User Manual
HR-RTLS1-PDOA

Haorutech co. Ltd

CATALOG

1 Introduction

HR-RTLS1-PDOA is a high-precision real-time positioning system(based on DW3000 series chips of Decawave company) developed by HR Technology.

HR-RTLS1-PDOA supports two positioning mode: TOF and PDOA Angle measurement. It can be applied as a following system or single anchor positioning mode. By different module combinations, it can adapt to most location application scenarios.

2 System features

> **Popular MCU-STM32, friendly to beginners:**

The ULM1/ULM3/LD150 module of HR-RTLS1 takes STM32F103CBT6 series (or fully compatible alternative chip made in China) as the main control MCU.

The wearable devices take STM32L151CBU6 low-power microcontroller, which is conTabled by CUBEmx tool, developed by HAL library and KEIL-MDK integrated development environment.

> **Easy extended interface:**

Modules provide external expansion data interfaces, which can be easily connected to **PC, mobile phone, other microcontroller, Raspberry PI, Arduino, PLC and other devices** for expansion and development.

> **High positioning accuracy:**

The system takes Decawave high-precision positioning IC as the core positioning module. It works with self-developed positioning algorithm and filtering algorithm, which makes the positioning tag adapting to various complicated field conditions. The positioning accuracy is 10cm (CEP95);

➢ **Support multi-tags and multi-anchors:**

The system can eaisly expands the number of anchors and tags by configuration, which is convenient for users to expand the system;

➢ **Built-in Kalman filter algorithm in module**

The built-in Kalman filter algorithm can be turned on/off to make the output data stable and smooth.

3 Product Superiority

Table 3-1 RTLS1-PDOA Product Superiority

Comparing Items	HaoruUWB	Other products
Core chip	Based on the latest DW3220 single chip solution, the first in the industry.	Based on the traditional DW1000 dual-chip solution.
On-board components of anchors.	Less components, easy to be integrated.	More components, hard to be integrated.
Overall cost	Less	Higher
Power Consumption	It only uses 10% of the power consumption of the traditional dual DW1000 chip.	High
Whether compatible with TWR multi-anchor positioning	Yes, PDOA anchor can also be used as a trilateral positioning anchor	No, PDOA anchor can only complete its own function.

4 Series Products

Pic 4-1 ULM3-PDOA Series Modules

Figure 4-1 Comparison Of Module Characteristics

| 序号	型号 Model	主要特点 Main Characteristics
1	ULM3	Official DWM3000 modules, displayer, 40 meters
2	ULM3-SH	Bracelet shell, built-in battery, motion detection, 40 meters
3	ULM3-PDOA	PDOA anchors, angle measuring, single anchor positioning, following vehicle, 40 meters.

As showing in below picture, HR-RTLS1 series modules

Pic 4-2 ULM3 Series Modules Combination

5 System Parameters

5.1 ULM3-PDOA Parameters

front   back
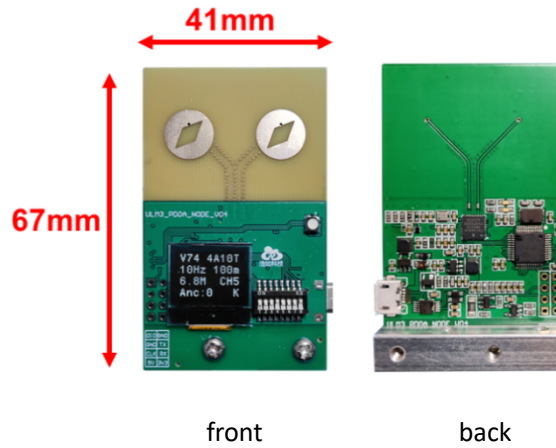
Pic 5-1 ULM3-PDOA Module

Figure 5-1 ULM3-PDOA Module Parameters

Category	Parameter
Power	DC5V external power supply
Maximum Detection Range	40m (open area) @6.8Mbps
MCU	STM32F103CBT6 (GD32F103CBT6)
Display Onboard	0.6 inch OLED
Module Size	41*67.5mm
Ranging Accuracy	±5cm
Detect Angle	120° (centralized by the module, -60°~+60°)
Angle Accuracy	±5
Working Temperature	-20~70℃
Communication Mode	USB to serial port / TTL serial
Data Update Frequency	100Hz (MAX, adjustable)
Frequency Domain	6250-8250MHz (CH5/CH9)
Bandwidth	500MHz

Type of Antenna	PCB double antenna
Emission power spectral density (Programmable)	-41dBm/MHz
Communication Rate	6.8Mbps

5.2 ULM3 Parameters

Pic 5-2 ULM3 Module

Table 5-2 ULM3 Module Parameters

Category	Parameter
Power	DC3.7V~5V external power supply (power bank or li-ion battery)
Maximum Detection Range	40m (open area) @6.8Mbps
MCU	STM32F103CBT6 (GD32F103CBT6)
Display Onboard	0.6inch OLED
Module Size	27*70mm (include antenna and base)
Ranging Accuracy	±5cm
Working Temperature	-20~70℃
Communication Mode	USB to serial port / TTL serial

Data Update Frequency	100Hz (MAX, adjustable)
Frequency Domain	6250-8250MHz (CH5/CH9)
Bandwidth	500MHz
Type of Antenna	Onboard ceramic antenna
Emission power spectral density (Programmable)	-41dBm/MHz
Communication Rate	6.8Mbps

6 System Application

1) Small range positioning of single anchor;

2) Following luggage, tool car and other following systems;

3) Anti-loss tag, airtag, etc.;

4) One finger pointing connection application;

7 System Deployment

7.1 Equipment Preparation

1 ULM3-PDOA module, some ULM3 tags(or ULM3-mini wristband-tags), 1 microUSB cable, 1 anchor holder.

List Number	Component Name
1	1 ULM3-PDOA module
2	ULM3 tags(or ULM3-mini wristband-tags) as many as needed
3	1 power bank matches ULM3 tag for power supply.
4	1 microUSB cable
5	1 Anchor holder, 4 M3 screws，2 copper pillar.

7.2 PDOA Anchor Installation

The antenna of ULM3-PDOA module is oriented towards the positioning tag. The module is powered by an external 5V power supply. There is a square block fixed on the bottom of the module, which can be fixed on the UGV or the desktop with M3 screws. Also, it can be connected to a copper column to increase the supporting force to placed on the horizontal platform.
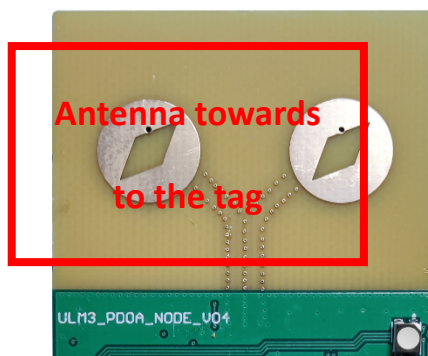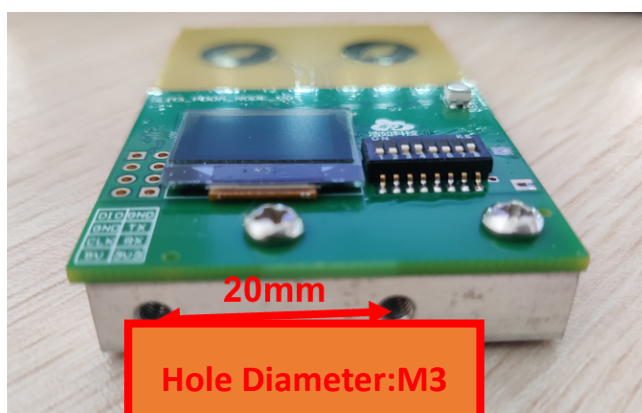

Figure 7-1 Orientation of antenna

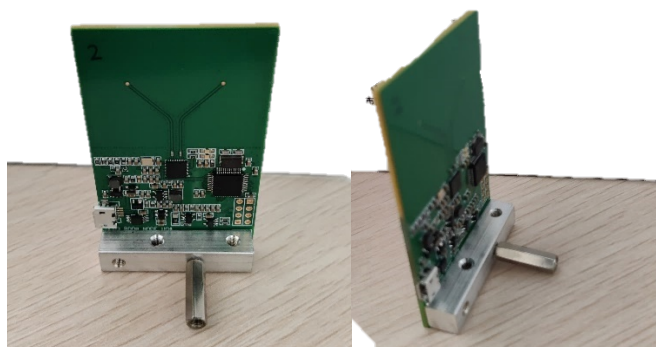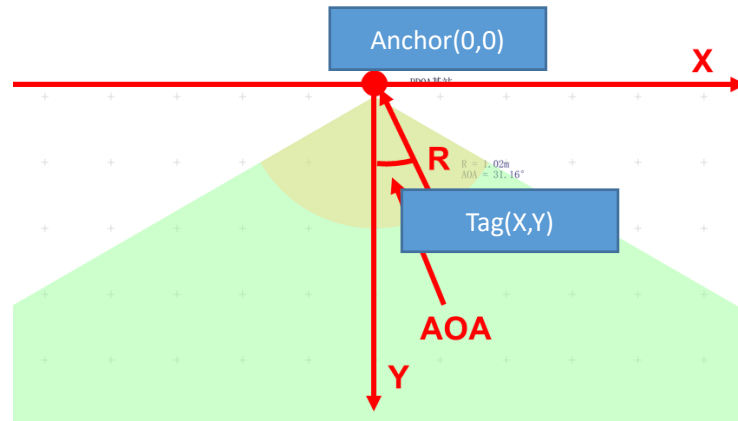**Figure 7-2 Mounting holes of bottom block**

Figure 7-3 Bottom block is connecting to a copper column

The anchor was set as the coordinate point (0,0) to establish the coordinate system, and the Y axis was directly in front of the anchor. The tag positioning and AOA calculation could be completed from -60° to +60°.

Figure 7-4 Positioning Range And Coordinate System

Matters need attention:

1) The tag should be positioned within the correct coverage range of anchor, otherwise there may occur some errors, such as inaccurate positioning;

2) The antenna surface of anchor should be orientated towards the tag;

3) The distance between the anchor and the tag should be greater than 1 meter;

4) The anchor should be installed in an open area;

5) There should be no occlusion between the tag and the anchor, especially no steel plates and other metals.

7.3 Tag Installation

There is a USB interface at the bottom of the ULM3 tag, which should be connected to the charging bank,supplied with the goods, for power supply. The ULM3-mini bracelet tag has built-in battery, long pressing the SOS button for 3 seconds to power it up.

7.4 Driver Installation

Go to "HR-RTLS1-PDOA 开箱测试资料\串口驱动" catalogue，double click **CH341SER.EXE** to install it，use the default settings，click "install" button，follow the prompts to finish install process.

Pic 7-3 Serial Port Driver Installation

After the driver is installed, connect the anchor/tag module to the computer. Open the device manager on the computer and check if the serial port driver is installed properly. If the port is identified, record the serial port number of CH340. For example, the following picture shows that the driver is installed, the device is identified, and the serial port number is COM5. If the serial port is not displayed or there is "!" exclamation mark error, please contact the corresponding after-sales engineers.
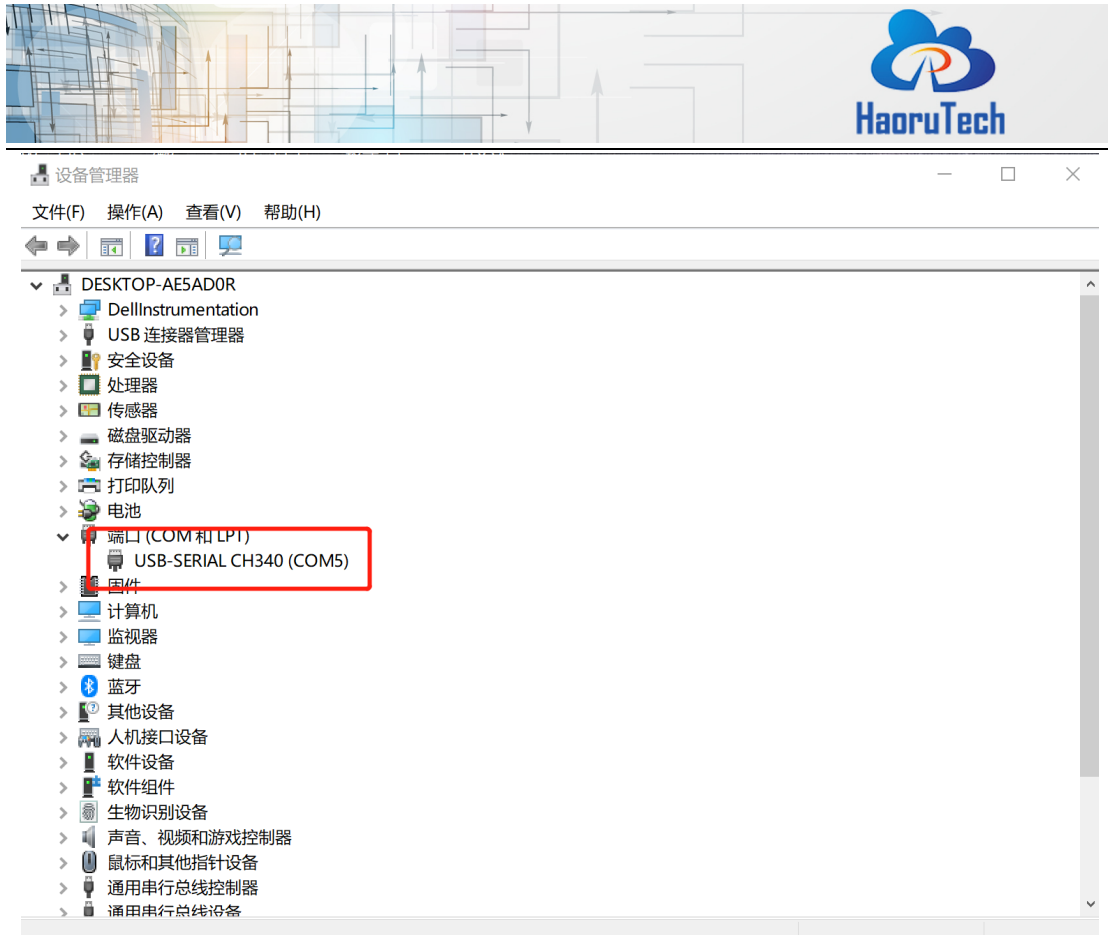
Pic 7-4 The Device Manager Identifies The Serial Port

Go to "HR-RTLS1-PDOA <mark>开箱测试资料\串口驱动</mark>" catalog，double click XCOM V2.0.exe to run the Serial port debugging assistant，select the serial port number identified，set baud rate to 115200, click "<mark>打开串口</mark>"。

Run tag module, if the message box can receive string data beginning with MP, it means that the serial port data communication is working and the anchor is successfully connected to the computer.

Pic 7-5 The Serial Assistant Displays The Serial Data
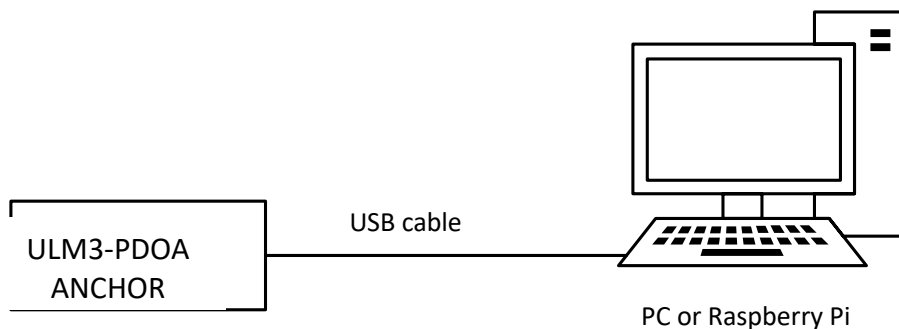
7.5 Connect To PC Software

Figure 7-8 Anchor Connects to PC

Open " HR-RTLS1-PDOA 开箱测试资料\上位机软件 " catalog， unzip
"HR_PDOA_RTLS.zip"，run HR_PDOA_RTLS.exe，now we can run PC software.
Select the correct serial port number in the upper right corner of the software, click
"Connect"。
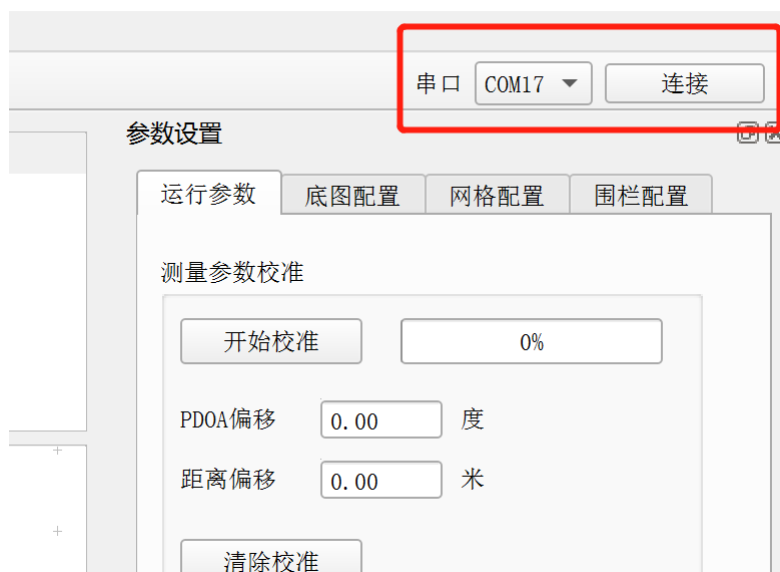
Pic. 8-6 Select And Connect The Right Port Number

After connecting to the PC and switch on the tag successfully, the PC software can display the tag information and positioning trace.
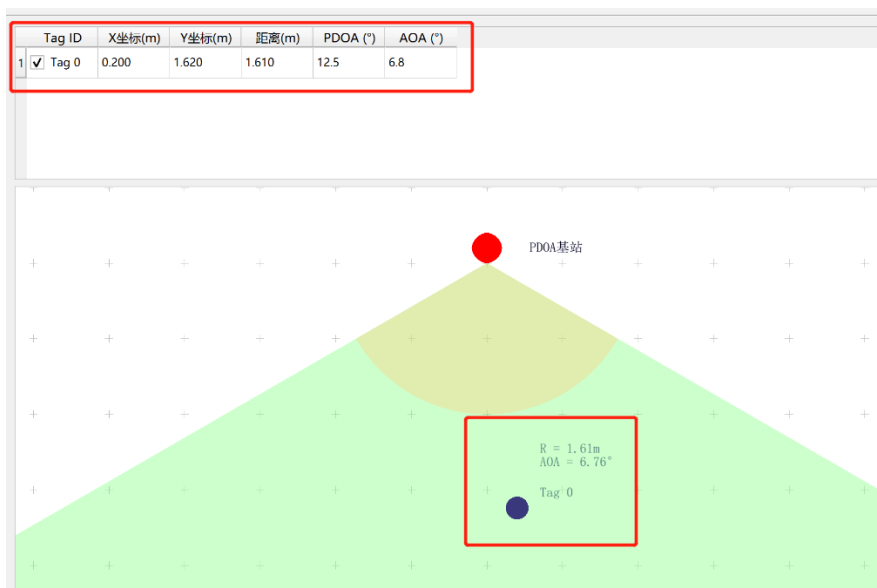
Pic 8-7 Tag Information And Positioning Trace.

8 Communication protocol

8.1 Uplink data protocol

The uplink data protocol is the data uploaded actively by the UWB module

through the serial port.

Serial communication baud rate: 115200bps-8-n-1

Communication protocol：

MPxxxx,tag_id,x_cm,y_cm,distance_cm,RangeNumber,pdoa_deg,aoa_deg,distance_offset_cm,pdoa_offset_deg\r\n

Serial communication data example:

MP0036,0,302,109,287,23,134.2,23.4,23,56

Table 8-1 Serial Communication Protocol Description

Content	Example	Description
MPxxxx	MP0036	Head of the data packet, 0036 is the number of all data bytes except MPxxxx, including the ending \r\n, which is fixed to 4 characters. If it is less than the length, fill up with 0.
tag_id	0	The current tag ID
x_cm	302	X coordinates of the tag, integers, units:cm
y_cm	109	Y coordinates of the tag, integers, units:cm
distance_cm	287	Direct distance between the anchor and the tag, integers, units:cm
RangeNumber	23	Serial number of ranging，0-255
pdoa_deg	134.2	PDOA value, Float, units:degree
aoa_deg	23.4	AOA value, Float, units:degree
distance_offset_cm	23	Calibration value of direct distance between the anchor and the tag, integers, units:cm
pdoa_offset_deg	56	Calibration value of PDOA value, Float, units:degree
\r\n		Ending data

9 Anchor Calibration

Due to the influence of welding, PCB manufacturing process and other factors, the RF transmission line of the two antennas of the ULM3-PDOA module will cause small errors, resulting in PDOA Angle deviation, which can be calibrated by the PC software.

After the ULM3-PDOA module is successfully connected to PC and the tag location data is displayed, click the "Start calibration" button, place the anchor and tag at the same height as prompted, place the tag in front of the two antenna centers of the anchor, and measure the distance between the anchor and tag. It is recommended that the distance should be more than 2 meters.

Pic 9-1 ULM3-PDOA Module Calibration

Fill the measured distance value into the PC software, **and keep the position of the tag and anchor unchanged until the calibration progress bar rolls to 100%, which is when the calibration is completed.**
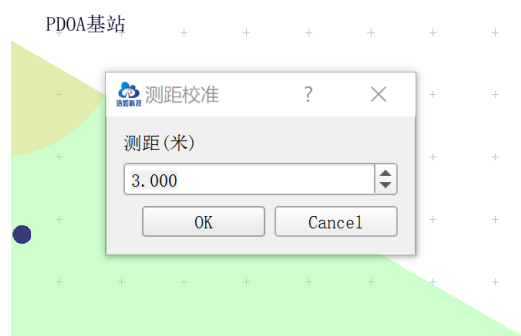
Pic 9-2 ULM3-PDOA Module Calibration

After the calibration is completed, the PC software prompts the calibration deviation, and the anchor will output calibration data according to this deviation. If you

need to clear the calibration data, you can click the "Clear calibration" button to reset the deviation value and re-calibrate.

Pic 9-3 ULM3-PDOA Module Calibration

9.1 On Board OLED Display
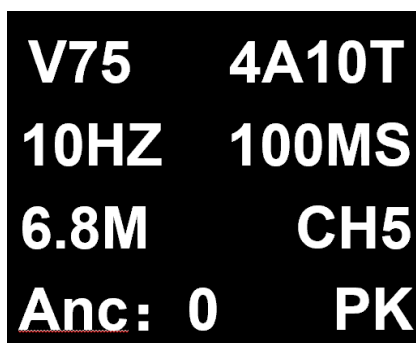
Pic 10-1 Display Example

Figure 10-1 Display Information Description

Example	Description
V75	Firmware Version
4A10T	Maximum 4 anchors and 10 tags
10HZ	Data update rate(current mode)
100ms	Current data update period(=1/ Data update rate)

6.8M	Current UWB air rate is 6.8Mbps(Alternative option: 110k)
CH5	Current UWB channel is CH5(Alternative option: CH2 Channel 2)
Anc:0	Current module is anchor, ID=0 (Alternative option: Tag)
K	Kalman filtering is enabled (no display: disabled)

10 Development and learning files

List of development and learning materials we provide after purchasing：

Table 10-1 Documents

No.	Category	File type
1	Quick guide of QT software	PDF
2	RTLS1-PDOA Bilateral ranging agreement	PDF
3	ULM3-PDOA_UserManual	PDF
4	RTLS1-PDOA _UserManual	PDF
5	DW3000 UserManual by Qorvo	ZIP

11 FAQ

1. Is the system open source?

   The system is completely open sourced, including embedded code, upper computer code, algorithm and etc. Besides, it provides related development manuals and video tutorials, which helps the user to begin secondary development easily.

2. Is the system mature? Does it need redeveloping before use?

    The system is already mature, it provides complete positioning function, which means the user can get positioning data through ports directly. Also, users can redevelop the system to meet their own needs through editing source code.

3. How many modules do I need?

    It depends. Here are some examples:

1) If you need to range from one to one, it needs two.

2) If you need to set up 2D position, it needs 4, which includes 3 anchors and 1 tag.

3) If you need to set up 3D position, it needs 5 at least, which includes 4 anchors and 1 tag.

4) If you already had modules in hand and want to increase the number of anchors or tags, you need to buy related numbers of the missing modules.

5) If you need to position 10 tags, then you need to get 4 anchors and 10 tags, which results in 14 modules.

    We recommend buying 5 modules at least, for the following reasons:

    1) 4 anchors positioning can cover two times the area than 3 anchors positioning.

    2) There always some communication failure during the testing; for 4 anchors positioning method, it will finish the positioning by 3 anchors data out of 4, but for 3 anchors positioning method, it needs to finish the positioning by all 3 anchors data, which leads to reduce the success rate.

    3) Also, 4 anchors & 1 tag can be reset to 3 anchors & 2 tags as well.

4. What is the positioning accuracy? Is the accuracy related to the area?

    For XY positioning, the accuracy is 10cm (CEP95); for Z direction, the accuracy is 30cm (CEP95). There is no direct relationship between usage area and

accuracy. There is no reducing accuracy when increase the usage area. But it should be noted that for the large power needed for ULM1-LD600, it will have an obvious multipath effect when use in 5*5cm area, so we recommend using it in a larger area.

5. Does the module have shell? Is it waterproof?

ULM1 does not have shell, LD150/LD600 have shell and external antenna. But the shell is not either sealed or waterproof.

6. How long is the battery standby time?

It depends on the external power supply capacity and emission frequency. For ULM1 equipped with matching power supply, the anchor standby time is approx. 10 hours, and the tag standby time is approx. 12 hours.

7. What the difference between RTLS1, RTLS2, RTLS3?

RTLS1, RTLS2, RTLS3 are the third generation UWB positioning product that developed by our company.

1) RTLS1 is based on the STM32 platform development kit, open source and available by two types:50m and 600m. It is suit for study assessment, study UWB underlying drive method, product source code migration, system integration and etc.

2) RTLS2 is productized equipment, closed source, communicate by ethernet, WEB interface. It is suit for application directly in the project.

3) RTLS3 is based on Arduino platform development kit, open source, the underlying drive is encapsulated and easy to redevelop. It is suit for study assessment, development research, project study in college, system integration and etc.

8. What is the update frequency for the tag?

The default frequency is 112ms, it can set to 10ms(6.8Mhz) for minimum duration through modify the firmware parameter.

9. How does the module connect with PC?

The module uses USB port to connect with PC. It only requires one out of 4 anchors to connect with PC.

10.　How does the module connect with the other embedded devices?

The module uses UART-TTL port onboard to connect with the other embedded devices.

11.　Do I need to buy other accessories after purchasing the system?

The system provides matched portable power source and data cable. If the user needs to use it in the open air and need better stability and accuracy, we recommend buying tripods to hold the anchors. The height of the tripods had better not exceed 3m.

12.　Is the modular suit for the drone or AGV?

There is no problem to use it for drone or AGV. Until now many customers use it in this way and get good feedback.

13.　Is it easy to use?

It is easy to build up the system with the help of video tutorial. It is also easy for redeveloping the system using development manual if the user has background knowledge of embedded development.

14.　When can I get the full set of technical data?

After purchasing, the user will need to build up the system and finish testing according to the information in the package first to make sure the function will meet his need. If the product suit for the user, after confirming the payment, our customer service will send all the technical data to the user. If the product does not meet the user's need, he can return the product and get refund without damage the appearance of the product. The product will not be returned after the user receives the technical data.

15.　How will the obstructions affect the positioning?

　　　1)　Wall: LD600 can pass through 1 solid wall, but error will increase about 30cm, depends on the material and thickness of the wall.

ULM1, ULM3 cannot pass-through walls.

2) Wire pole, trees, and other long and narrow objects: Depends on the distance between tags and anchors. For example, if the distance between the tag and anchor is 60m, the obstruction will play little role on the result accuracy. But if the distance between the tag and anchor is only1 m, It will affect the result in a large part.

3) Glass: Glass will affect the accuracy of UWB positioning in a large part.

4) Steel, iron and other metal: Metal will absorb electromagnetic wave from the UWB, especially when it is closed to the modular. It will block signal and lead to no result.

5) Paperboard and wood board: it will not affect the result much if the thickness is about 10cm, but the signal will get reduction.

16. What is the probable reason for the low accuracy of the result.

1) Check whether the anchor coordinate on the upper computer software is correct.

2) Check whether the anchor height is above 1.8m.

3) Check if any signal of the anchors is too weak, then try to move the anchor to get better signal.

4) Check if there are any obstructions between the modular.

5) Check all the anchors are in the same plane (if the project requires).

6) Check if any tag is too far from all the anchors.

17. Why it says too close between the anchor and the tag?

1) In the situation of long-distance communication, we recommend to use tripods to hold the anchors and tags, and also keep the height above 1.8m during the testing.

2) Check if there is obstructions or strong electromagnetic interference around.

3) Check if antenna is installed in the right way.