

# Ultrasonic Ranging

## Ultrasonic Ranging

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This tutorial demonstrates: how to externally connect and use an ultrasonic module on the expansion board for ranging and display data on OLED.

## 1. Software and Hardware

- KEIL5
  - MSPM0G3507 Expansion Board
  - Ultrasonic Module
  - Type-C data cable or DAP-Link

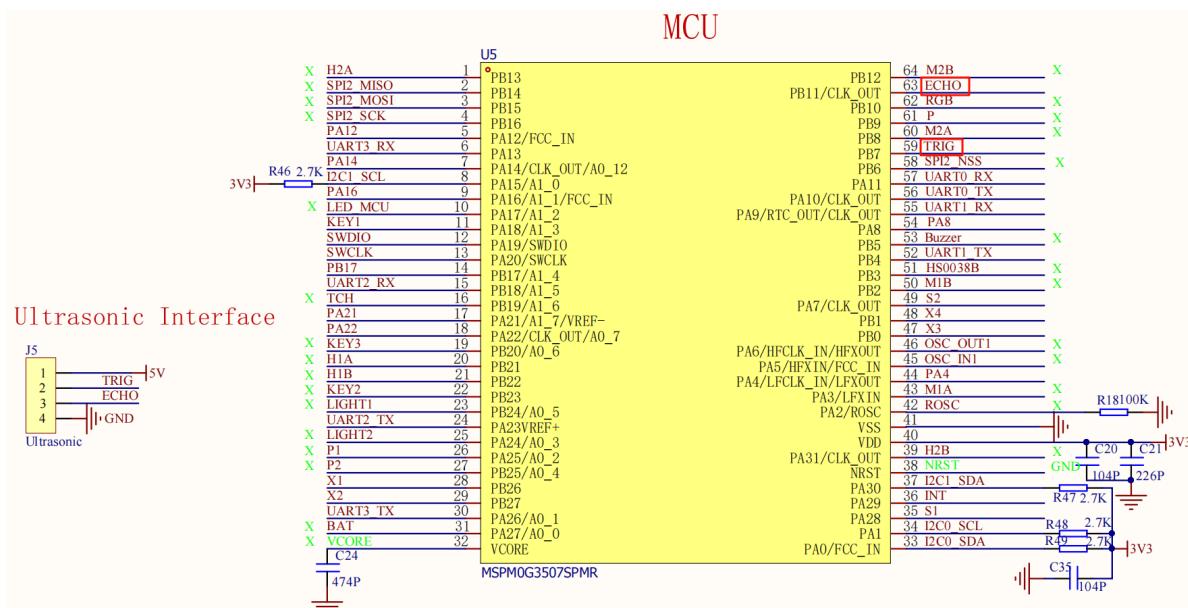
For programming download or simulation to the development board

- **Serial Port Assistant**

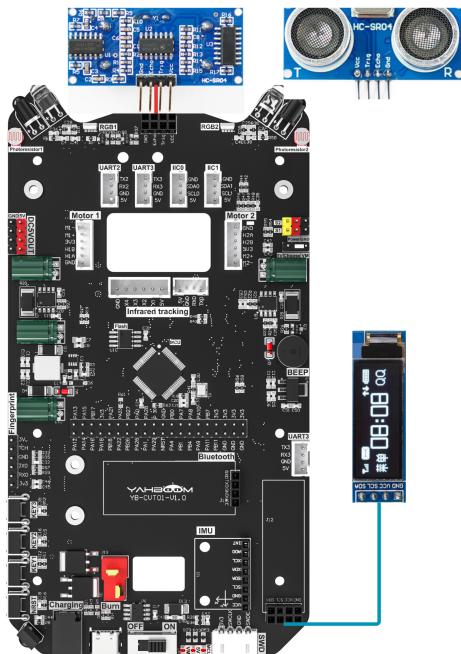
## Receive and print serial port data

## 2. Basic Principles

## 2.1 Hardware Schematic



## 2.2 Physical Connection Diagram



## 2.3 Control Principle

(Schematic Name)	Control Pin	Specific Meaning
TRIG	PB7	Trigger End
ECHO	PB11	Receiver End

### Ultrasonic Module:

It is a module that uses ultrasonic waves for non-contact physical quantity measurement. It can accurately measure physical quantities such as distance, speed, and flow rate by emitting and receiving ultrasonic signals, and convert the measurement results into digital signal outputs. This article will explain the working principle and function of the ultrasonic module.

### Main types of ultrasonic modules on the market:

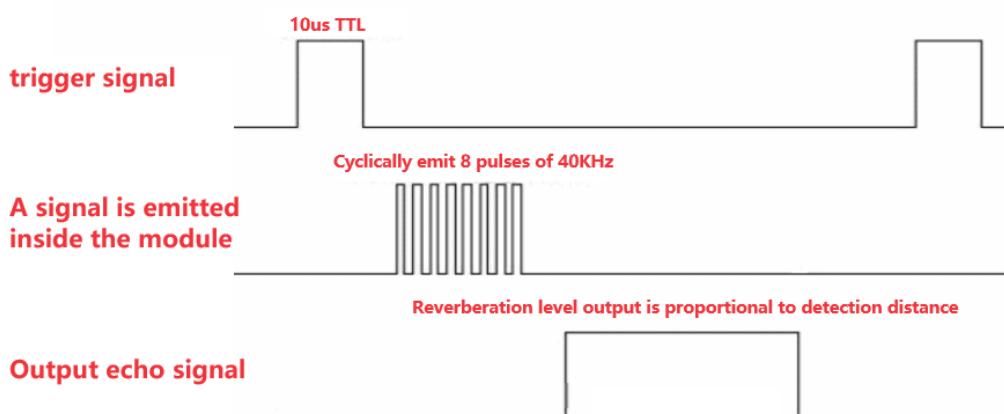
- HC-SR04 Ultrasonic Module
- US-100 Ultrasonic Module
- US-015 Ultrasonic Module
- HY-SRF05 Ultrasonic Module
- HC-SR04 Ultrasonic Ranging Module

### This experiment's ultrasonic module information:

Model	HC-SR04	Detection Distance	2-400cm
Working Voltage	5V	High Precision	Up to 0.3cm
Working Current	15mA	Blind Zone	2cm
Working Frequency	40KHz	Pin Wiring Sequence	VCC, Trig (Control End), Echo (Receiver End), GND
Static Working Current	<2mA	Input Trigger Signal	10uS TTL pulse
Detection Angle	Not more 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 of more than 10 microseconds at the trigger end of the ultrasonic module to emit ultrasonic waves. After emitting the ultrasonic waves and before receiving the returned ultrasonic waves, the receiver end is at high potential. Therefore, the program can calculate the distance of the measured object from the high-level pulse duration of the "response" pin. **Test Distance = (High Level Time \* Sound Speed (340M/S)) / 2;**

**Ultrasonic timing diagram**



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

### 3. Project Configuration

## 3.1 Description

You can refer to the basic tutorial to complete the development environment setup.

## 3.2 Pin Configuration

The screenshot shows the MSP430 Pin Configuration tool interface. The left sidebar lists various peripheral modules and their sub-components. The right panel shows the configuration for two specific modules: OLED and SR04. The OLED configuration includes fields for Name (OLED), Port (PORTA), and Port Segment (Any). The SR04 configuration includes fields for Name (SR04), Port (PORTA), and Port Segment (Any). Below these, there are sections for Group Pins (with SCL1 and SDA1 selected), Digital IOMUX Features (with Assigned Port set to PORTA, Assigned Port Segment set to Any, and Assigned Pin set to 15), Interrupts/Events (with LaunchPad-Specific Pin set to No Shortcut Used), PinMux Peripheral and Pin Configuration, and Other Dependencies.

FILE ABOUT

Type Filter Text... X

PROJECT CONFIGURATION... Project Config... 1/1 ✓ +

MSP430 DRIVER LIBRARY ...

SYSTEM (9)

Board 1/1 ✓ +

Configuration NVM +

DMA +

GPIO 4 ✓ +

MATHACL +

RTC +

SYSCTL 1/1 ✓ +

SYSTICK 1/1 ✓ +

WWDT +

ANALOG (6)

ADC12 +

COMP +

DAC12 +

GPAMP +

OPA +

VREF +

COMMUNICATIONS (6)

I2C +

I2C - SMBUS +

MCAN +

SPI 1/2 ✓ +

UART 1/4 ✓ +

UART - LIN +

TIMERS (6)

TIMER 2/7 ✓ +

TIMER - CAPTURE +

TIMER - COMPARE +

TIMER - PWM +

TIMER - QEI +

Timer Fault +

OLED

SR04

Name: OLED

Port: PORTA

Port Segment: Any

Group Pins:

2 added

+ ADD - REMOVE ALL

SCL1

SDA1

Name: SCL1

Direction: Output

Initial Value: Set

IO Structure: Any

Digital IOMUX Features

Assigned Port: PORTA

Assigned Port Segment: Any

Assigned Pin: 15

Interrupts/Events

LaunchPad-Specific Pin: No Shortcut Used

PinMux Peripheral and Pin Configuration

Other Dependencies

Type Filter Text... X ← → Software > GPIO

PROJECT CONFIGURATION... Project Config... 1/1 ✓ +

MSP400 DRIVER LIBRARY... SYSTEM (9)

- Board 1/1 ✓ +
- Configuration NVM +
- DMA +
- GPIO 4 ✓ +

MATHACL +

RTC +

SYSCTL 1/1 ✓ +

SYSTICK 1/1 ✓ +

WWDT +

ANALOG (6)

- ADC12 +
- COMP +
- DAC12 +
- GPAMP +
- OPA +
- VREF +

COMMUNICATIONS (6)

- I2C +
- I2C - SMBUS +
- MCAN +
- SPI 1/2 ✓ +
- UART 1/4 ✓ +
- UART - LIN +

TIMERS (6)

- TIMER 2/7 ✓ +
- TIMER - CAPTURE +
- TIMER - COMPARE +
- TIMER - PWM +
- TIMER - QEI +
- Timer Fault +

OLED ✓

SR04 ✓

Name OLED

Port PORTA

Port Segment Any

Group Pins

2 added

+ ADD REMOVE ALL

SCL1 ✓

SDA1 ✓

Name SDA1

Direction Output

Initial Value Set

IO Structure Any

Digital IOMUX Features

Assigned Port PORTA

Assigned Port Segment Any

Assigned Pin 30

Interrupts/Events

LaunchPad-Specific Pin No Shortcut Used

PinMux Peripheral and Pin Configuration

Other Dependencies

Type Filter Text... X

Software > GPIO

PROJECT CONFIGURATION... Project Config... 1/1 ✓ +

MSPM0 DRIVER LIBRARY... SYSTEM (9)

- Board 1/1 ✓ +
- Configuration NVM +
- DMA +
- GPIO 4 ✓ +
- MATHACL +
- RTC +
- SYSCTL 1/1 ✓ +
- SYSTICK 1/1 ✓ +
- WWDT +

ANALOG (6)

- ADC12 +
- COMP +
- DAC12 +
- GPAMP +
- OPA +
- VREF +

COMMUNICATIONS (6)

- I2C +
- I2C - SMBUS +
- MCAN +
- SPI 1/2 ✓ +
- UART 1/4 ✓ +
- UART - LIN +

TIMERS (6)

- TIMER 2/7 ✓ +
- TIMER - CAPTURE +
- TIMER - COMPARE +
- TIMER - PWM +
- TIMER - QEI +
- Timer Fault +

OLED ✓

SR04 ✓

Name SR04

Port Any

Port Segment Any

Group Pins

2 added

+ ADD REMOVE ALL

✓ TRIG ✓ ECHO

Name TRIG

Direction Output

Initial Value Set

IO Structure Any

Digital IOMUX Features

Assigned Port PORTB

Assigned Port Segment Any

Assigned Pin 7

Interrupts/Events

LaunchPad-Specific Pin No Shortcut Used

PinMux Peripheral and Pin Configuration

Other Dependencies

Type Filter Text...

PROJECT CONFIGURATION...  Project Config... 1/1

MSP400 DRIVER LIBRARY...

SYSTEM (9)

- Board 1/1
- Configuration NVM
- DMA
- GPIO 4  
  - MATHACL
  - RTC
  - SYSCTL 1/1
  - SYSTICK 1/1
  - WWDT
- ANALOG (6)  
  - ADC12
  - COMP
  - DAC12
  - GPAMP
  - OPA
  - VREF
- COMMUNICATIONS (6)  
  - I2C
  - I2C - SMBUS
  - MCAN
  - SPI 1/2
  - UART 1/4  
    - UART - LIN
- TIMERS (6)  
  - TIMER 2/7  
    - TIMER - CAPTURE
    - TIMER - COMPARE
    - TIMER - PWM
    - TIMER - QEI
    - Timer Fault

Software > GPIO

Infrared\_borad

OLED

SR04

Name	SR04
Port	Any
Port Segment	Any

Group Pins

2 added

TRIG

ECHO

Name	ECHO
Direction	Input
IO Structure	Any

Digital IOMUX Features

Assigned Port PORTB   
Assigned Port Segment Any   
Assigned Pin 11

Interrupts/Events

LaunchPad-Specific Pin No Shortcut Used

PinMux Peripheral and Pin Configuration

Other Dependencies

## 4. Main Functions

### 4.1 User Functions

Function: `Ultrasonic_GPIO_Init`

<b>Function Prototype</b>	<code>void Ultrasonic_GPIO_Init(void)</code>
Function Description	<b>Ultrasonic pin initialization</b>
Input Parameters	<b>None</b>
Output Parameters	<b>None</b>

Function: `Ultrasonic_Printf`

<b>Function Prototype</b>	<b>float Ultrasonic_Printf(void)</b>
Function Description	<b>Print distance through serial port and display on OLED</b>
Input Parameters	<b>None</b>
Output Parameters	<b>None</b>

#### Function: Hcsr04GetLength

<b>Function Prototype</b>	<b>float Hcsr04GetLength(void)</b>
Function Description	<b>Get measured distance</b>
Input Parameters	<b>None</b>
Output Parameters	<b>Measured distance</b>

#### Function: Get\_TIMER\_Count

<b>Function Prototype</b>	<b>uint32_t Get_TIMER_Count(void)</b>
Function Description	<b>Get timer timing time</b>
Input Parameters	<b>None</b>
Output Parameters	<b>Data</b>

## 5. Experimental Phenomenon

After downloading the program, you need to place an obstacle in the direction facing the ultrasonic module. The distance to the obstacle can be viewed through the OLED.

For program download, refer to **【3. Development Environment Setup and Usage: 3. Uniflash burning】**

The effect is as follows:



