User Manual
ULM3-PDOA

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CATALOG

1   Introduction

ULM3-PDOA is a PDOA positioning module, based on the latest DW3000 series chip. Core UWB module of ULM3-PDOA is official Decawave DWM3220, and MCU is STM32F103CBT6 (or GD32F103CBT6 which based on the price fluctuation and batches difference). ULM3-PDOA can be used for precise ranging, indoor positioning and other high-speed data communication applications. ULM3-PDOA also integrates the OLED display. All the features make ULM3-PDOA easy to use, with high precision and small size.

For positioning applications, ULM3-PDOA module normally plays the role as an anchor, and the ULM3 modules and ULM3-SH can be tags, which can form a single-anchor PDOA positioning system or following system.

Combination 1
Anchor: ULM3-PDOA
Tag: ULM3

Combination 2
Anchor: ULM3-PDOA
Tag: ULM3-SH

Figure 1-1 ULM3 Series Combinations

2   DW3000 features

➢   Ultra-low power consumption

Through comprehensive optimization, DW3000 series can make power consumption 5 times lower than DW1000 by reducing peak current, frame duration and startup time. The power consumption of DW3000 is lower than BLE, and more friendly to low power

standby duration.

➢ Excellent security

DW3000 supports for the new IEEE802.15.4z standards, and preamble encryption.

➢ High compatibility

DW3000 is compatible with the latest IEEE802.15.4z. After developing of FiRa compatible code, it supports main commercial mobile phones available in the market.

➢ Highly-integrated

By integrating baluns, capacitors and other components inside the chip, DW3000 reduced its size by reducing the number of external components from 30+ to 10.

➢ PDOA with single chip

DW1000 series requires two DW1000 chips to realize PDOA with the same clock source. But DW3x20 supports external double antennas, which can measure the arrival phase difference. The cost, size and power can be reduced by using one single chip.

3 Module selection

Table 3-1 Comparison of Module Features

No.	Type	Main features
1	ULM3	Official DWM3000 module, display integrated, 40m
2	ULM3-SH	Wristband, battery inside, motion detection, 40m
3	ULM3-PDOA	PDOA anchor, angle detection, single base positioning, car-following, 40m

Above are the related module based on DW3000 core chip, which can be combined used.
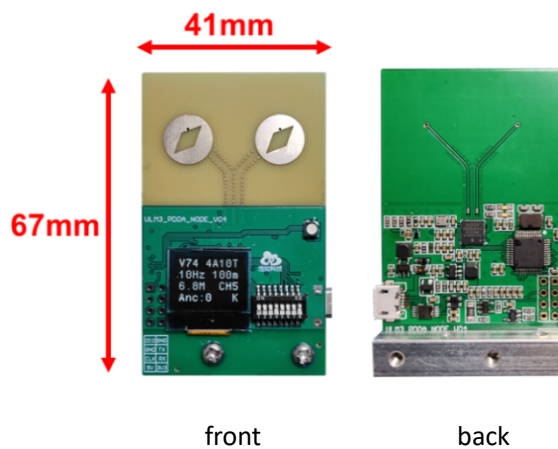
4   Product parameters

front   back

Figure 4-1 ULM3-PDOA

Table 4-1 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

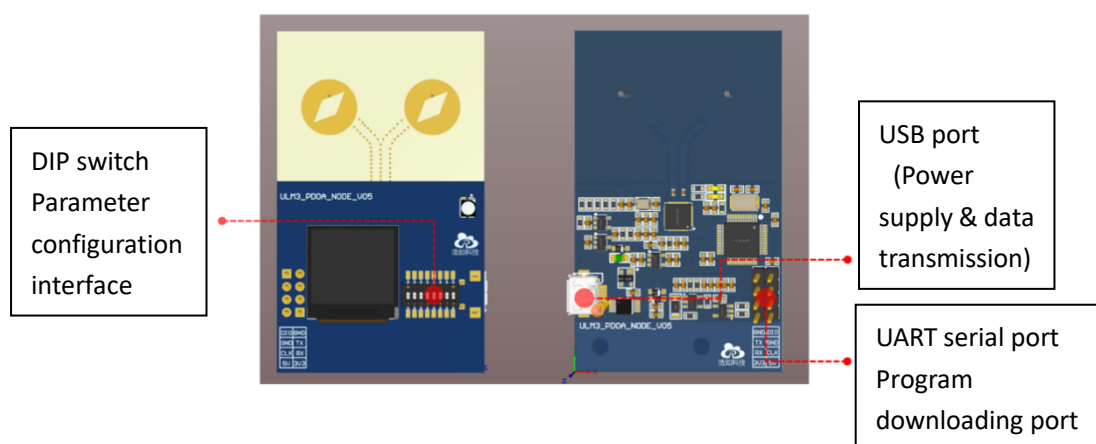|	
Emission power spectral density (Programmable)	-41dBm/MHz
Communication Rate	6.8Mbps

5 Module interfaces

Figure 5-1   Module Interfaces

5.1 USB port (power supply & data transmission)

The port can be connected to a standard 5VDC module such as a charging bank or other 5V power adapters. It can also be connected to the USB port of a computer for power supply and data transmission and data display on the computer.

5.2 Program downloading port

The port is the SWD debugging interface of STM32 microcontroller, which can be used for program downloading, simulation debugging, etc. It is mainly used for embedded program development and firmware update, and it can be used with the ST-LINK downloading tool.

5.3 UART serial port

ULM3-PDOA module can connect to PC or Raspberry PI and other systems through USB port for data transmission, but also has UART serial port (TTL) on board, which

can connect to other microcontrollers, Arduino and other devices for data transmission and secondary development. While Connecting, the TX pin of ULM3-PDOA should be connected to the RX pin of the target module, and the GND pin of the two modules should be connected directly.
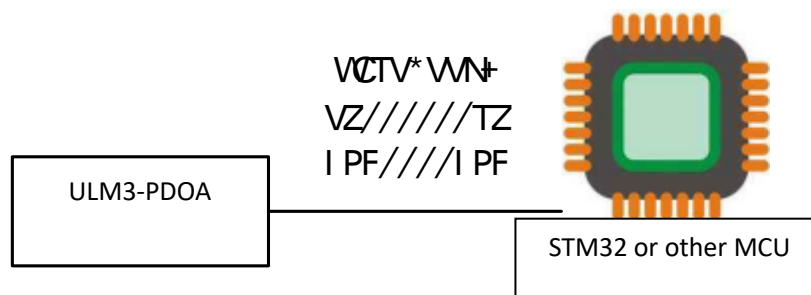

Figure 5-2 ULM3-PDOA UART Connection Diagram

5.4 LED indicator

On board RGB indicator indicates the current system status.

Table 5-1 Indicator Status Description

Working Status: **Tag**	Start ranging and successfully get response from 1 or more anchors, and establish ranging communication.	GREEN LED BLINK
	Start ranging but get no response from anchors.	RED LED BLINK
Working Status: **Anchor**	Successfully establish a ranging connection with any tag.	LIGHT BLUE LED BLINK
	No tag connected.	LIGHT BLUE LED NOT BLINK (ON or OFF)

5.5 Parameter configuration interface

ULM3-PDOA module integrated the 8-bit DIP switch. The following figure 5-3 lists the switch configuration attributes. Users can easily configure the communication frequency, role, ID, and built-in Kalman filter switch of the module.

During using and onsite debugging, users can quickly change the module configuration without any other devices to adapt more environments.

Before modifying parameters, users should disconnect the power supply first, then switch the DIP switch to the corresponding configuration position, and finally re-power the module to load the new configuration.

Table 5-2 ULM3-PDOA Module DIP Switch Configuration

	S1	S2* (Maximum number of tags and communication period)	S3* (Increase the external current)	S4(Role)	S5-S7 (Device address)	S8 (Kalman filter)
ON	Reserved	Maximum number of tags: **1** Total communication period：**10ms**	ON	Anchor	Device address 000-111	ON
OFF	Reserved	Maximum number of tags: **10** Total communication period：**100ms**	OFF	Tag		OFF

The default configuration of the system:

1. Maximum number of tags：10tags

2. Update period：100ms (10Hz)

3. External current increase：open

4. Kalman filter：open.

* Note: Due to the low power consumption of DW3000 series modules, most of the power banks will actively turn off the external power supply when the load current is low. This will make the module reboot again and again. **S3** increases the external current to actively increase the current of the module, which helps the power bank to maintain continuous output.

5.6 On Board OLED Display

Figure 5-3 Display Example

Table 5-3 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)

6   System installation and utilization

6.1 System installation and notes

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.
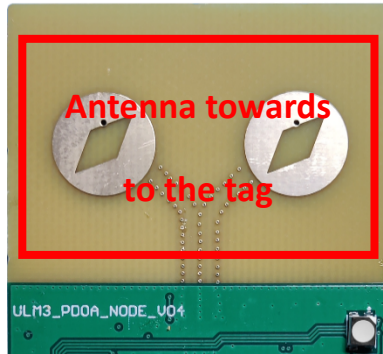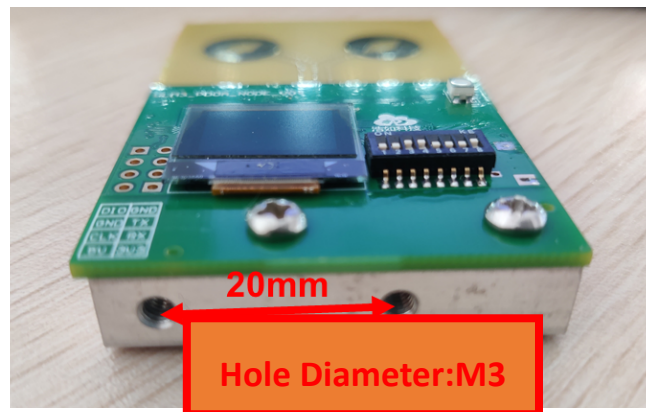

Figure 6-1 Orientation of antenna

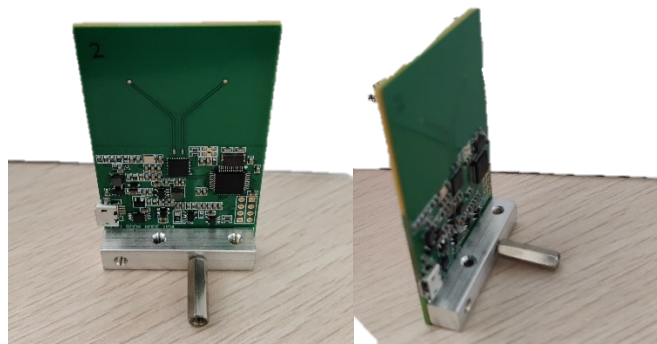**Figure 6-2 Mounting holes of bottom block**

图 6-3 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
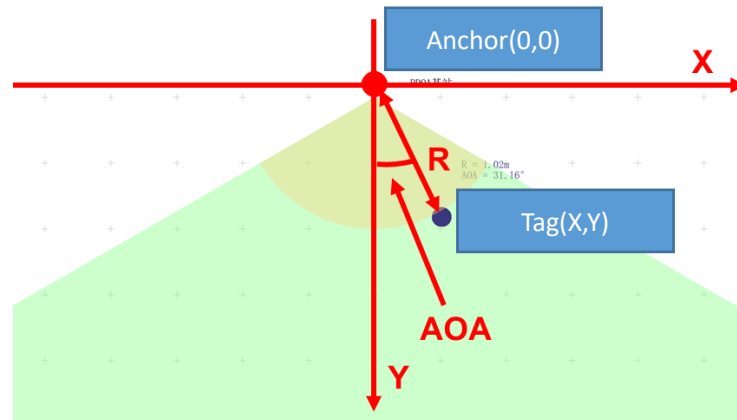
could be completed from -60° to +60° .

Figure 6-3 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.
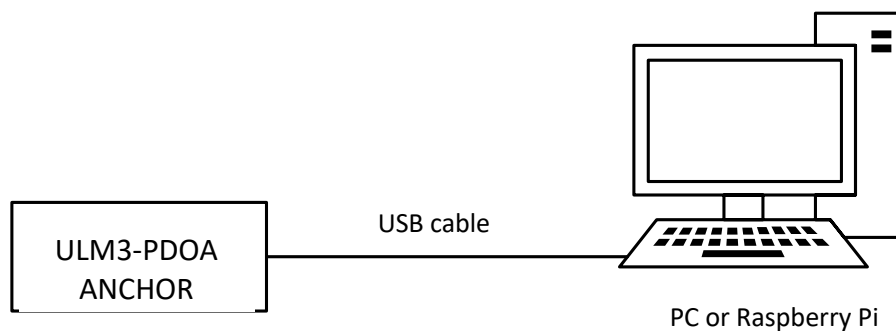
6.2 Connecting to PC

Figure 6-5 Anchor Connects to PC

For the initial utilization, CH340 driver should be installed at first. After identifying the

serial port on the PC, please open the PC software, select the serial port, and click "Connect" button to complete module connection and data communication.
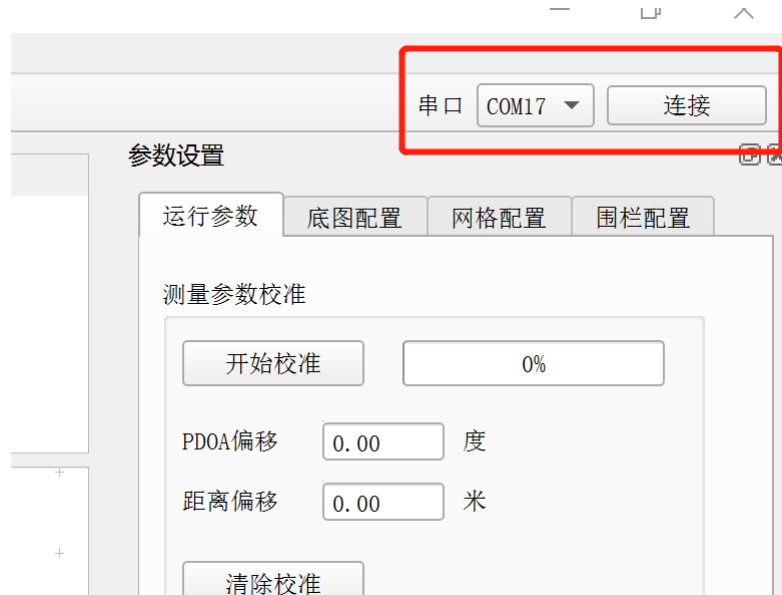

Figure 6-6 Serial Selection and Connection

After connecting to the PC and switch on the tag successfully, the PC software can display the tag information and positioning trace.

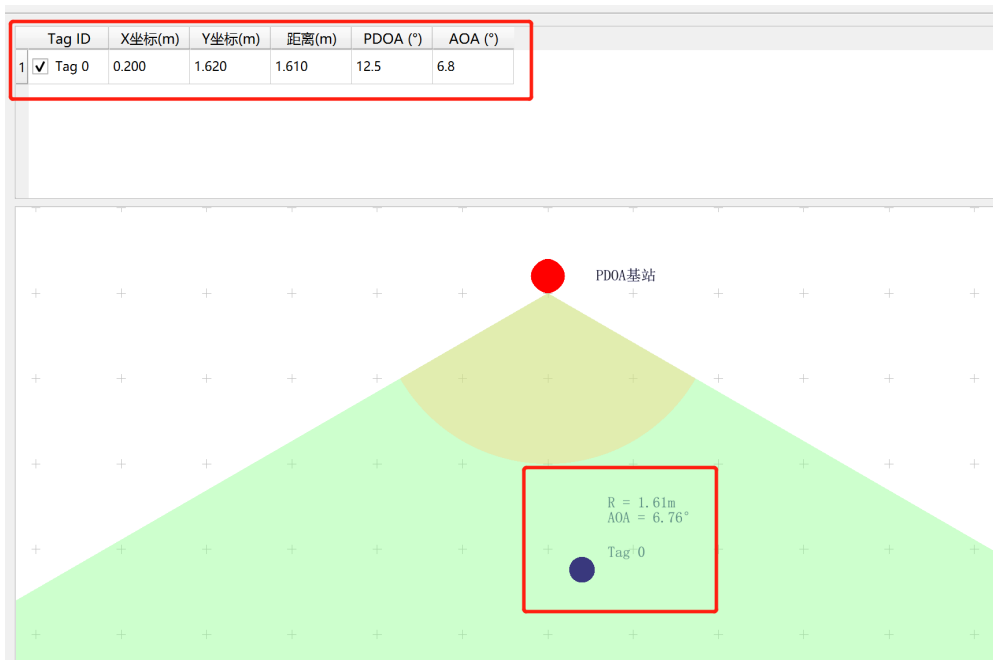**Figure 6-7 Tag Information and Positioning Track**

For more details about the utilization of system deployment, please download the <HR-RTLS1-PDOA UserManual-EN> to get more information.

Download HR-RTLS1-PDOA UserManual：

http://rtls1.haorutech.com/download/HR-RTLS1-PDOA_UserManual-EN.pdf

7 Communication protocol

7.1 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 7-1 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

8   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.

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.
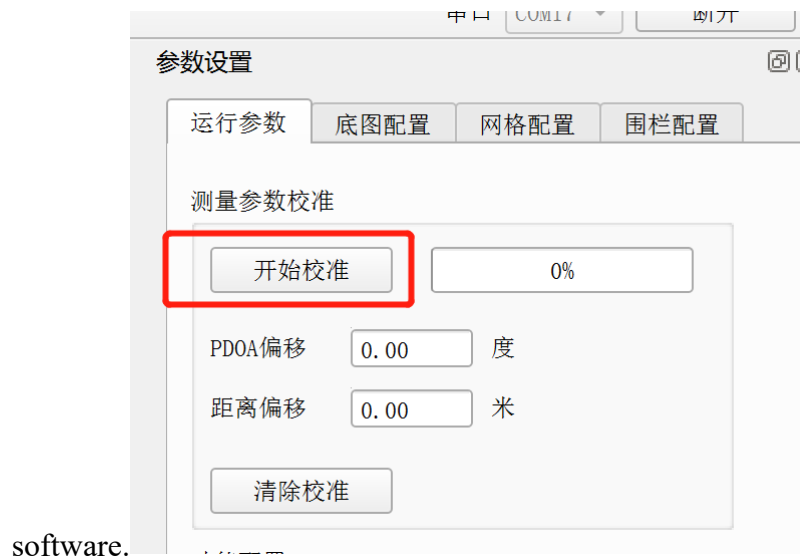

software.

Figure 8-1 ULM3-PDOA Module Calibration

<u>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.</u>
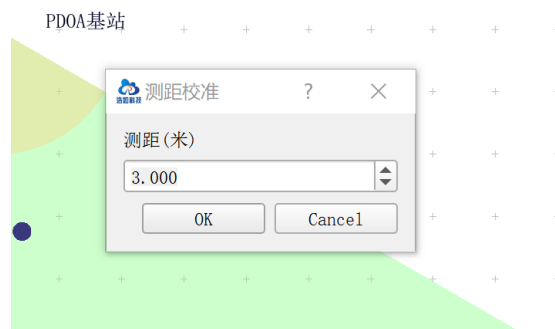
Figure 8-2 ULM3-PDOA Module Calibration

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.

Figure 8-3 ULM3-PDOA Module Calibration

9 Shipping list

Shipping list of single ULM3-PDOA module: (Highly recommendation: purchasing more than 4 modules to get a whole positioning system.)

Table 9-1 Shipping List

No.	Category	Number	Notes
1	ULM3-PDOA module	1	
2	Micro-USB data cable	1	

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