

# Ultrasonic ranging

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## Ultrasonic ranging

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**This tutorial demonstrates: How to connect an external expansion board and use the ultrasonic module to measure distance and then print the data through the serial port.**

## 1. Software-Hardware

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- **STM32F103CubeIDE**
- **STM32 expansion board**
- **Ultrasonic Module**
- **Type-C data cable or ST-Link**

Download programs or simulate the development board.

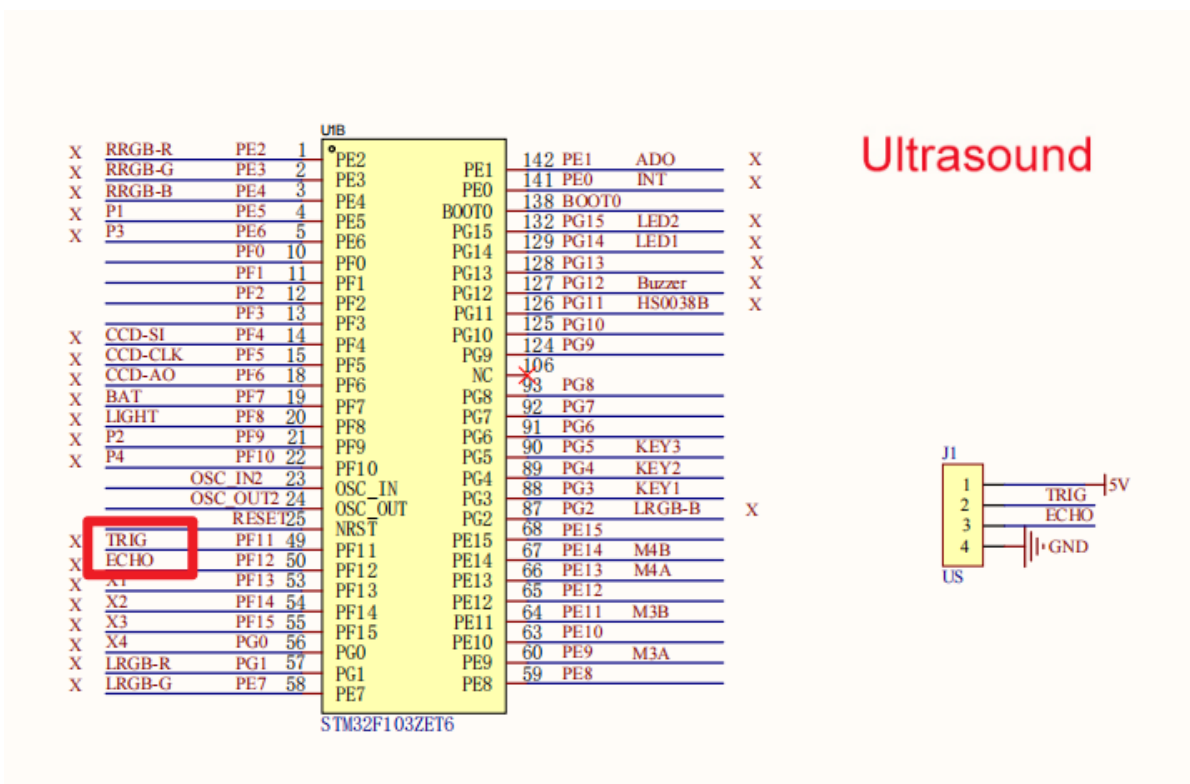
- **Serial Assistant**

Receive serial port data and print

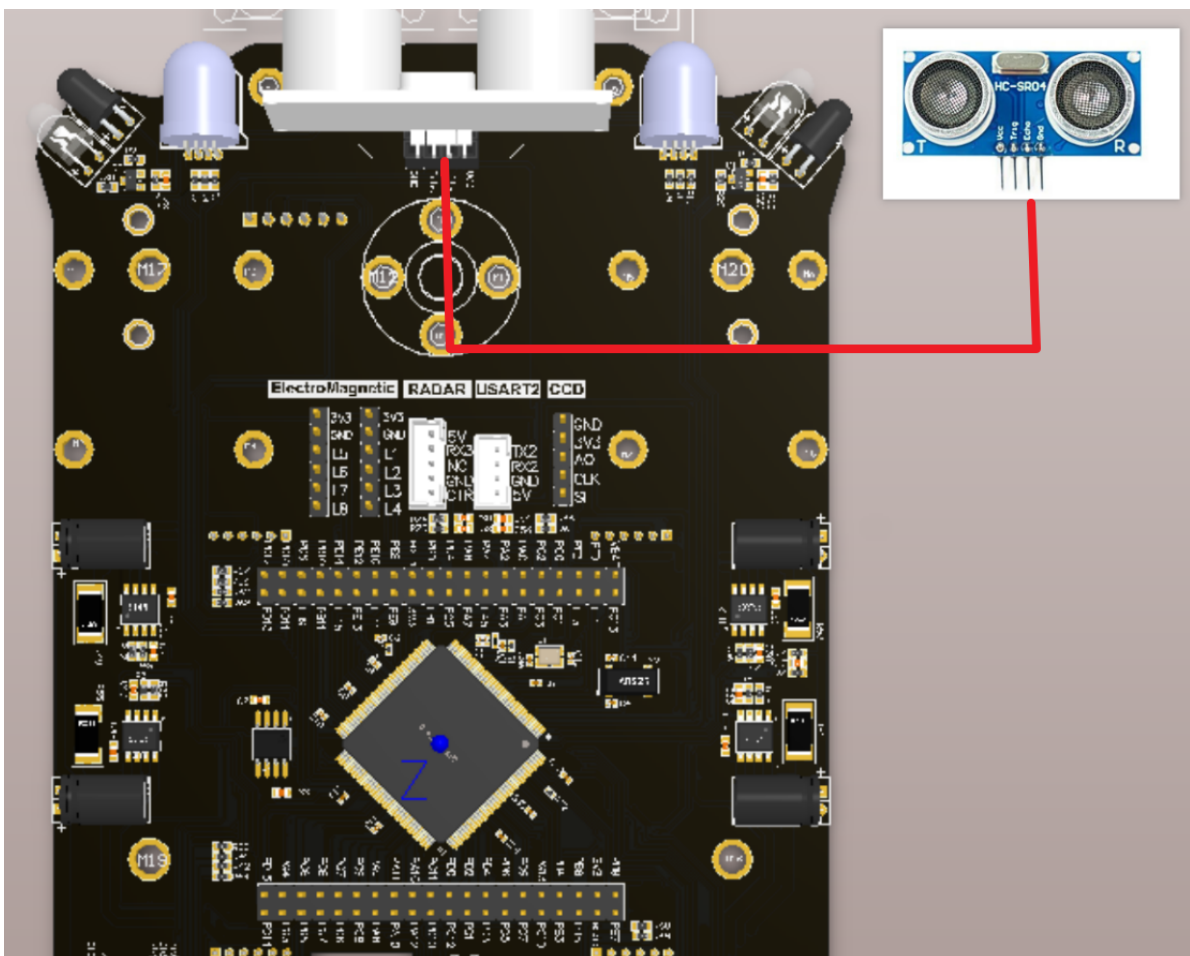
## 2. Brief principle

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### 1. Hardware schematic diagram



## 2、Physical connection diagram



### 3. Control principle

(Schematic name)	Control pin	Specific meaning
TRIG	PF11	Trigger terminal
ECHO	PF12	Receiver

#### Ultrasonic Module:

It is a module that uses ultrasonic waves for non-contact physical quantity measurement. It can accurately measure distance, speed, flow and other physical quantities by transmitting and receiving ultrasonic signals, and converts the measurement results into digital signal output. This article will popularize the ultrasonic module Its working principle and function.

**The types of ultrasonic modules on the market are mainly divided into the following categories:**

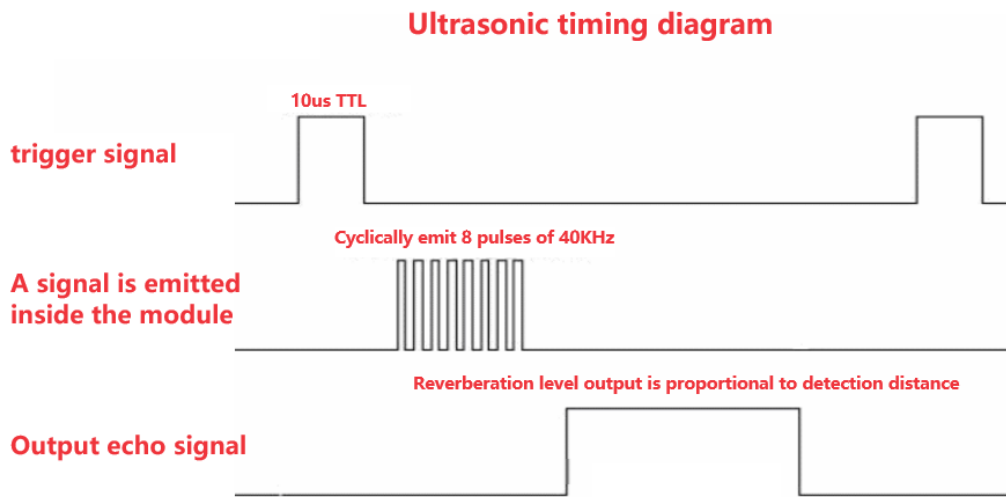
- HC-SR04 ultrasonic module
- US-100 ultrasonic module
- US-015 ultrasonic module
- HY-SRF05 ultrasonic module
- HC-SR04 ultrasonic ranging module

#### Ultrasonic module information for this experiment:

Model	HC-SR04	Detection distance	2-400cm
Working voltage	5V	High precision	Up to 0.3cm
Operating current	15mA	Dead zone	2cm
Operating frequency	40KHz	Pin sequence	VCC, Trig (control end), Echo (receiving end), GND
Quiescent operating current	<2mA	Input trigger signal	10uS TTL pulse
Sensing angle	Not greater than 15°	Input echo signal	Output TTL level signal, proportional to range
Range range	2cm-4m (peak)	Level output	TTL level

**Ranging principle:** Input a high potential for more than 10 microseconds at the trigger end of the ultrasonic module to emit ultrasonic waves. After transmitting the ultrasonic waves and before receiving the returned ultrasonic waves, the receiving end is at a high potential. Therefore, the program can calculate the distance of the measured object from the high pulse duration of the "response" pin.

**Test distance = (high level time \* speed of sound (340M/S))/2;**



**Note:** The above timing diagram shows that you only need to provide a pulse trigger signal of more than 10µs, and the module will internally send out 8 40kHz cycle levels and detect echoes. Once an echo signal is detected, an echo signal is output. The pulse width of the reverberated signal is proportional to the measured distance. The distance can be calculated from the time interval between the transmitted signal and the received echo signal.

## 3. Project configuration

### 1. Description

Omitted project configuration part: **New project, chip selection, project configuration, SYS of pin configuration, RCC configuration, clock configuration and project configuration** content


Please refer to [2. Development environment construction and use: STM32CubeIDE installation and use] to understand how to configure the omitted parts of the project.

### 2. Pin configuration

re Packs

Pinout

Pinout viewSystem view











# STM32F103ZETx

## LQFP144

PA1	PC4	PC5	PB0	PB1	PB2	PF11	PF12	VSS	VDD	PF13	PF14	PF15	PG0	PG1	PE7	PE8	PE9	VSS	VDD	PE10	PE11	PE12	PE13	PE14	PE15	PB10	PB11	VSS	VDD
						TRIG	ECHO																						

PG6	PG5	PG4	PG3	PG2	PD15	PD14	VDD	VSS	PD13	PD12	PD11	PD10	PD9	PD8	PB15	PB14	PB13	PB12
-----	-----	-----	-----	-----	------	------	-----	-----	------	------	------	------	-----	-----	------	------	------	------



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Categories

System C... ▾

DMA

**GPIO**

IWDG

NVIC

✓ RCC

✓ SYS

WWDG

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### GPIO Mode and Configuration

Configuration

Group By Peripherals ▾

☒ GPIO
 ☒ RCC
 ☒ SYS

Search Signals

Search (Ctrl+F)

☐ Show only Modified Pins

Pin Na...	Signal on ...	GPIO outp...	GPIO mode	GPIO Pull...	Maximum ...	User Label	Modified
PF11	n/a	High	Output Pu...	No pull-up...	High	TRIG	<input checked="" type="checkbox"/>
PF12	n/a	n/a	Input mode	No pull-up...	n/a	ECHO	<input checked="" type="checkbox"/>

PF11 Configuration :

GPIO output level

GPIO mode

GPIO Pull-up/Pull-down

Maximum output speed

User Label

High

Output Push Pull

No pull-up and no pull-down

High

TRIG

Pinout & Configuration

Clock Configur

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NVIC Mode and Configuration

Configuration

✓ NVIC

✓ Code generation

Priority Group .. ▼

☐ Sort by Preemption Priority and Sub Priority

☐ Sort by interrupts names

Search

⌕

Show

available interrupts ▼

✓ Force DMA channels Interru

NVIC Interrupt Table	Enabled	Preemption Priority	Sub Prior
Non maskable interrupt	✓	0	0
Hard fault interrupt	✓	0	0
Memory management fault	✓	0	0
Prefetch fault, memory access fault	✓	0	0
Undefined instruction or illegal state	✓	0	0
System service call via SWI instruction	✓	0	0
Debug monitor	✓	0	0
Pendable request for system service	✓	0	0
Time base: System tick timer	✓	2	0
PVD interrupt through EXTI line 16	<input type="checkbox"/>	0	0
Flash global interrupt	<input type="checkbox"/>	0	0
RCC global interrupt	<input type="checkbox"/>	0	0
USART1 global interrupt	<input type="checkbox"/>	0	0
TIM7 global interrupt	✓	1	1

☐ Enabled

Preemption Priority

▼

Sub Priority

▼

**NVIC Mode and Configuration**

**Configuration**

☒ NVIC
 ☒ Code generation

Enabled interrupt table	Select for init sequen...	Generate Enable...	Generat...	Call HAL h...
Non maskable interrupt	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Hard fault interrupt	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Memory management fault	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Prefetch fault, memory acc...	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Undefined instruction or ille...	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
System service call via SW...	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Debug monitor	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Pendable request for syste...	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Time base: System tick ti...	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
TIM7 global interrupt	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

Interrupt unmasking ordering table (interrupt init code is moved after all the peripheral init code)

Rank	Interrupt name
------	----------------



Pinout & Configuration

Clock Configuration

Software

A-Z

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Timers >

RTC

TIM1

TIM2

TIM3

TIM4

TIM5

TIM6

✓

TIM7

TIM8

Connectivity >

Multimedia >

Computing >

Middlewar... >

TIM7 Mode and Configuration

Mode

✓

Activated

One Pulse Mode

Configuration

Reset Configuration

✓

Parameter Settings

✓

User Constants

✓

NVIC Settings

✓

DMA Settings

Configure the below parameters :

Search (Ctrl+F)

Counter Settings

Prescaler (PSC - 16 bits value)

71

Counter Mode

Up

Counter Period (AutoReload Register - ...)

9

auto-reload preload

Disable

Trigger Output (TRGO) Parameters

Trigger Event Selection

Reset (UG bit from TIMx\_EGR)

Pinout & Configuration

Clock Configuration

Software

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TIM7 Mode and Configuration

Mode

☒ Activated

☐ One Pulse Mode

Configuration

Reset Configuration

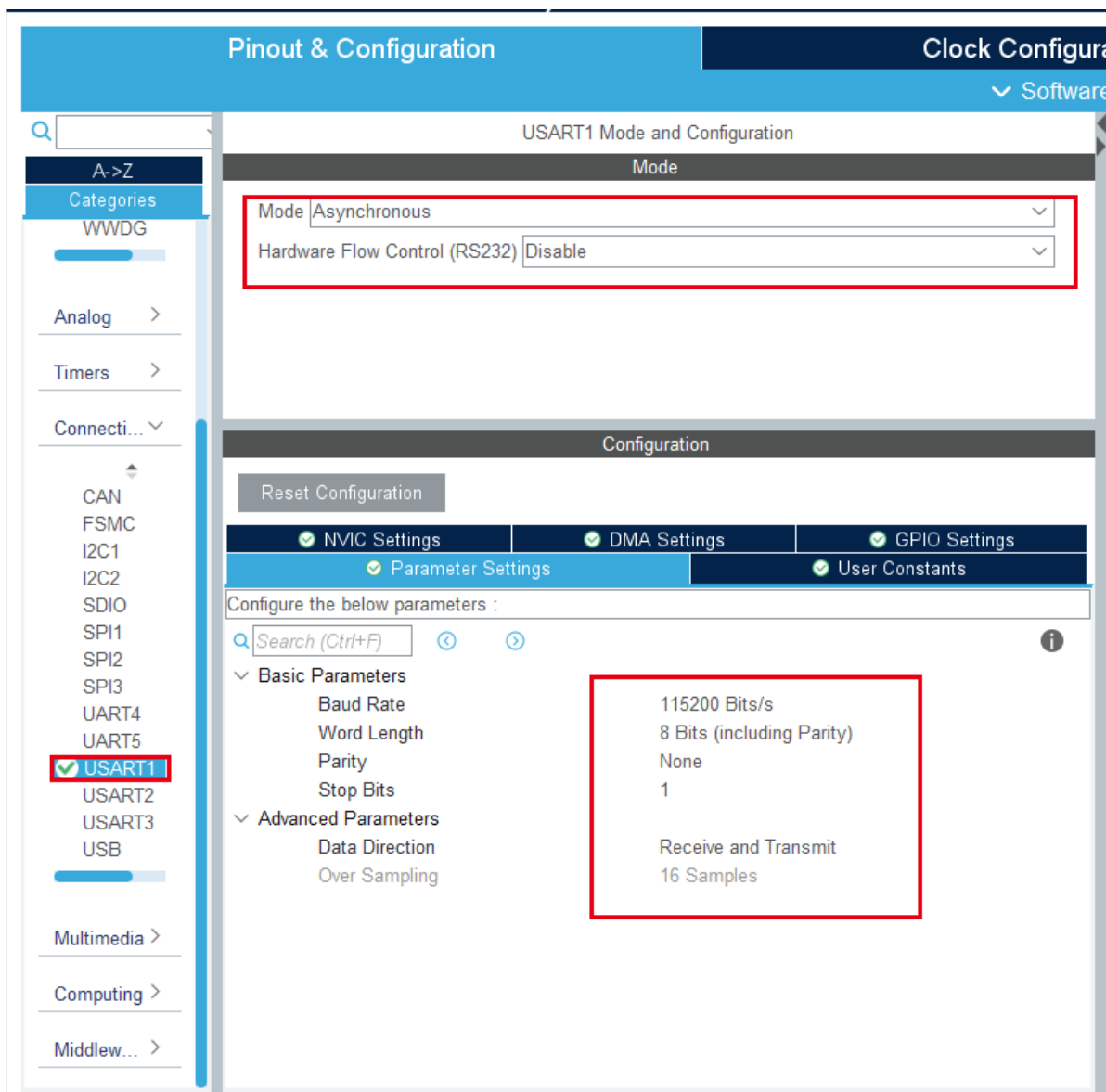
Parameter Settings

User Constants

NVIC Settings

DMA Settings

NVIC Interrupt Table	Enabled	Preemption Priority	Sub Priority
TIM7 global interrupt	<input checked="" type="checkbox"/>	1	1



## 4. Main functions

According to our tutorial STM32CubeIDE can generate the corresponding gpio.c, gpio.h, tim.c and tim.h files. For later transplantation and peripheral module driver, we will place the automatically generated code in the BSP under the project file. folder.

### 1. User function

**Function: Ultrasonic\_GPIO\_Init**

<b>Function prototype</b>	<b>void Ultrasonic_GPIO_Init(void)</b>
Function description	<b>Ultrasonic pin initialization</b>
Input parameters	<b>None</b>
Output parameters	<b>None</b>

**Function: Get\_distance**

<b>Function prototype</b>	<b>float Get_distance(void)</b>
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<b>Function prototype</b>	<b>float Get_distance(void)</b>
Function description	<b>Ultrasonic range detection</b>
Input parameters	<b>None</b>
Output parameters	<b>Output distance</b>

#### Function: Bsp\_TIM7\_Init

<b>Function prototype</b>	<b>void Bsp_TIM7_Init(void)</b>
Function description	<b>Open timer terminal</b>
Input parameters	<b>None</b>
Output parameters	<b>None</b>

## 5. Experimental phenomena

After downloading the program, you need to place obstacles in the direction facing the ultrasonic module. Open the serial port assistant and set the parameters as shown in the figure below. Then we can use the serial port assistant to view the measured ultrasonic distance.

For program download, please refer to [2. Development environment construction and use: program download and simulation]

The effect is as follows:

