User Manual
ULM3

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CATALOG

1 Introduction

Figure 1-1 ULM3 UWB Module

ULM3 is a UWB module, based on the latest DW3000 series chip. Core UWB module of ULM3 is official Decawave DWM3000, and MCU is STM32F103CBT6 (or GD32F103CBT6 which based on the price fluctuation and batches difference). ULM3 can be used for precise ranging, indoor positioning and other high-speed data communication applications. ULM3 also integrates the OLED display. All the features make ULM3 easy to use, with high precision and small size.

For positioning applications, ULM3 module can be used as an anchor or tag, and the combination of multiple ULM3 modules can form a complete positioning system development kit.

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.

- High-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 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

Table 4-1 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

5 Module interfaces

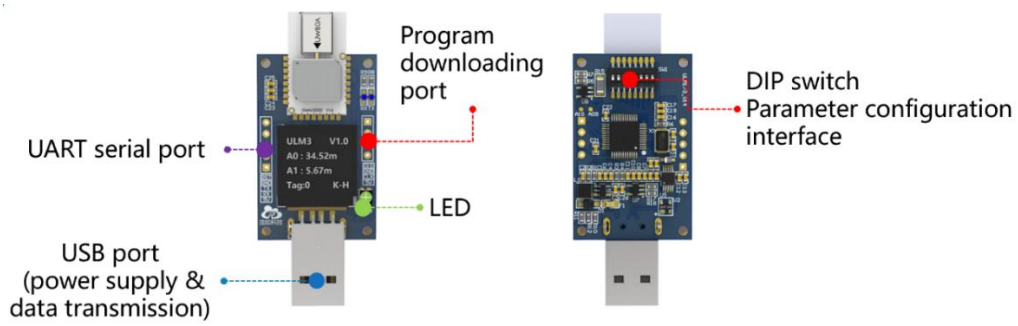


Figure 5-1 5-Module Interfaces

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 at the computer end.

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 burning tool.

5.3 UART serial port

ULM3 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 should be connected to the RX pin of the target module, and the GND of the two modules should be connected directly.

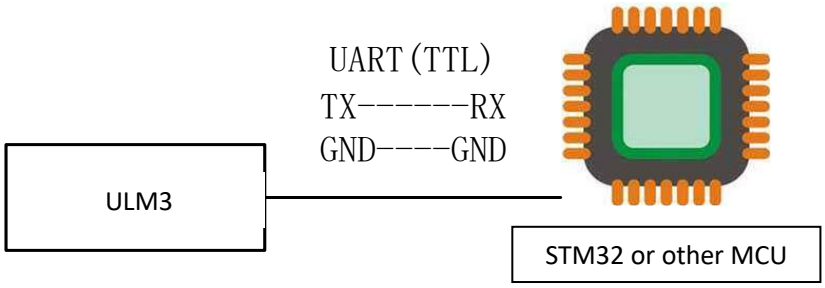


Figure 5-2 ULM3 UART Connection Diagram

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 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 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.

S2 Note: At the communication rate of 6.8Mbps, the ranging period of 1 ULM3 tag and 4 ULM3 anchors system is 10ms. Because multiple Tags positioning is in the form of TDMA, the total communication period =10ms numbers of tag.

For example, if the system has 10 tags, the ranging period is 10*10ms=100ms. Within this period, the ranging data of tags will be outputted every 10ms according to the sequence of tag ID. If one of the tags is offline, the output is empty during its 10ms period. The maximum number of tags can also be modified to other numbers through embedded code.

* S3 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
V48	Firmware Version
4A10T	Maximum 4 anchors and 10 tags (current mode)
100ms	Current data update period
6.8M	Current UWB air rate is 6.8Mbps
CH5	Current UWB channel is CH5
Anc:0	Current module is anchor, ID=0 (Alternative option: Tag)
K	Kalman filtering is enabled (no display: disabled)
P	Increase the external is enabled (no display: disabled)

6 System deployment

There are two system deployment modes: navigation mode and monitoring mode. During the navigation mode, the tag needs to be connected to the PC while other anchors only need to power on. The position data and real-time track of the currently

connected tag can be displayed on the PC software. In the monitoring mode, one of the anchors is connected to the PC, while the other anchors and labels are powered on. The position data and real-time track of all labels in the coverage area of the current anchor can be displayed in the PC software.

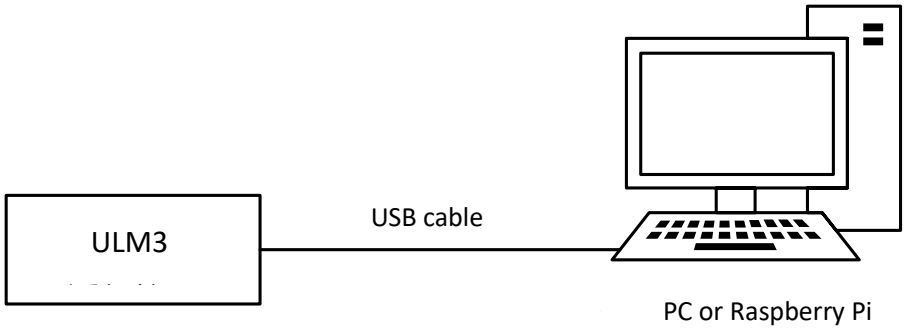


Figure 6-1 Module Connects to PC

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.

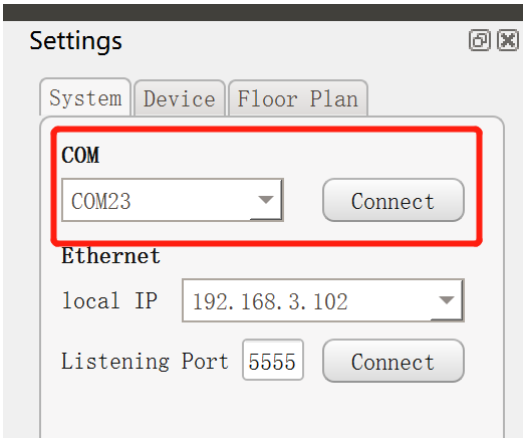
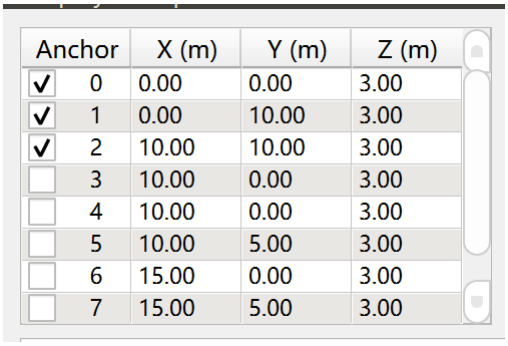


Figure 6-2 Serial Port Connection

After successfully connecting, users can complete the equipment deployment by configuring the position coordinates of the anchors based on the relative position of the anchors, and then the tags can be located and displayed.



Anchor	X (m)	Y (m)	Z (m)
☑ 0	0.00	0.00	3.00
☑ 1	0.00	10.00	3.00
☑ 2	10.00	10.00	3.00
☐ 3	10.00	0.00	3.00
☐ 4	10.00	0.00	3.00
☐ 5	10.00	5.00	3.00
☐ 6	15.00	0.00	3.00
☐ 7	15.00	5.00	3.00

Figure 6-3 Configure the Coordinates of Anchors

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

Download HR-RTLS1 UserManual：

http://rtls1.haorutech.com/download/HR-RTLS1_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

Serial communication data example:

mc 0f 00000663 000005a3 00000512 000004cb ffffffff ffffffff ffffffff ffffffff 095f c1 00146fb7 a0:0 22be

Table 7-1 Serial Communication Protocol Description

Content	Example	Description
HEAD	mc	Head of the data packet，fixed：”mc”
MASK	0f	If ranging results are valid. For example: mask=0x07(0000 0111) means RANGE 0,1,2 are valid.
RANGE0	00000663	Distance from tag to anchor A0，hexadecimal notation，unit: mm，result of the example is 1.635m.
RANGE1	000005a3	Distance from tag to anchor A1
RANGE2	00000512	Distance from tag to anchor A2
RANGE3	000004cb	Distance from tag to anchor A3
RANGE4*	ffffffff	Distance from tag to anchor A4（Invalid ranging or no anchor）
RANGE5*	ffffffff	Distance from tag to anchor A5（Invalid ranging or no anchor）
RANGE6*	ffffffff	Distance from tag to anchor A6（Invalid ranging or no anchor）
RANGE7*	ffffffff	Distance from tag to anchor A7（Invalid ranging or no anchor）
NRANGES	095f	message flow, accumulated，0x0-0xffff
RSEQ	c1	Range number, accumulated，0x0-0xff
RANGTIME	00146fb7	Ranging timestamp，timestamp of MCU，unit: ms
rIDt:IDa	a0:0	r means the role: a-anchor，t-tag; IDt-tag address，IDa-anchor address
DIAGNOSIS	22be	Only existing when the role is anchor, and default is RX_POWER(current anchor and last communicated tag)=-88.94dBm
END	\r\n	End of the data packet

***tips：** Users can only get data from RANGE4/ RANGE5/ RANGE6/ RANGE7 when the firmware program works as 8 anchors, and nothing will output when it is a 4 anchors firmware program.

If the current device is a tag, the ranging and positioning information will closely follow "mc…";

Example: $KT0, 1.69, 2.93, 4.98, NULL, LO = [-2.45, 5.44, 1.43]

Description:

Current role-T0;

K- Kalman filtering is enabled;

NK- Kalman filtering is not enabled;

Distance to anchor A0 is 1.69m;

Distance to anchor A1 is 2.93m;

Distance to anchor A2 is 4.98m;

Distance to anchor A3 fails to range, or A3 does not exist or A3 is not turned on.

the real-time positioning coordinates of the tag locates in the brackets after LO, and the coordinates is calculated within the tag. Users should note that the calculation can be completed only after the anchor coordinates are configured to the tag successfully.

7.2 Downlink data protocol

The downlink data protocol is the serial port command sent by the host to the UWB module, which is mainly used for parameter configuration. The length of the command is variable. The command begins with "$" as the data header and end with "\r\n".

Table 7-2 Downlink Data Command

$rboot	Module reboots, and inputs the startup information.
$reset	Restore system parameters to defaults.
$santdly,16375	Setting the antenna delay parameter (decimal) for ranging calibration: -if ranging result is smaller than the actual distance, the number needs to be reduced to increase the ranging distance. -if ranging result is bigger than the actual distance, the number needs to be increased to reduce the ranging distance.
$stxpwr,1f1f1f1f	Setting transmit gain parameter （hexadecimal）
$sanccd,0,0,2,0,3.1,2,3.1,0,2,3.1,3.1,2	Setting anchors coordinates（only valid for tags setting） A0X,A0Y,A0Z,A1X,A1Y,A1Z,A2X,A2Y,A2Z,A3X,A3Y,A3Z Coordinates unit：m，float
$saddr,9	Setting tag ID. The device ID will not be controlled by the DIP switch after the setting (only valid for tags Settings).

8 Shipping list

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

Table 8-1 Shipping List

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

9 Development and learning files

List of development and learning materials we provide after purchasing：

Table 9-1 Development Code

No.	Category	Language
1	STM32 embedded code (KEIL MDK project) and STM32cube project	C
2	PC software code	C++ QT
3	Trilateral positioning algorithm code	C
4	DW3000 embedded API	C

Table 9-2 Hardware Documents

No.	Category	File type
1	ULM3 module hardware schematic diagram	PDF
2	Chip DATASHEET	PDF

Table 9-3 UserManual

No.	Category	File type
1	ULM3_UserManual	PDF
2	RTLS1_UserManual	PDF
3	DW3000 UserManual by Qorvo	ZIP