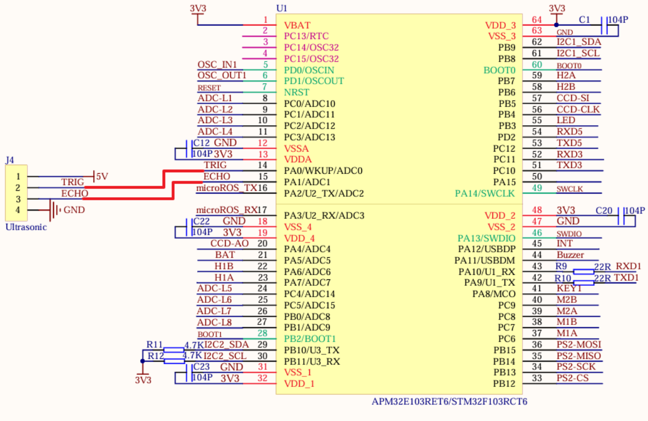
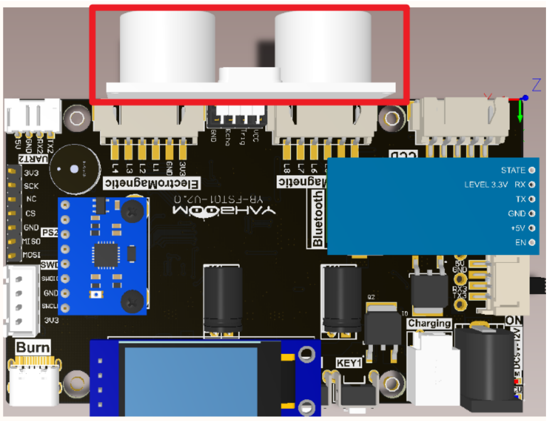
# Ultrasonic module-measuring distance (TIM)

The tutorial mainly demonstrates the implementation of the ultrasonic module distance measurement function.

```
GPIO general push-pull output function triggers the ultrasonic module distance
measurement; timer input capture obtains the ultrasonic high level time, thereby
calculating the obstacle distance.
The tutorial only introduces the standard library project code
```

## Hardware connection

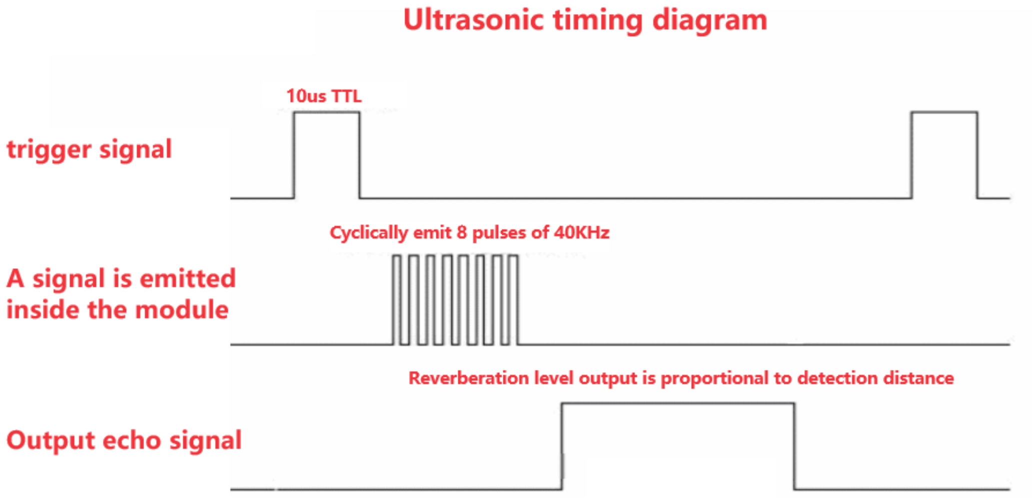




Just install it to the corresponding interface:

| Ultrasonic module | STM32F103RCT6 |
|---|---|
| VCC | 5V |
| TRIG | PA0 |
| ECHO | PA1 |
| GND | GND |

# Control principle


Ultrasonic timing diagram
10us TTL
trigger signal
Cyclically emit 8 pulses of 40KHz
A signal is emitted inside the module
Reverberation level output is proportional to detection distance
Output echo signal

> ### Trigger ranging signal

The TRIG pin sends a high level signal for more than 10us.

```
The ultrasonic module will automatically send 8 40KHz square waves and
automatically detect whether there is a signal return
```

> ### Receive echo signal

If there is a signal return, the ECHO pin will output a high level. The duration of the high level is the time from the ultrasonic wave transmission to the return.

> ### Distance conversion

$$D_{istance} = \frac{T_{high} * V_{speed}}{2}$$

```
T: Echo signal high level time
V: Sound speed (approximately equal to 340m/s)
```

## Pin definition

| Main control chip | Pin | Main function (after reset) | Default multiplexing function | Redefine function |
|---|---|---|---|---|
| STM32F103RCT6 | PA0 | PA0 | WKUP/USART2_CTS/ADC123_IN0/TIM2_CH1_ETR/TIM5_CH1/TIM8_ETR | |
| STM32F103RCT6 | PA1 | PA1 | USART2_RTS/ADC123_IN1/TIM5_CH2/TIM2_CH2 | |

## Software code

Since the default function of all pins is the ordinary IO pin function, we need to use the multiplexing function.

```
Product supporting materials source code path: Attachment → Source code summary →
2.Extended_Course → 2.Ultrasonic
```

## Control function

The tutorial only briefly introduces the code, you can open the project source code to read it in detail.

> **ultrasonic_init**

```
static void ultrasonic_init(void)
{
    GPIO_InitTypeDef GPIO_InitStructure;
    RCC_APB2PeriphClockCmd(ULTRASONIC_RCC, ENABLE);   // Enable the GPIOA clock

    GPIO_InitStructure.GPIO_Pin  = ECHO_PIN;
    GPIO_InitStructure.GPIO_Mode = GPIO_Mode_IPD;  //PA1 Input
    GPIO_InitStructure.GPIO_Speed = GPIO_Speed_50MHz;      //50M
    GPIO_Init(ECHO_PORT, &GPIO_InitStructure);

    GPIO_InitStructure.GPIO_Pin  = TRIG_PIN;
    GPIO_InitStructure.GPIO_Mode = GPIO_Mode_Out_PP;      //PA3 output
    GPIO_InitStructure.GPIO_Speed = GPIO_Speed_50MHz;      //50M
    GPIO_Init(TRIG_PORT, &GPIO_InitStructure);
}
```

> **TIM2_Cap_Init**

```
void TIM2_Cap_Init(u16 arr,u16 psc)
{
    TIM_ICInitTypeDef TIM2_ICInitStructure;
    TIM_TimeBaseInitTypeDef TIM_TimeBaseStructure;
    NVIC_InitTypeDef NVIC_InitStructure;

    ultrasonic_init();
    RCC_APB1PeriphClockCmd(RCC_APB1Periph_TIM2, ENABLE); //Enable TIM2 clock

    //Initialize timer 2 TIM2
    TIM_TimeBaseStructure.TIM_Period = arr; //Set counter auto-reload value
    TIM_TimeBaseStructure.TIM_Prescaler = psc; //Prescaler
    TIM_TimeBaseStructure.TIM_ClockDivision = TIM_CKD_DIV1; //Set clock division:
TDTS = Tck_tim
    TIM_TimeBaseStructure.TIM_CounterMode = TIM_CounterMode_Up; //TIM up counting
mode
    TIM_TimeBaseInit(TIM2, &TIM_TimeBaseStructure); //Initialize the time base
unit of TIMx according to the parameters specified in TIM_TimeBaseInitStruct

    //Initialize TIM2 input capture parameters
    TIM2_ICInitStructure.TIM_Channel = TIM_Channel_2; //CC1S=02 Select input IC2
to map to TI1
    TIM2_ICInitStructure.TIM_ICPolarity = TIM_ICPolarity_Rising; //Rising edge
capture
    TIM2_ICInitStructure.TIM_ICSelection = TIM_ICSelection_DirectTI;
    TIM2_ICInitStructure.TIM_ICPrescaler = TIM_ICPSC_DIV1; //Configure input
frequency division, no frequency division
    TIM2_ICInitStructure.TIM_ICFilter = 0x00; //Configure input filter No
filtering
    TIM_ICInit(TIM2, &TIM2_ICInitStructure);
    //Interrupt group initialization
    NVIC_InitStructure.NVIC_IRQChannel = TIM2_IRQn; //TIM2 interrupt
    NVIC_InitStructure.NVIC_IRQChannelPreemptionPriority = 1; //Preempt priority level 1
    NVIC_InitStructure.NVIC_IRQChannelSubPriority = 1; //From priority level 1
    NVIC_InitStructure.NVIC_IRQChannelCmd = ENABLE; //IRQ channel is enabled
    NVIC_Init(&NVIC_InitStructure); //Initialize peripheral NVIC registers according to the parameters specified in NVIC_InitStruct
    TIM_ITConfig(TIM2,TIM_IT_Update|TIM_IT_CC2,ENABLE);//Allow update interrupts, allow CC2IE to capture interrupts
    TIM_Cmd(TIM2,ENABLE); //Enable timer 2
}
```

### TIM2_IRQHandler

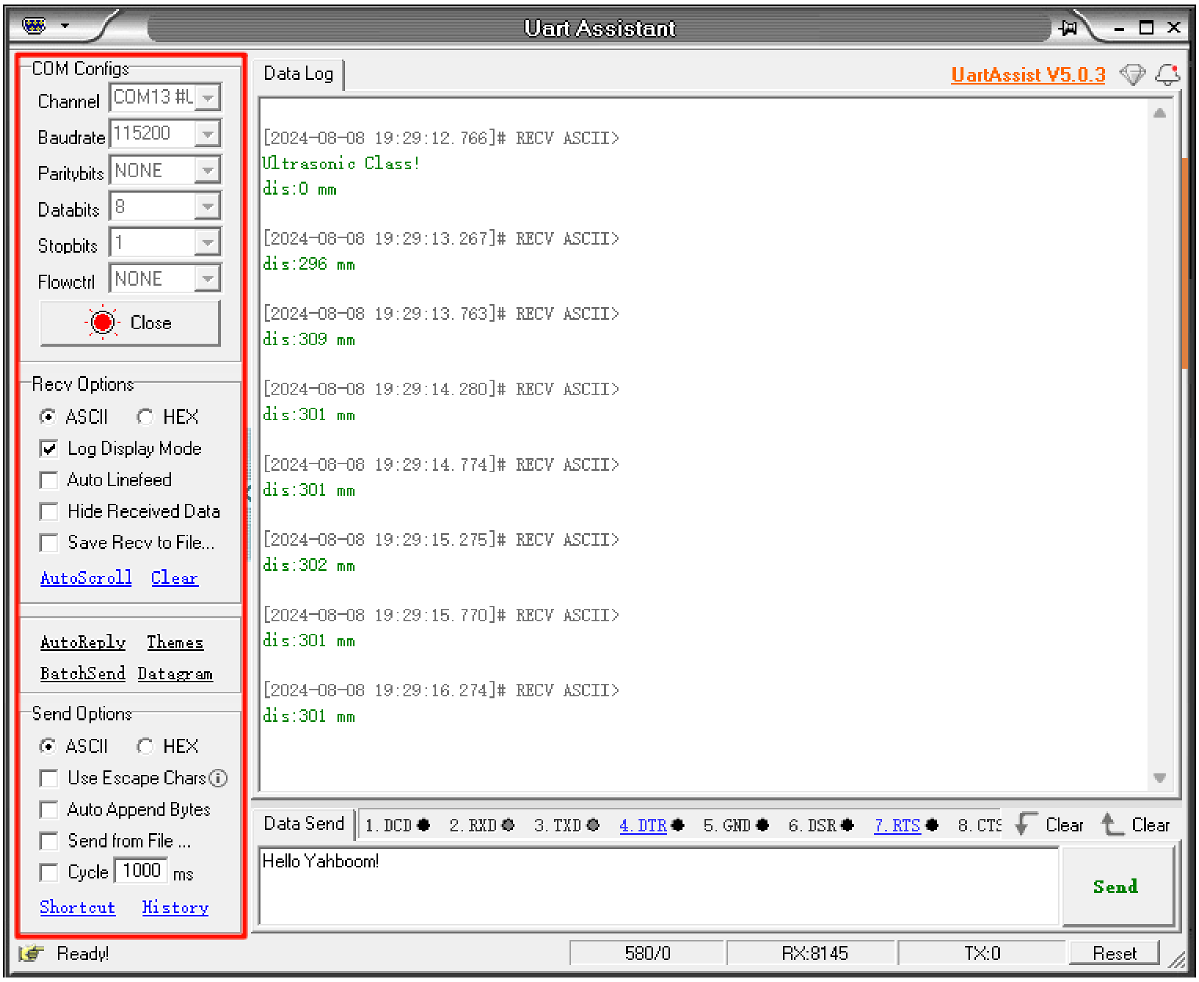
```
void TIM2_IRQHandler(void)
{
    u16 tsr;
    tsr=TIM2->SR;
    if((TIM2CH2_CAPTURE_STA&0X80)==0)// Capture has not succeeded
    {
        if(tsr&0X01)// The timer overflows
        {
            if(TIM2CH2_CAPTURE_STA&0X40)// The high level has been captured
            {
                if((TIM2CH2_CAPTURE_STA&0X3F)==0X3F)// The high level is too long
                {
                    TIM2CH2_CAPTURE_STA|=0X80;       // Indicates a successful capture
                    TIM2CH2_CAPTURE_VAL=0XFFFF;
                }else TIM2CH2_CAPTURE_STA++;
            }
        }
        if(tsr&0x04)// Capture 2 A capture event occurred
        {
            if(TIM2CH2_CAPTURE_STA&0X40) // Captures a falling edge
            {
                TIM2CH2_CAPTURE_STA|=0X80;         // Mark that a high level pulse width was successfully captured
                TIM2CH2_CAPTURE_VAL=TIM2->CCR2;  // Gets the current capture value.
                TIM2->CCER&=~(1<<5);                   //CC2P=0 Set to rising edge capture
            }
        else // Not yet started, first capture rising edge
        {
            TIM2CH2_CAPTURE_STA=0;    // Empty
            TIM2CH2_CAPTURE_VAL=0;
            TIM2CH2_CAPTURE_STA|=0X40;       // The flag captures the rising edge
            TIM2->CNT=0;                                     // The counter is cleared
            TIM2->CCER|=1<<5;                        //CC2P=1 Set to falling edge capture
        }
        }
    }
    TIM2->SR=0; // Clears the interrupt flag bit
}
```

## Experimental phenomenon

The Ultrasonic.hex file generated by the project compilation is located in the OBJ folder of Ultrasonic project. The corresponding Ultrasonic.hex file is found and the program is downloaded into the development board by using FlyMcu software.

After successful download: Serial port will print Ultrasonic Class! After hardware initialization Then control LED status switch and print obstacle distance every 500ms.

```
When using the serial port debugging Assistant, pay attention to the serial port
Settings. Incorrect Settings may cause inconsistency
```



COM Configs
Channel: COM13 #L
Baudrate: 115200
Paritybits: NONE
Databits: 8
Stopbits: 1
Flowctrl: NONE

Recv Options: ● ASCII ○ HEX
☑ Log Display Mode
□ Auto Linefeed
□ Hide Received Data
□ Save Recv to File...

Send Options: ● ASCII ○ HEX
□ Use Escape Chars
□ Auto Append Bytes
□ Send from File ...
□ Cycle 1000 ms

```
[2024-08-08 19:29:12.766]# RECV ASCII>
Ultrasonic Class!
dis:0 mm

[2024-08-08 19:29:13.267]# RECV ASCII>
dis:296 mm

[2024-08-08 19:29:13.763]# RECV ASCII>
dis:309 mm

[2024-08-08 19:29:14.280]# RECV ASCII>
dis:301 mm

[2024-08-08 19:29:14.774]# RECV ASCII>
dis:301 mm

[2024-08-08 19:29:15.275]# RECV ASCII>
dis:302 mm

[2024-08-08 19:29:15.770]# RECV ASCII>
dis:301 mm

[2024-08-08 19:29:16.274]# RECV ASCII>
dis:301 mm
```

Data Send: Hello Yahboom!

Ready! 580/0 RX:8145 TX:0