UWB Tag portable instrument
User Guide

Version V1.0

Contents

1 Introduction of the development board

1.1 Brief introduction

UWB Tag handheld development board designed to implement the U-WB M *ini 3 module* or *U-WB NANO X1 MODULE* The TOF Report Message data output from the serial port is parsed in a certain format, combined with the exclusive Trilateration of the Internet of Things Trilateral positioning algorithm, simplified mathematical operation, truly realize the real-time solution of ranging data on STM32F103C8T6 microcomputer (embedded system), and calculate the coordinates X,Y , Z is displayed on the OLED.

STM32F103C8T6 single-chip microcomputer without the support of DSP library and FPU floating-point arithmetic, can still solve coordinates once in 5ms, the algorithm is cleverly calculated, simple to call, and can minimize the solution time.

This function is suitable for applications that do not have a PC in the field but need to display positioning information, such as highways, factories, deserts, mines, drones, etc.

Figure 1.1 Actual diagram of the UWB Tag handheld development board

1.2 Introduction to the UWB Mini 3 module

UWB Mini 3 module adopts STM32F105 microcontroller as the main control chip. Peripheral circuits include: DWM1000 module, power module, LED indication module, DIP switch, reset circuit, etc. The module can be used both as a base station and as a tag, switching via DIP switches.
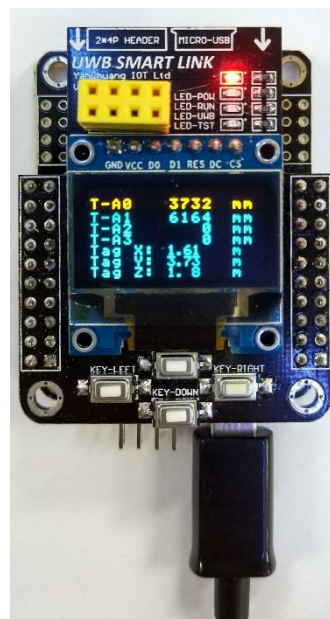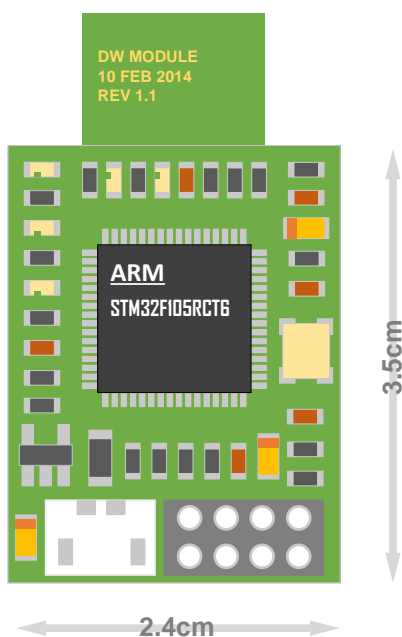

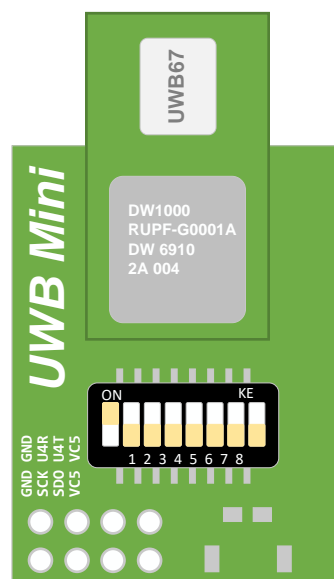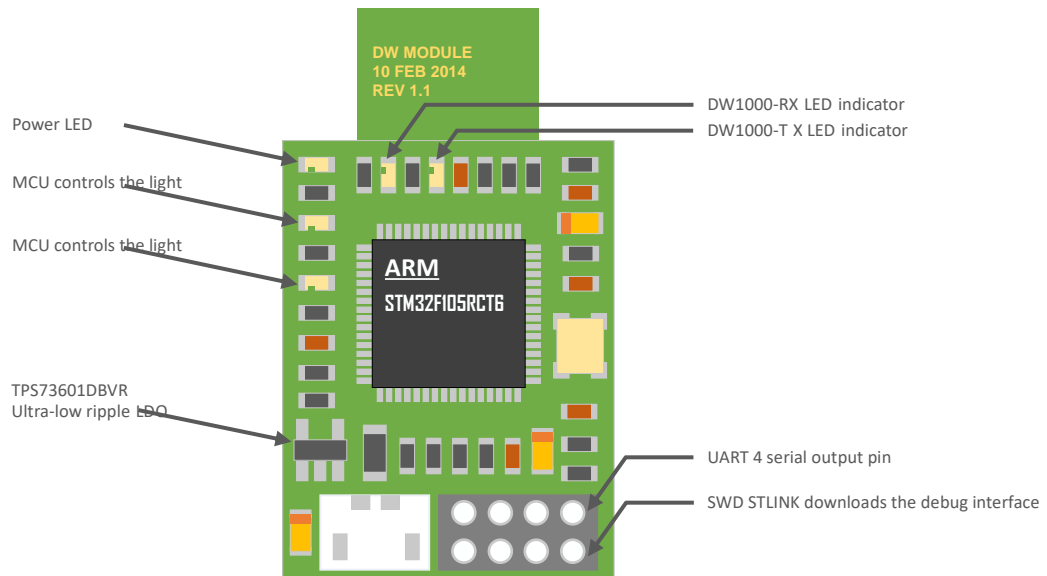**Figure 1. 2.1 UWB Mini3 frontal view**

Figure 1. 2.2 UWB Mini3 back picture

1.3 UWB Nano module introduction

UWB Nano module adopts STM32F103T8U6 microcontroller as the main control chip. The Nano series is a research and innovation IoT micro-small device, and its mini shape is very suitable for the development of portable devices, such as UWB portable tags, UAV UWB formation. UWB NANO MODULE PERIPHERAL CIRCUITS INCLUDE: DWM1000 module, power module, LED indicator module, etc. The module can be used as a base station or as a tag, switching by sending serial AT command switches.

1.4 Introduction to the development environment

The software development and compilation platform is KEIL version 5.20, and the firmware library adopts STM32 KEIL standard library V3 5. Writing. The language is standard C. Please reserve at least 1G of computer hard disk space to install the software, and see Chapter 4 for the installation process of developing the software.

1.5 Glossary of professional terms

Table 1.5 Glossary of terminology

Shorthand	Full name in English	meaning
ANCHOR		A base station, also known as a beacon anchor, is a node that obtains location coordinates in advance by other means
DW1000		A chip from Decawave
DWM1000		A module from Decawave
IC	integrated circuit	chip
PHY	physical layer	Physical layer
PSR	preamble symbol repetitions	The leading symbol repeats
RTLS	real time location system	Real-time location system
DAY		label
TX	receive	reception
TCXO	temperature compensated crystal oscillator	Temperature compensated crystal oscillator
TDOA	time difference of arrival	TDOA positioning is a method of positioning that takes advantage of time differences. By measuring the time it takes for the signal to reach the monitoring station, the distance to the signal source can be determined.
TOA	time of arrival	TOA localization is a method of positioning directly using the time of arrival of the signal.
TOF	time of flight	TOF time-of-flight ranging method, which mainly measures the distance between nodes using the flight time of the signal to and from two asynchronous transceivers (or reflective surfaces).
TX	transmit	Send
TWR	two-way ranging	Bidirectional ranging method, that is, two asynchronous

www.ychiot.com

		transceivers (Transceiver) can obtain ranging values.
UWB	ultra-wide band	UWB (Ultra Wideband) is a carrierless communication technology that transmits data using nanosecond to picosecond non-sine wave narrow pulses.

www.ychiot.com

2 Data reading and analyzing

The control idea of this software can be divided into three steps: TOF Message Report serial port data analysis, Trilateration algorithm calculation, OLED liquid crystal display.

2.1   TOF Message Report Serial port data analysis

The data format sent from the UWB module is:

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 2.1 TOF data format table

content	function
MID	Message ID, there are three types, namely mr, mc, ma MR stands for Label-Base Station Distance (Native Data) mc stands for Tag-Base Station Distance (optimized corrected data for positioning labels) MA stands for Base Station-Base Station Distance (corrected and optimized for base station automatic positioning)
MASK	INDICATES WHICH MESSAGES ARE VALID FOR RANGE0, RANGE1, RANGE2, RANGE3; For example, MASK=7 (0000 0111) means that RANGE0, RANGE1, RANGE2 are all valid
RANGE0	If MID = mc or mr, it represents the distance from label x to base station 0 in millimeters
RANGE1	If MID = mc or mr, it represents the distance from label x to base station 1 in millimeters If MID = ma, it represents the distance from base station 0 to base station 1 in millimeters
RANGE2	If MID = mc or mr, it indicates the distance from label x to base station 2 in millimeters If MID = ma, it represents the distance from base station 0 to base station 2 in millimeters
RANGE3	If MID = mc or mr, it indicates the distance from label x to base station 3 in millimeters If MID = ma, it represents the distance from base station 1 to base station 2 in millimeters
NRANGES	Unit raw range count value (accumulates continuously).
RSEQ	Range sequence number count values (which accumulate over time).
DEBUG	If MID=ma, it represents TX/RX antenna delay
aT:A	T is the tag ID and A is the base station ID The ID mentioned here is just a short ID, and the full ID is a 64-bit ID

In order to ensure that the data of serial communication is received in time and reliably, and other tasks are not affected, the UART serial communication mode based on the combination of DMA and interrupt mode is adopted. Using the exclusive DMA transmission idle interrupt method, the content Rang0 / Rang1 / Rang2   /   Rang3 in the table   is parsed out and stored in the variable Range_deca[0] / Range_deca[1] / Range_deca[2] /   Range_deca[3]。   DMA is an abbreviation for Direct Memory Access, which means "Memory Direct Access", which is a high-speed data transfer operation that allows data to be read/written directly between external devices and memory, i.e. without CPU intervention or CPU intervention. The entire data transfer operation is carried out under the control of a controller called a DMA controller. The CPU can do other work during the transfer process except for a little processing at the beginning and end of the data transfer.

2.2   Trilateration algorithm calculation

2.2.1   Theoretical basis of trilateration method based on UWB ranging

The principle of trilateration is shown in the figure on the right, with three nodes A, B, C as the center of the circle as a circle, the coordinates are respectively, these three circumferences intersect at a point D, the intersection point D is the moving node, A, B, C is the reference node, and the distance between A, B, C and the intersection point D is ,,。   Suppose the coordinates of the intersection point D are $\left(X_a,\ Y_a\right)$, $\left(X_b,\ Y_b\right)$, $\left(X_c,\ Y_c\right) d_a d_b d_c (X, Y)$.

$$\begin{cases} \sqrt{(X-X_a)^2+(Y-Y_a)^2}=d_a \\ \sqrt{(X-X_b)^2+(Y-Y_b)^2}=d_b \\ \sqrt{(X-X_c)^2+(Y-Y_c)^2}=d_c \end{cases} \qquad (2.2.1.1)$$

From Equation 2.2.1.1 we can get that the coordinates of the intersection point D are :

$$\begin{pmatrix} X \\ Y \end{pmatrix} = \begin{pmatrix} 2(X_a - X_c) & 2(Y_a - Y_c) \\ 2(X_b - X_c) & 2(Y_b - Y_c) \end{pmatrix}^{-1} \begin{pmatrix} X_a^2 - X_c^2 + Y_a^2 - Y_c^2 + d_c^2 - d_a^2 \\ X_a^2 - X_c^2 + Y_b^2 - Y_c^2 + d_c^2 - d_b^2 \end{pmatrix} \qquad (2.2.1.2)$$

The disadvantage of the trilateration method is: because the hardware and power consumption of each node are not the same, the measured distance cannot be the ideal value, resulting in the above three circles may not be exactly intersected at one point, in practice, it must be intersected in a small area, so the (X, Y) coordinate value calculated by this method has a certain error. In this way, a relatively ideal position needs to be estimated by a certain algorithm as the optimal solution of the coordinates of the current moving node.

2.2.2 Trilateration Function

IN *POSICAL In the c* file, the function GetLocation() implements the function of passing in the coordinates of the base station (unit: m) and the distance from each base station to the label (unit: mm), and calculating the Tag *Best Solution* (unit: m). where the function that completes the calculation is, *result = GetLocation(&report, 0, &anchorArray[0], &Range_deca[0]);*

As mentioned in the previous section, because the measured distance cannot be an ideal value, resulting in the above three circles may not be exactly intersected at one point, so when the base station A0/A1/A2 is working, from a mathematical point of view, there will be 2 solutions; When there is A0/A1/A2/A3 in operation, there must be an optimal solution. A3 as an auxiliary base station, after completing the Trilateration algorithm in A0/A1/A2, two solutions are obtained, and the solution closest to the A3 sphere is taken as the optimal solution.

After the algorithm is calculated, there is no software filtering, and developers can customize and develop the filtering algorithm (Kalman filter, median filter, first-order filter, etc.) according to actual needs.

2.3 OLED liquid crystal display

The hardware adopts OLED as the display module, which is a small size (0.96 inch), high-brightness, high-performance OLED display module with a boost circuit, with a resolution of 128*64, the module adopts the original Visionox high-brightness OLED screen, using SSD1306 driver IC, the chip integrates DCDC boost, only 3.3V power supply, can work normally, no need for users to add boost DCDC circuit. Communicate with STM32 through the SPI interface. The LCD screen displays the following contents:

T-A0	1000	mm
T-A1	1000	mm
T-A2	1000	mm
T-A3	1000	mm
Day X:	0.74	m
Tag Y:	0.74	m
Day Z:	2.00	m

Figure 2.3 OLED liquid crystal display content

3　Using method

3.1　Connect the UWB module

Flash the UWB Mini 3 module or UWB Nano X1 module into the firmware version with serial port output capability, UWB Mini3, download the new firmware "DecaRangingEVB1000_Ver20170310_Beta3" in Baidu cloud network disk, and update the UWB module firmware with STLINK. UWB NANO SERIES, PLEASE FLASH THE FIRMWARE "Nano_X1_20170324". Through the pin header-female interface, the handheld is docked with the UWB module, and the specific connection method is shown in the figure below.
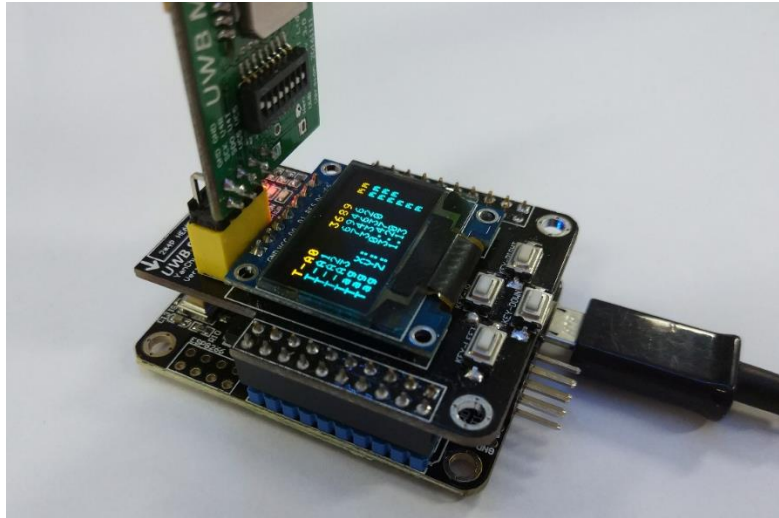
Figure 3.1 Physical diagram of　UWB module connected to handheld

3.2　Handheld power supply

The handheld has a Micro-USB interface, which can be used directly by users who already have a UWB Mini3 mobile power bank.

3.3　tag Enter the coordinate information of the base station

Follow step 4.3 to open the Keil Engineering software. In addition, according to the placement of the actual base station, modify the actual coordinates of the base station A0　/　A1 / A2 / A3. This step solidifies the information of the base station into the program of the Tag handheld, and after this setting, as long as the relative position of the base station does not change, the program of the Tag handheld does not need to change. Follow Step 4.4 to update the firmware for the Tag handheld.

Figure 3.3　Modifying the XYZ coordinates of each base station in the Keil project

3.4　Test results

Move the Tag handheld into the coverage area of the base station, and the Tag handheld will start to automatically resolve the distance and coordinate calculation.　The calculation result is consistent with the calculation result of the PC computer.

4 KEIL 5 installation and development steps

4.1 Develop software

Two pieces of software are required, the Keil5 installation software *mdk520* and Keygen *Keygen*. Please note that enterprise users are requested to purchase genuine Keil software, and the company will not bear any consequences if there is a legal dispute caused by the use of *Keygen*.

4.2 Install KEIL 5

Double-click mdk511 to start the installation until it is completed, and the installation prompt of the pack will automatically pop up;
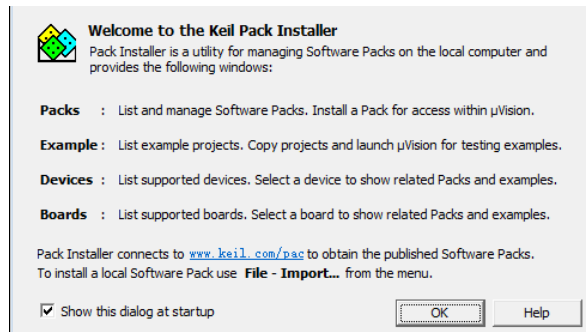
图 4.2.1 Pack Installer 图

Click OK to enter the package installation interface (t does not pop up, press). In the Pack column, all the types of single-chip microcomputers are listed, and there is an Install button on the right side of each one, to develop which single-chip microcomputer, click the corresponding Install, and the corresponding package will be automatically installed.

This hardware uses STM32F103C8T6 microcontroller, so, in the left column, select *STM32F103C8T6*, the project package that must be downloaded is:

- *ARM::CMSIS* project package, otherwise all microcontrollers will not work.

- *Wedge::ARM_Complier*
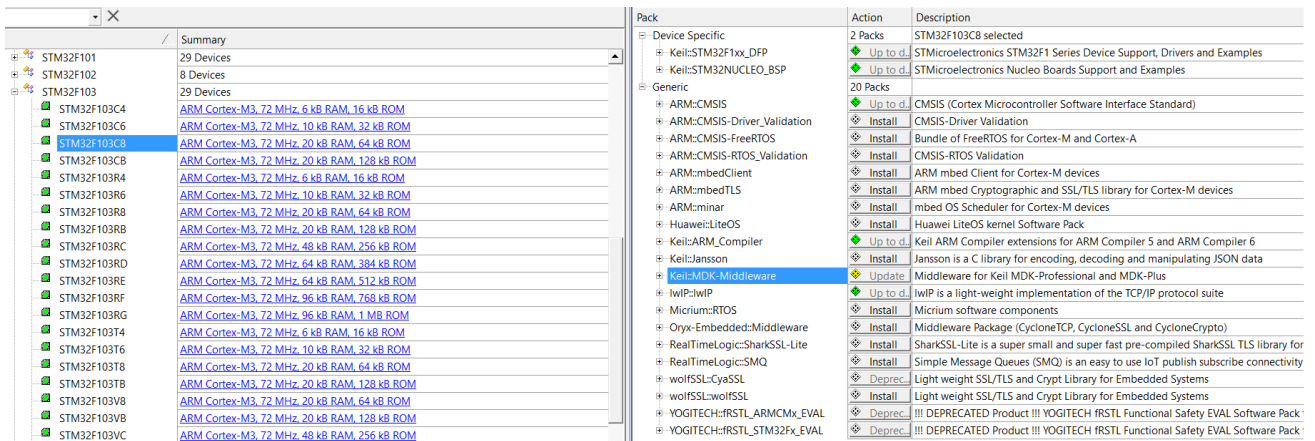
- *Keil::MDK-Middleware*

- *Wedge::STM32F1xx_DFP*

Figure 4.2.2 Firmware library installation and selection

You can also install it manually, find the single-chip microcomputer model to be developed, the summary bar will appear blue words, click will automatically link to the download page. Click the *DownLoad* button to download, double-click the downloaded Keil.STM32F1xx_DFP.2 1.0, start the installation, the same effect as the previous automatic installation.

Figure 4.2 3 Install the Device Pack manually

4.3   Open the project

Under *the Project->MDK* folder, open Project Project, and the interface is shown in the following figure.
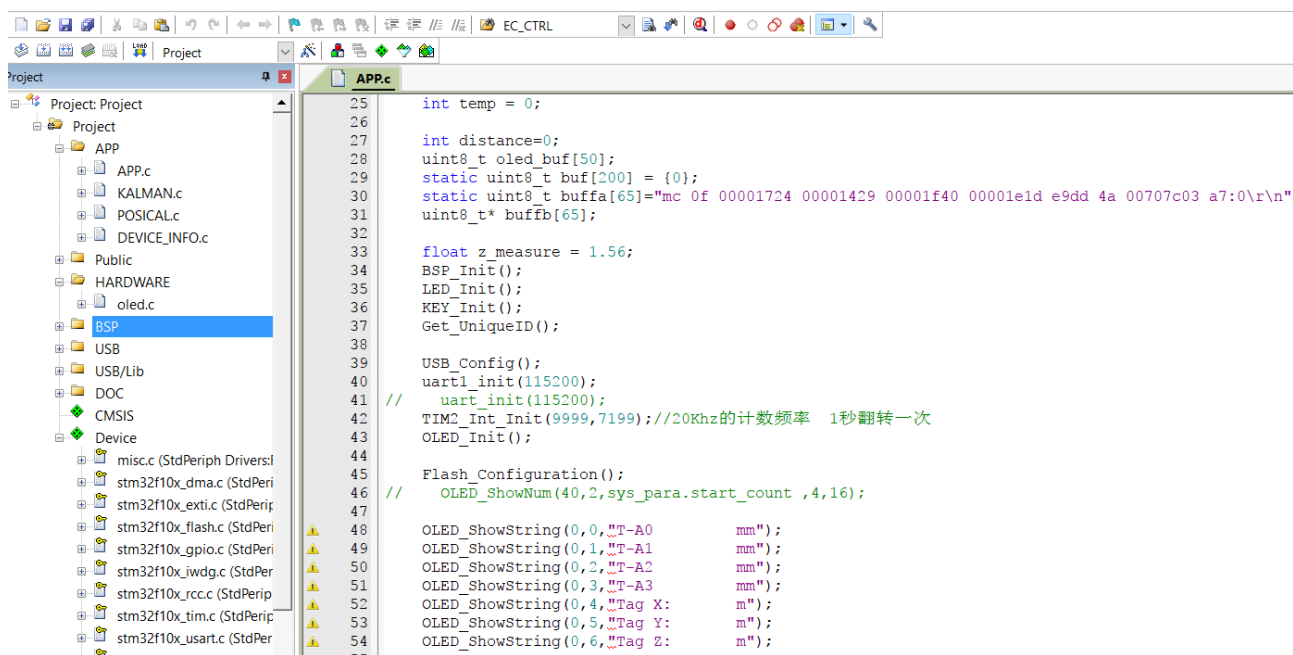

Figure 4.3 Developing the project file interface

4.4   Compile and download

In *Target*->D ebug, select the downloader as ST-LINK *Debugger*, set the hardware emulation to ST-Link, and click *Settings* , SWD download method, speed is 4M.
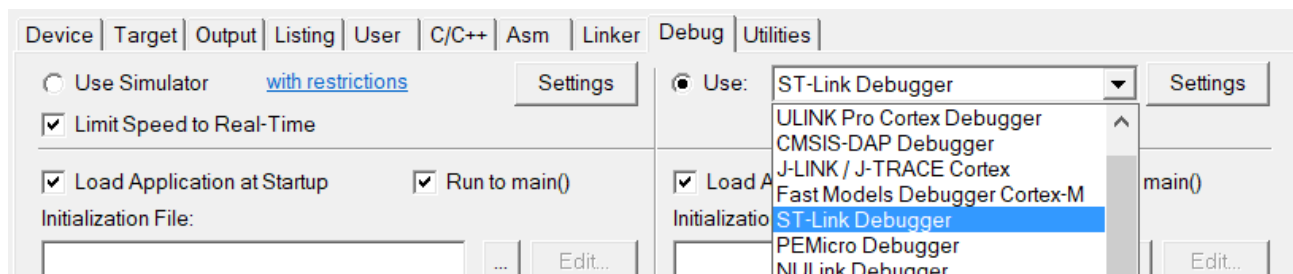

Figure 4.4.1 Downloader settings

When finished, close it, click " d" to complete the compilation; Clic ⟨LOAD⟩ wnload" to consider the download successful.

5 Document Management Information Sheet

topic	YCHIOT UWB Tag portable instrument datasheet
version	V1.0
Reference documentation	KEIL MDK Help Manual UWB Mini3 User Manual V3.3.1
Creation time	2017/4/23
Created by	Zhipeng Wu / Lynn
The latest release date	2017/4/23

Change the person	date	Document change history
Lynn	2017/4/23	YCHIOT UWB Tag portable instrument datasheet V1.0

www.ychiot.com