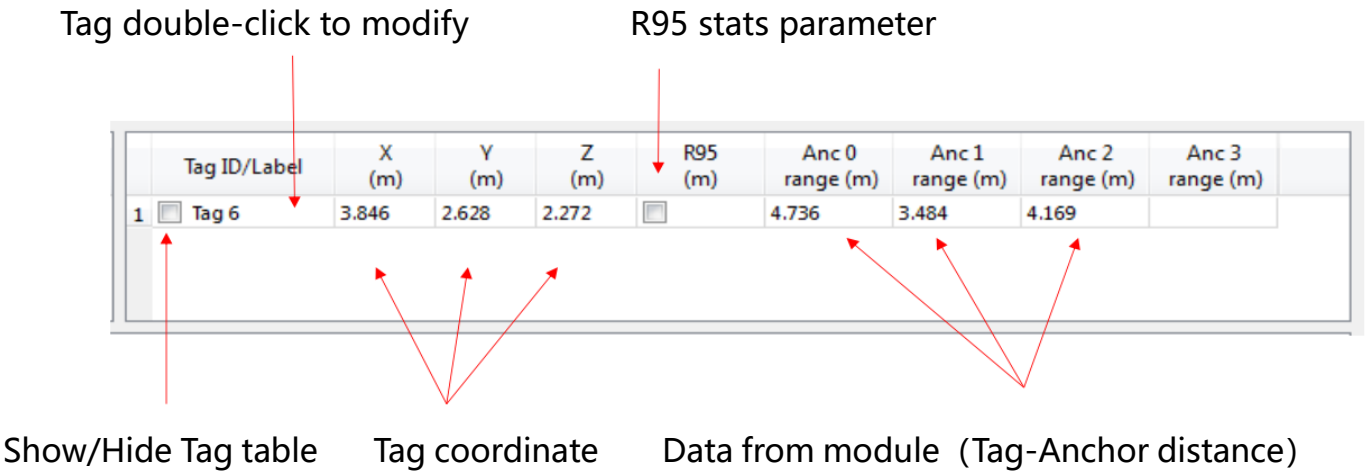


Picture 6.2.1 RTLS Upper computer interface

◆ Graphics

- Tag and Anchor Tables

Tag Table contains Tag ID、distance information、coordinate。



Picture 6.2.2 Tag Table

- R95 stats parameter reference：https://baike.baidu.com/item/%E7%BD%AE%E4%BF%A1%E5%8C%BA%E9%97%B4/7442583?fr=aladdin
- Tag calculated coordinate is based on tag-anchor distance，please refer to chapter 7.5 for details

Anchor ID	X (m)	Y (m)	Z (m)
0	0.00	0.00	3.00
1	6.00	0.00	3.00
2	0.00	4.00	3.00
3	5.00	5.00	3.00

Picture 6.2.3 Anchor Table

Anchor Tables contains Anchor ID，and anchor location information.

◆ Status Bar

Bottom left corner shown information:

- "DecaRangeRTLS Anchor/Tag ID Mode" – Open the software and connection success.
- "Connected to Anchor/Tag/Listener ID" – Tag/Anchor has been connected and is receiving data from TOF
- "No location solution" – Location cannot be calculated
- "Open error" – Software failed to open virtual serial port

◆ View Settings

View settings contains 2 tables：configuration, floorplan, and grid。

- Configuration Table

Name	Explanation
Tracking/Navigation Mode	Positioning mode
Geo-Fencing Mode	Out of range alarm mode
Zone1	Range 1
Zone2	Range 2
Alarm Outside/Inside	Alarm outside / inside the circle
Show Tag History (N)	Display the latest historical points(N)
Show Tag Table	Show Tag Table
Show Anchor Table	Show Anchor Table
Auto Positioning	Automatic positioning mode. In this mode, the location of the base station does not need to be set
Filtering	Set up data filtering
Logging	Generate log

- Grid Table

Name	Explanation

Width	Width in meters
Height	Height in meters
show	Show grid

- Floor Plan tab

Name	Explanation
Open	Open a map and import the software
X offset	Offset the map in pixels in the X direction
Y offset	Offset the map in pixels in the Y direction
X scale	Scale the map in pixels in the X direction
Y scale	Scale the map in pixels in the Y direction
Flip X	Flip on X-axis
Flip Y	Flip on Y-axis
show	Show Origin (0,0,0)
Set Origin	Set Origin
X Scale button	Click this button to generate a small tool for measuring the distance on the map, entering the actual distance and setting the zoom value of X
Y Scale button	Click this button to generate a small tool for measuring the distance on the map, entering the actual distance and setting the zoom value of Y

6.3 TOF Report Message

Open any serial port debugging assistant, without setting baud rate and other parameters, it can be observed that base station A0 transmits data to PC via USB virtual serial port in the following format:

```
1. mr 0f 000005a4 000004c8 00000436 000003f9 0958 c0 40424042 a0:0
2. ma 07 00000000 0000085c 00000659 000006b7 095b 26 00024bed a0:0
3. mc 0f 00000663 000005a3 00000512 000004cb 095f c1 00024c24 a0:0
   MID  MASK     RANGE0        RANGE1        RANGE2     RANGE3     NRANGES  RSEQ      DEBUG    aT:A
```

Table 6.3.1 TOF Data format

Item	Function
MID	ID information of mr, mc, ma

	MC stands for the distance between tag and anchor (optimized and corrected data for locating tags)
MASK	Indicate RANGE0, RANGE1, RANGE2, RANGE3 which one is valid; Example: MASK=7 (0000 0111) indicates RANGE0, RANGE1, RANGE2 are all valid
RANGE0	If MID = mc，then Tag x to Anchor0 Distance, Unit: mm
RANGE1	If MID = mc，then Tag x to Anchor1 Distance, Unit: mm
RANGE2	If MID = mc，then Tag x to Anchor2 Distance, Unit: mm
RANGE3	If MID = mc，then Tag x to Anchor3 Distance, Unit: mm
NRANGES	unit raw range count（Cumulative value）
RSEQ	range sequence number count（Cumulative value）
DEBUG	If MID=ma，then TX/RX Antenna delay
aT:A	T is Tag ID，A is Anchor ID This ID is an artificial short ID，the full ID is a 64 bit ID

6.4 Log Files

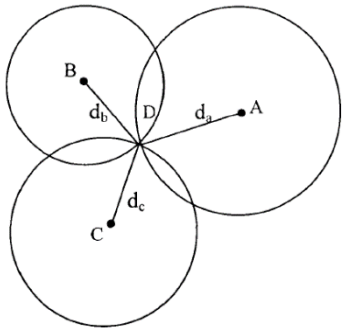
When using the upper computer, click "Start", and under the log folder, yyyymmdd will be generated_ hhmmssRTLS_ log.txt The log file in text format has the following meanings:

Table 6.4.1 Log Explanation

Log Content	Meaning
T:151734568:DecaRangeRTLS:LogFile:Ver. 2.10 TREK:Conf:Anchor0:1:Chan2	15:17, 34 second,568 ms, version V2.10; current connection to A0, 6.8M, Channel 2
T:151734600:AP:0:-2.4:0:0 T:151734600:AP:1:4.8:0:0 T:151734600:AP:2:4.8:11.5:0 T:151734600:AP:3:-2.4:11.5:0	15:17, 34 second ,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: TagID: AnchorID: Reported Range: Corrected Range: Sequence# : Range Number

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

6.5 The principle and calculation method of Trilateration



6.5.1 Based on UWB Trilateration method

The principle of trilateral measurement is shown in the right figure. The three nodes a, B and C are used as the center of the circle to make the circle, and the coordinates are (X_a, Y_a), (X_b, Y_b), (X_c, Y_c), the three circles intersect at a point D, and the intersection D is the moving node, a, B and C are reference nodes, and the distances between a, B, C and intersection D are d respectively d_a, d_b, d_c。Assume that the coordinate of intersection D is (X , Y)。

$$\begin{cases} \sqrt{(X-X_a)^2+(Y-Y_a)^2} = d_a \\ \sqrt{(X-X_b)^2+(Y-Y_b)^2} = d_b \\ \sqrt{(X-X_c)^2+(Y-Y_c)^2} = d_c \end{cases} \qquad (6.5.1)$$

From equation 7.5.1, the coordinates of intersection D can be obtained as:

$$\begin{pmatrix} X \\ Y \end{pmatrix} = \begin{pmatrix} 2(X_a-X_c) & 2(Y_a-Y_c) \\ 2(X_b-X_c) & 2(Y_b-Y_c) \end{pmatrix}^{-1} \begin{pmatrix} X_a^2-X_c^2+Y_a^2-Y_c^2+d_c^2-d_a^2 \\ X_a^2-X_c^2+Y_b^2-Y_c^2+d_c^2-d_b^2 \end{pmatrix} \qquad (6.5.2)$$

The defect of trilateral measurement method is: because the hardware and power consumption of each node are not the same, the measured distance can not be the ideal value, resulting in the above three circles may not just intersect at a point, in practice, it must intersect in a small area, so there is a certain error in the (x, y) coordinate value calculated by this method. In this way, we need to estimate a relatively ideal position through a certain algorithm as the optimal solution of the current mobile node coordinates.

6.5.2 Trilateration Function

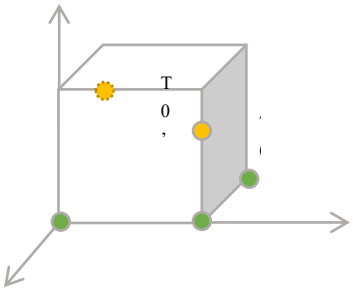
In trilateration.cpp document，GetLocation() is to calculate the best solution of tag, which is the coordinate (unit: m) of the incoming base station and the distance from each base station to the tag (unit: mm).

As mentioned in the previous section, because the distance measured cannot be ideal, the above three circles may not be just intersected at a point, so when the anchor A0/A1/A2 is working, there will be two solutions from the mathematical point of view; when a0/a1/a2/a3 is working, there must be an optimal solution. A3 is used as the auxiliary base station. After the completion of a trilateration algorithm in a0/a1/a2, two solutions are obtained, which will be the nearest solution to A3 sphere as the optimal solution.

Note：trilateration.cpp document，is the source code for PC，free to give for 4 Anchor and 4 Tag suite purchase.

6.5.3 Why is the accuracy of Z-axis worse than that of X-axis and Y-axis?

As shown in the picture，A0/A1/A2 are the 3 anchors，T0 is tag，L_{A0T0} L_{A1T0} L_{A2T0} represents the distance from each anchor to tag. In the case of accurate ranging, calculated Tag coordinate should be at T0, but, the actual measured value L_{A0T0} L_{A1T0} L_{A2T0} may be too large, the calculated position is T0’. Because A0 / A1 / A2 are all in *xoy* surface, so, most of the ranging errors will be accumulated to z-axis, resulting in z-axis data jitter.



Picture 6.5.3 Z-axis data error

7 Document management information

主题	UWB Mini 4 开发文档
版本	V1.2
参考文档	dw1000-datasheet-v2.08 dwm1000-datasheet-v1.3 evk1000_user_manual_v1.11 trek1000_user_manual_v1.04
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Lynn	2021/3/15	V1.2 修改部分错误