Advanced timers

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This tutorial shows how to generate a PWM signal with a known frequency and duty cycle from the **Universal Timer (TIM3)** , measure the frequency and duty cycle of this known PWM signal using the PWM input mode of the ** Advanced Timer (TIM1) **, and print the relevant data via the** serial port (USART1) **.

1、software-hardware

- **STM32F103CubeIDE**
- **STM32 robot expansion board**

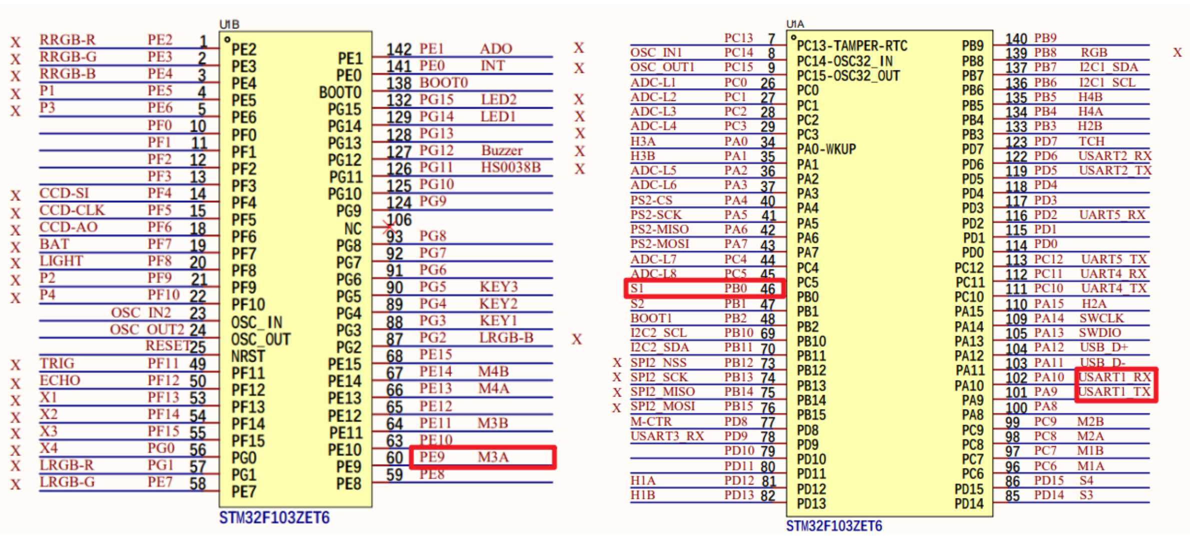
  TIM: Chip internal peripherals

  Mother to mother dupont wire: 1
- **Type-C cable or ST-Link**

  Download or simulate the program of the development board

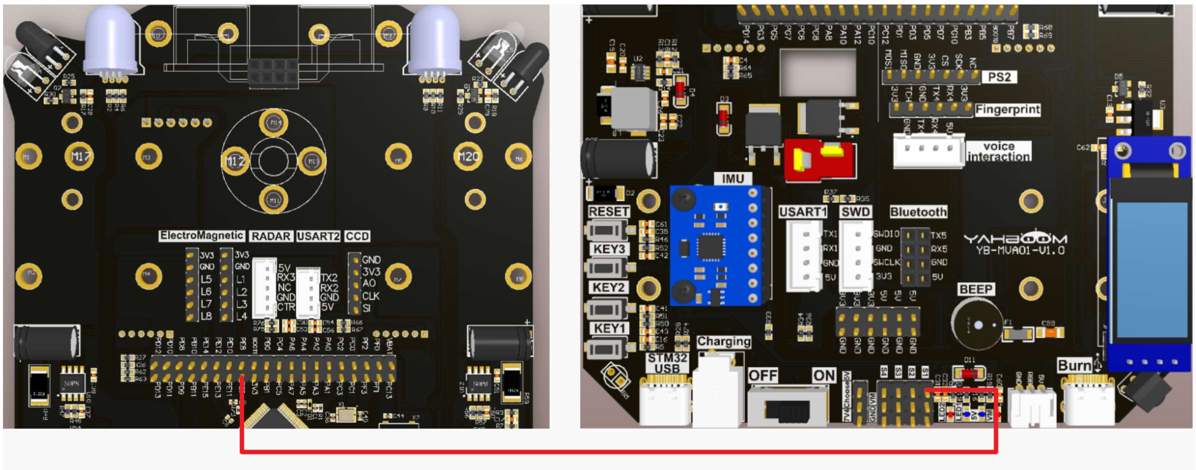
2、Brief principle

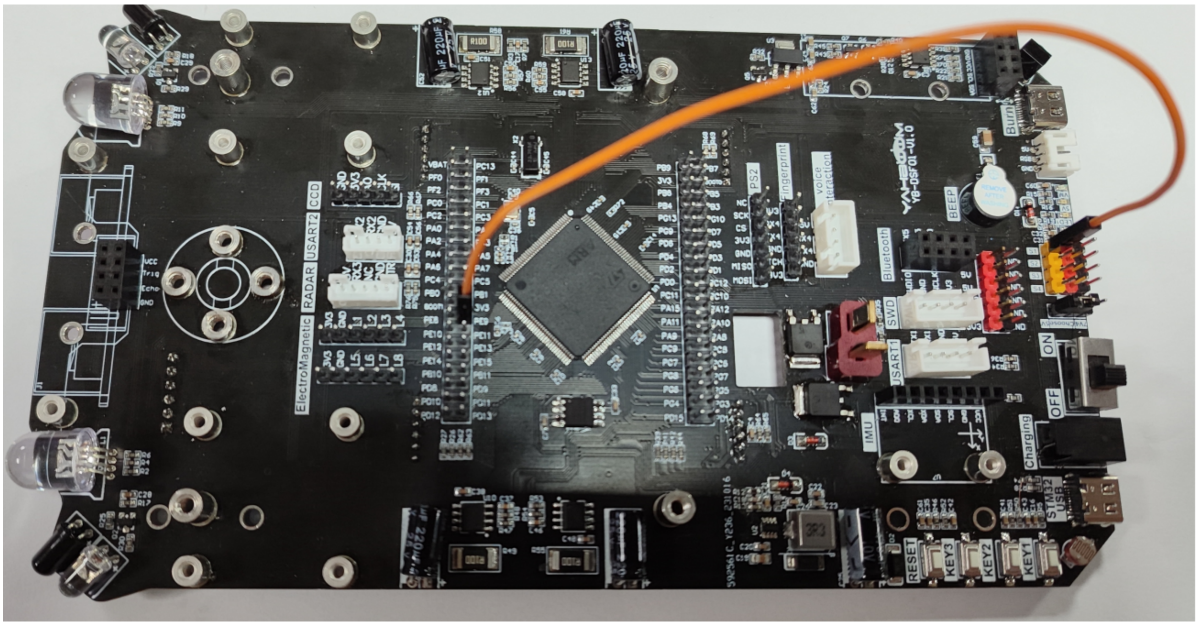
2.1、Hardware interface



2.2、Physical connection diagram

This tutorial requires connecting the S1 signal wire (yellow terminal) and PE9 pin of the servo





2.3、Principle of control

TIM1：The timer PWM input mode is configured to measure the frequency and duty cycle of the known PWM signal

TIM3：The timer PWM output mode is configured to generate PWM signals with known frequency and duty cycle

- **Advanced timers**

Timer types	Advanced timers
The timer name	TIM1、TIM8
Number of counter bits	16
Counting mode	Increase/decrease/center alignment
Predivision coefficient	1-65536
Generating DMA requests	Yes

Timer types	Advanced timers
Capture/compare channels	4
Complementary output	Yes
Clock frequency	72MHz（Max）
Mount bus	APB2

Time base cell

register	Function
The counter register（TIMx_CNT）	The current value of the counter
Predivider register（TIMx_PSC）	Set frequency division coefficient (1-65536)
Automatically reload registers（TIMx_ARR）	The counter counts the boundary and the overloaded value
Repeat count register（TIMx_RCR）	Set the repeat counter value

Timing formula

$$T(s) = \frac{(ARR+1)*(PSC+1)}{TIM\_CLK(Hz)}$$

parameters	meaning
T（s）	Timing time in seconds
ARR	Automatically reload the value
PSC	Predivision coefficient
TIM_CLK	The timer ticks in Hz

PWM period：T = 10ms → f = 100Hz

$$T(s) = \frac{(ARR+1)*(PSC+1)}{TIM\_CLK(Hz)} = \frac{(9999+1)*(71+1)}{72000000(Hz)} = 0.01s = 10ms$$

- **PWM input mode**

When PWM input mode is used, one input channel (TIx) will occupy two capture channels (ICx), and the two ICx signals are valid for edges, but with opposite polarity.

Measure pulse width and frequency

PWM is measured in PWM input mode, PWM signal input can only be input from channel 1 (CH1) or channel 2 (CH2).

Consider input channel TI1 working in PWM input mode：

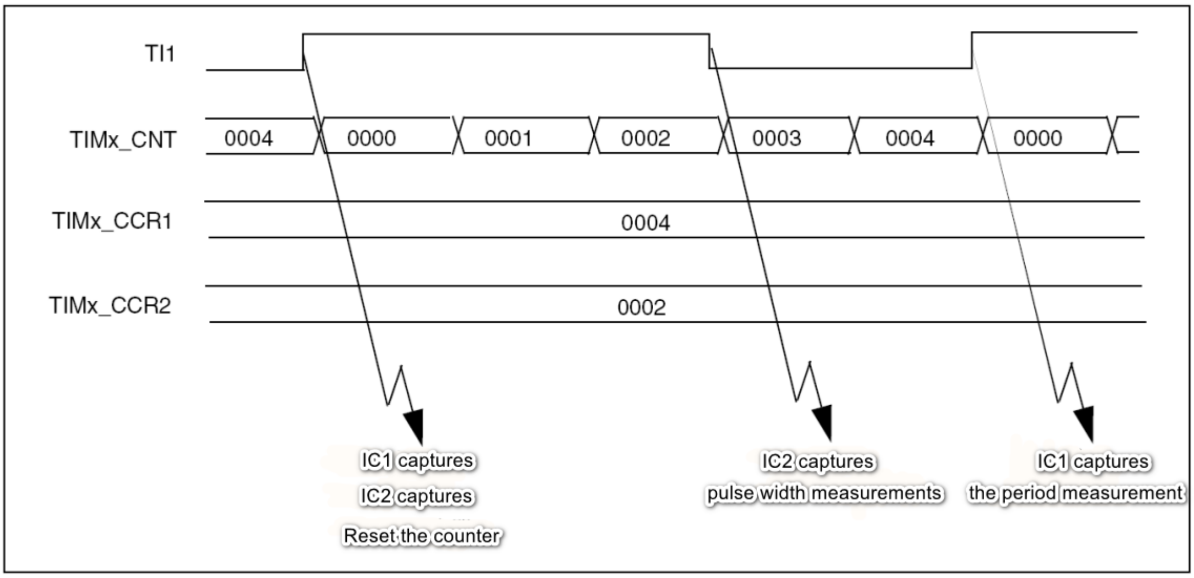
The PWM signal enters through the input channel TI1, and the signal will be divided into two channels, one is TI1FP1, and the other is TI1FP2.

Choose the effective polarity of TI1FP1: effective → period on the rising edge

The effective polarity of TI1FP2 is chosen: effective → duty cycle on the falling edge

When using PWM input mode, the slave mode controller must be configured to reset mode, that is, when we start the trigger signal to start the capture, we also reset the counter CNT to zero.

PWM input mode timing




```
The PWM signal is entered by the input channel TI1, and TI1FP1 is configured as
the trigger signal, and the rising edge is captured. When the rising edge is
captured by IC1 and IC2, the counter CNT is reset. When the falling edge is
reached, IC2 is captured and the value of counter CNT is latched into the capture
register CCR2. When the next rising edge is reached, IC1 is captured and the
value of counter CNT is latched into the capture register CCR1. Among them, CCR2
measures pulse width and CCR1 measures period.
```

3、Engineering configuration

3.1、Notes

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

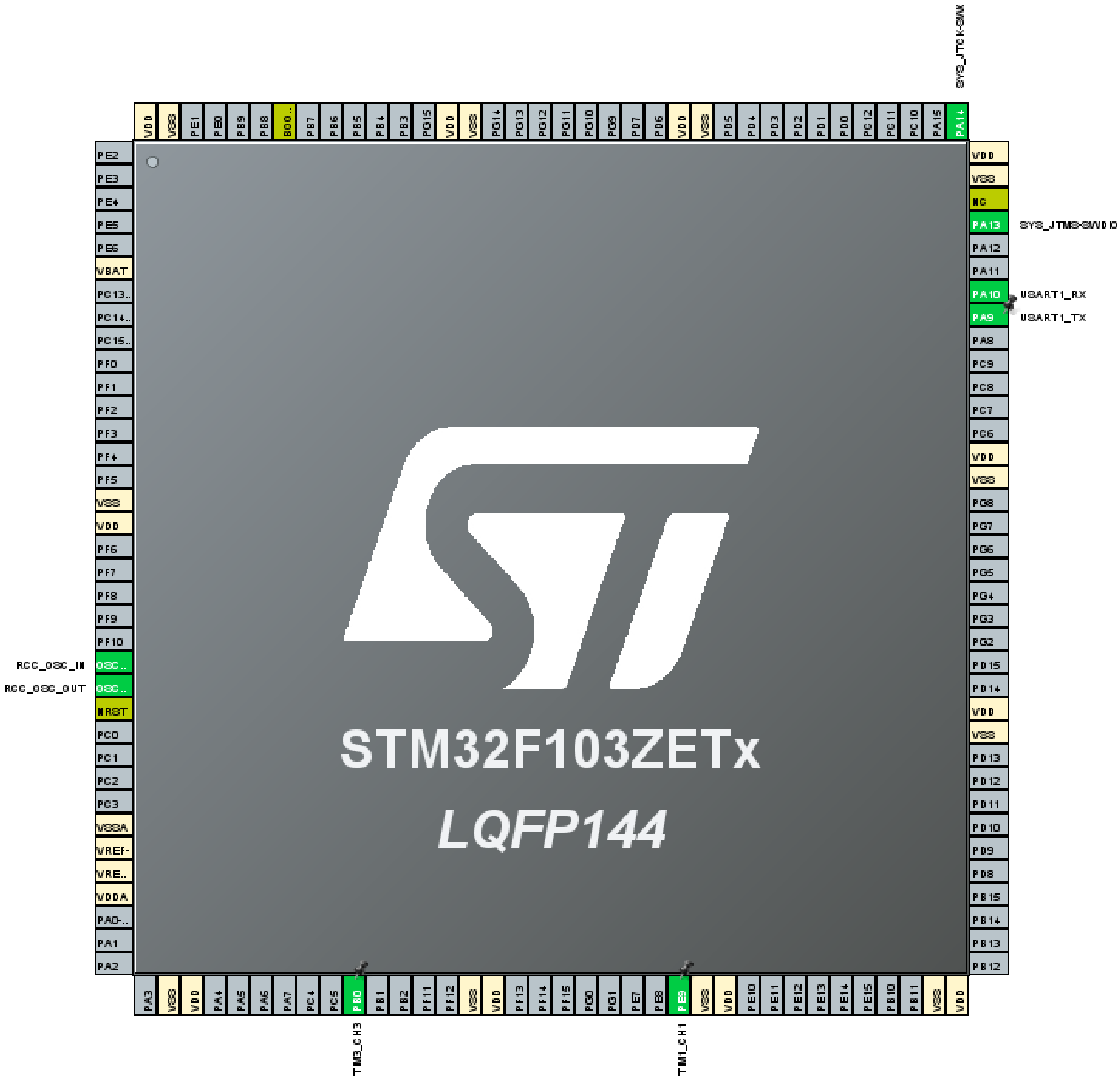
The project configuration part, which is not omitted, is the key point to configure in this tutorial.

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

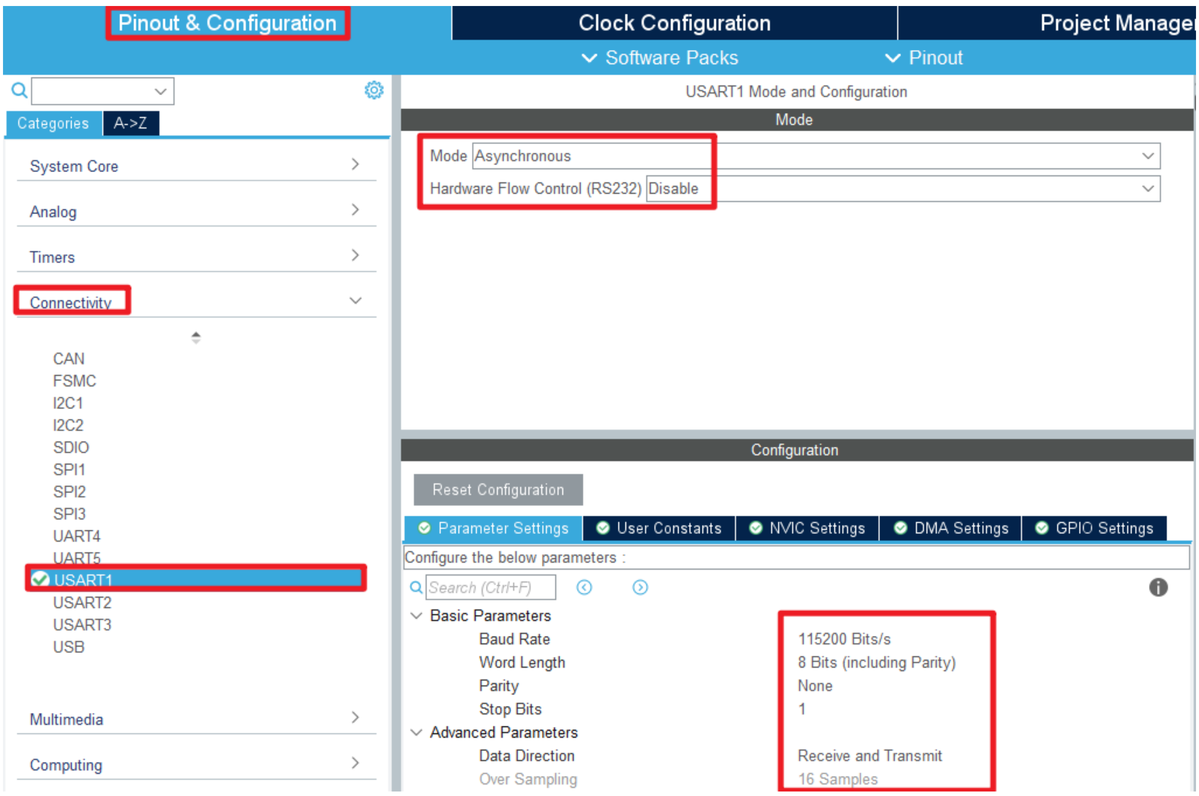
3.2、Pin configuration

- **Configure the specified pin function**

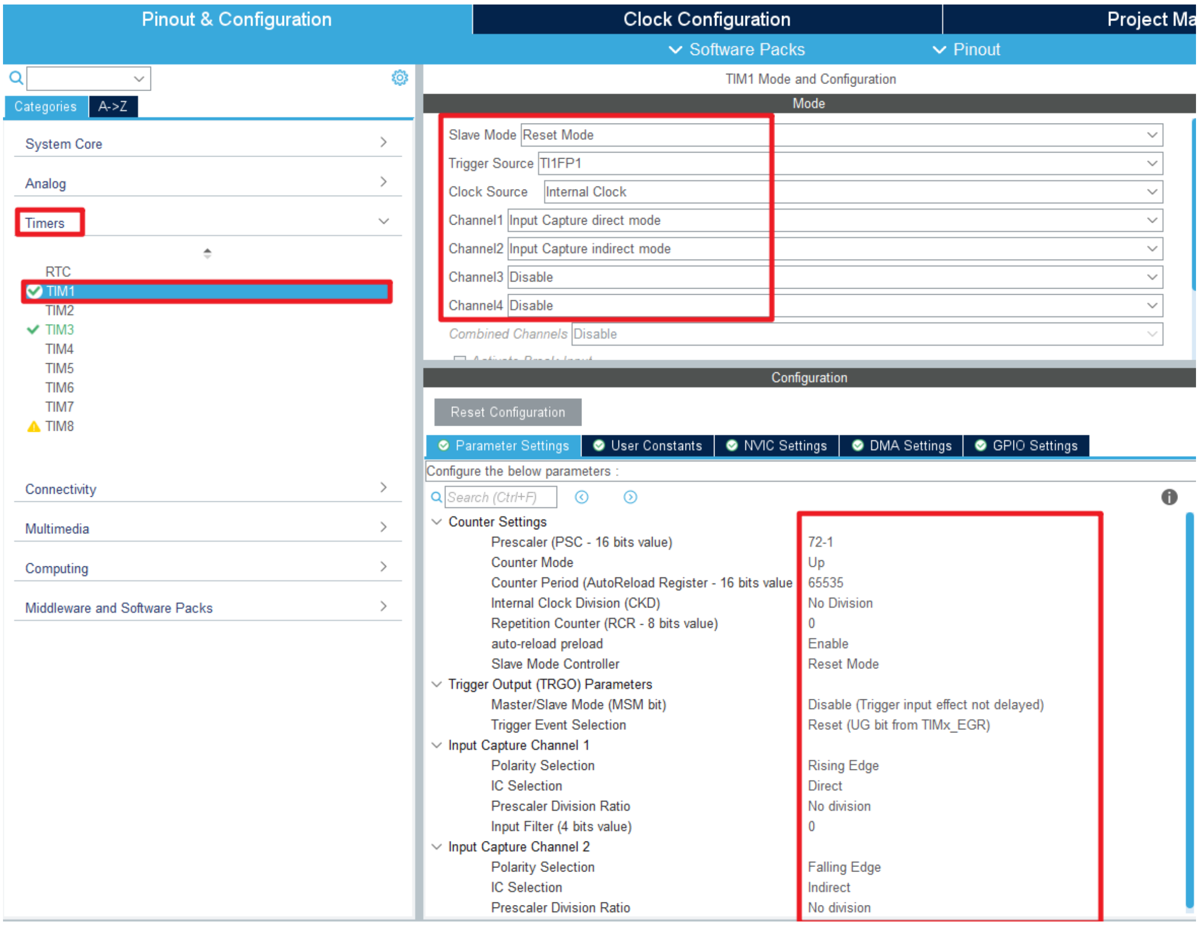
You can directly select the corresponding pin number in the pin view, and the corresponding option will appear when the mouse is left clicked


SYS_JTCK-SWCLK
SYS_JTMS-SWDIO
USART1_RX
USART1_TX
RCC_OSC_IN
RCC_OSC_OUT
STM32F103ZETx
LQFP144
TIM3_CH3
TIM1_CH1

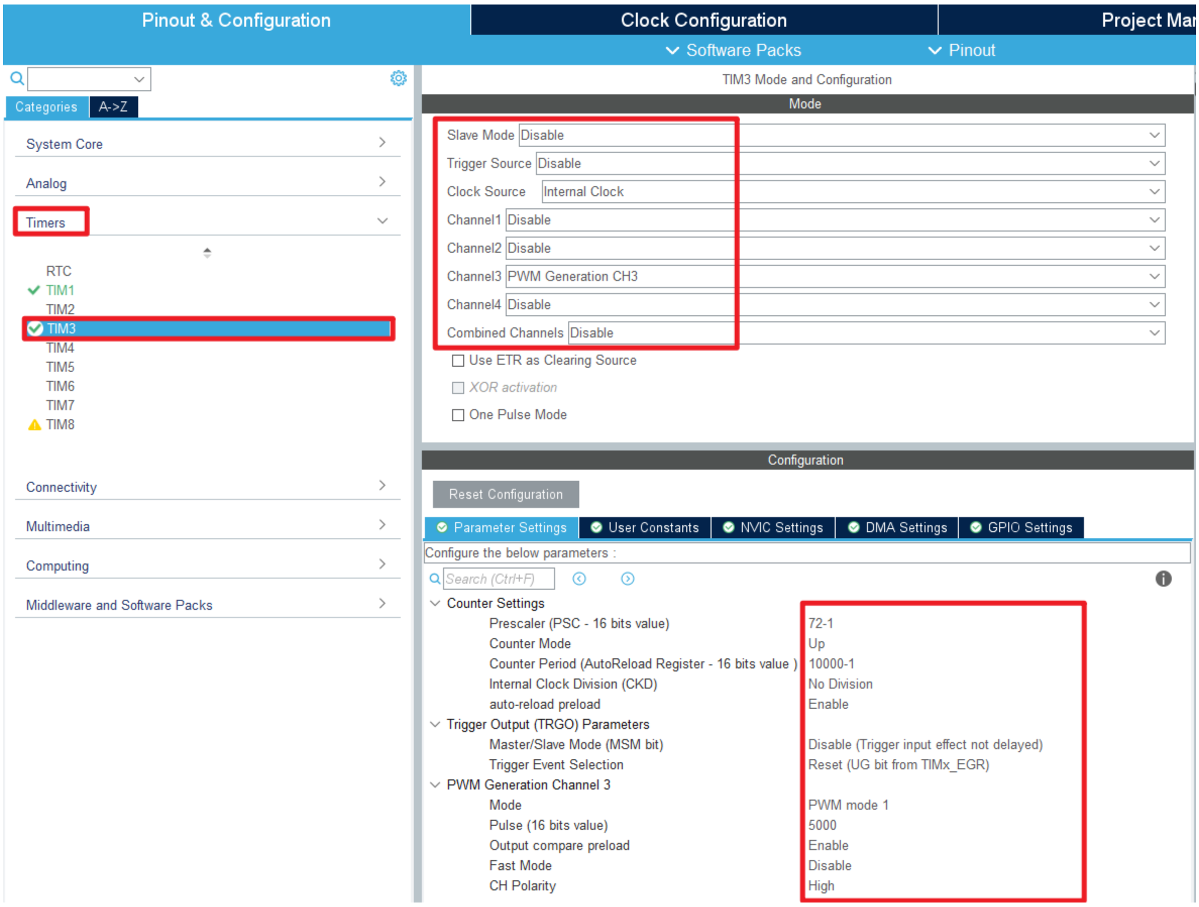
- **USART**


Pinout & Configuration
Clock Configuration
Project Manager
Software Packs
Pinout
Categories
A->Z
System Core
Analog
Timers
Connectivity
CAN
FSMC
I2C1
I2C2
SDIO
SPI1
SPI2
SPI3
UART4
UART5
USART1
USART2
USART3
USB
Multimedia
Computing
USART1 Mode and Configuration
Mode
Mode Asynchronous
Hardware Flow Control (RS232) Disable
Configuration
Reset Configuration
Parameter Settings
User Constants
NVIC Settings
DMA Settings
GPIO Settings
Configure the below parameters :
Search (Ctrl+F)
Basic Parameters
Baud Rate
Word Length
Parity
Stop Bits
Advanced Parameters
Data Direction
Over Sampling
115200 Bits/s
8 Bits (including Parity)
None
1
Receive and Transmit
16 Samples

- **TIM1**

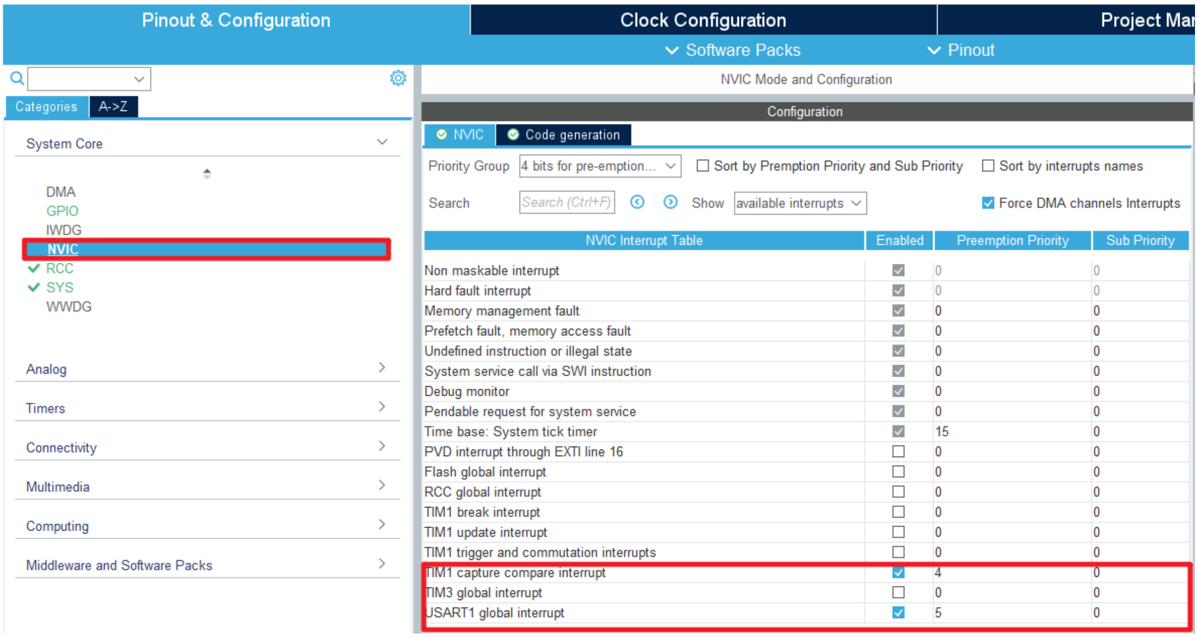


- **TIM3**

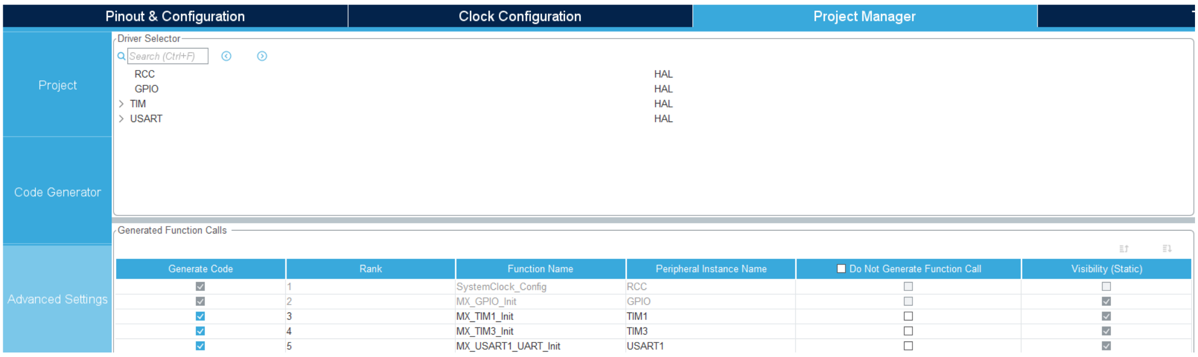


- **NVIC**

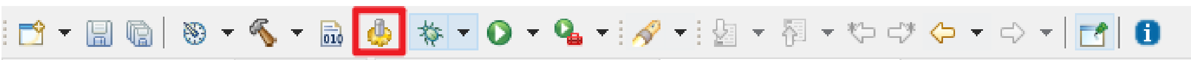
The NVIC option allows you to change the priority



- **Advanced Settings**



- **Generating code**



4、Main function

For detailed code, you can open the project file provided by us and go to the Bsp folder to view the source code.

4.1、User functions

> **HAL_TIM_IC_CaptureCallback**

Function prototypes	**void HAL_TIM_IC_CaptureCallback(TIM_HandleTypeDef *htim)**
Functional Description	The input capture interrupt event used to process the timer
Input parameters	**htim**： Timer handle address
Return value	None

Function prototypes	void HAL_TIM_IC_CaptureCallback(TIM_HandleTypeDef *htim)
notes	Inside the function, you can write code to handle input capture events, such as reading the capture register value, calculating the pulse width, and so on

In the HAL_TIM_IC_CaptureCallback function, we read the counts of IC1 and IC2, which are multiplied by a single count plus 1 to give the period and pulse width.

4.2、HAL library functions

The HAL library functions that were covered in the previous tutorial will not be covered

```
If you want to find the HAL library and LL library function analysis involved in the entire tutorial, you can view the documents in the folder [8. STM32 Manual: STM32F1_HAL Library and LL Library_User Manual]
```

> **function：HAL_TIM_PWM_Init**

Function prototypes	**HAL_StatusTypeDef HAL_TIM_PWM_Init(TIM_HandleTypeDef *htim)**
Functional Description	**Initialize the timer's PWM output mode**
Input parameters	**htim**：Timer handle address
Return value	**HAL status value**：HAL_OK、HAL_ERROR、HAL_BUSY、HAL_TIMEOUT

> **function：HAL_TIM_MspPostInit**

Function prototypes	**void HAL_TIM_MspPostInit(TIM_HandleTypeDef* timHandle)**
Functional Description	**Peripheral clock, GPIO, and NVIC to initialize the timer**
Input parameters	**htim**：Timer handle address
Return value	None
notes	The function performs additional initialization on top of HAL_TIM_Base_MspInit

> **function：HAL_TIM_PWM_Start**

Function prototypes	**HAL_StatusTypeDef HAL_TIM_PWM_Start(TIM_HandleTypeDef *htim, uint32_t Channel)**
Functional Description	**Start PWM output**

Function prototypes	**HAL_StatusTypeDef HAL_TIM_PWM_Start(TIM_HandleTypeDef *htim, uint32_t Channel)**
Input parameters1	**htim**：Timer handle address
Input parameters2	**Channel**：Timer channel number
Return value	**HAL status value**：HAL_OK、HAL_ERROR、HAL_BUSY、HAL_TIMEOUT

> **function：HAL_TIM_PWM_ConfigChannel**

Function prototypes	**HAL_StatusTypeDef HAL_TIM_PWM_ConfigChannel (TIM_HandleTypeDef *htim, const TIM_OC_InitTypeDef *sConfig, uint32_t Channel)**
Functional Description	**Set the PWM channel for the timer**
Input parameters1	**htim**：Timer handle address
Input parameters2	**sConfig**：The timer outputs the comparison parameters
Input parameters3	**Channel**：Timer channel number
Return value	**HAL status value**：HAL_OK、HAL_ERROR、HAL_BUSY、HAL_TIMEOUT

> **function：HAL_TIM_IC_Init**

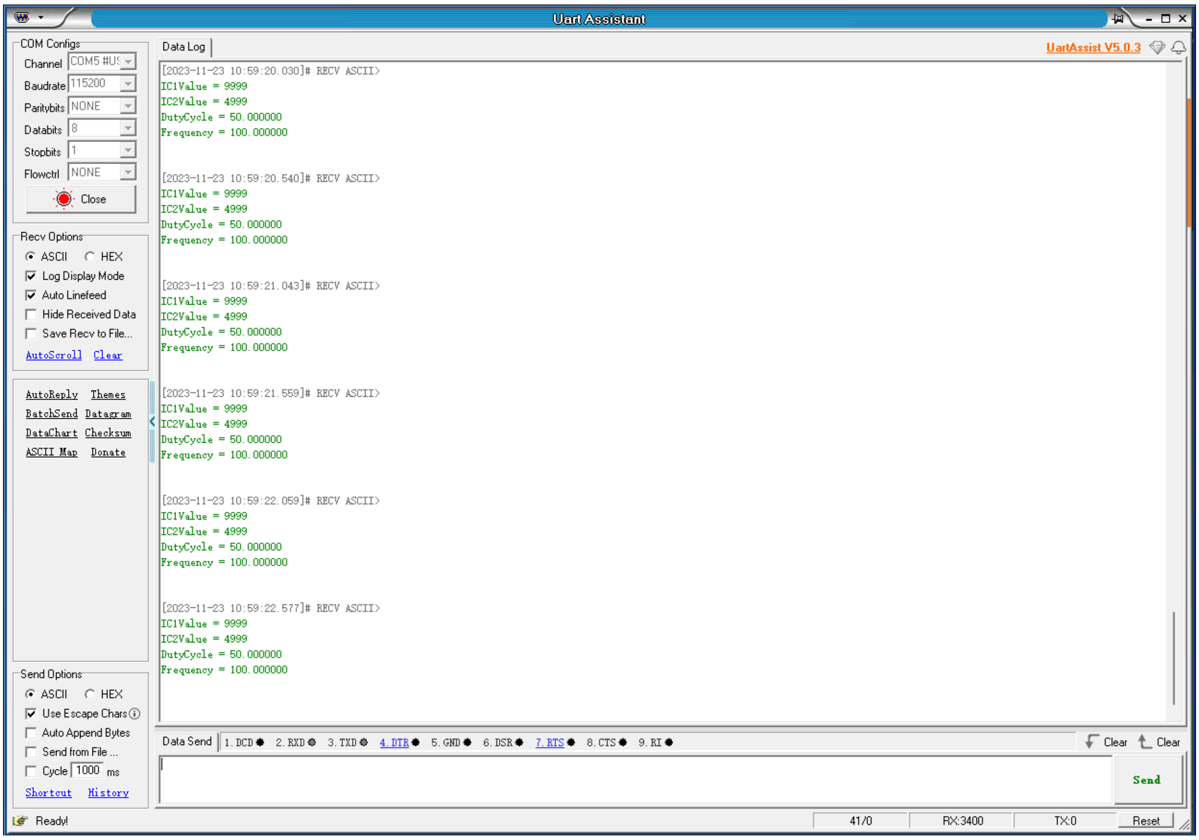
Function prototypes	**HAL_StatusTypeDef HAL_TIM_IC_Init(TIM_HandleTypeDef *htim)**
Functional Description	Initialize the input capture function of the timer
Input parameters	**htim**：Timer handle address
Return value	**HAL status value**：HAL_OK、HAL_ERROR、HAL_BUSY、HAL_TIMEOUT

5、Experimental phenomenon

After downloading the program successfully, press the RESET button of the development board to open the serial debugging assistant to observe the phenomenon

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

Phenomenon：You can see that the data displayed by the serial port is the same as the PWM signal data generated by the universal timer (TIM3).


Uart Assistant
COM Configs
Channel COM5
Baudrate 115200
Paritybits NONE
Databits 8
Stopbits 1
Flowctrl NONE
Close
Recv Options
ASCII HEX
Log Display Mode
Auto Linefeed
Hide Received Data
Save Recv to File...
AutoScroll Clear
AutoReply Themes
BatchSend Datagram
DataChart Checksum
ASCII Map Donate
Send Options
ASCII HEX
Use Escape Chars
Auto Append Bytes
Send from File ...
Cycle 1000 ms
Shortcut History
Ready!
Data Log
UartAssist V5.0.3
[2023-11-23 10:59:20.030]# RECV ASCII>
IC1Value = 9999
IC2Value = 4999
DutyCycle = 50.000000
Frequency = 100.000000
[2023-11-23 10:59:20.540]# RECV ASCII>
IC1Value = 9999
IC2Value = 4999
DutyCycle = 50.000000
Frequency = 100.000000
[2023-11-23 10:59:21.043]# RECV ASCII>
IC1Value = 9999
IC2Value = 4999
DutyCycle = 50.000000
Frequency = 100.000000
[2023-11-23 10:59:21.559]# RECV ASCII>
IC1Value = 9999
IC2Value = 4999
DutyCycle = 50.000000
Frequency = 100.000000
[2023-11-23 10:59:22.059]# RECV ASCII>
IC1Value = 9999
IC2Value = 4999
DutyCycle = 50.000000
Frequency = 100.000000
[2023-11-23 10:59:22.577]# RECV ASCII>
IC1Value = 9999
IC2Value = 4999
DutyCycle = 50.000000
Frequency = 100.000000
Data Send 1.DCD 2.RXD 3.TXD 4.DTR 5.GND 6.DSR 7.RTS 8.CTS 9.RI
Clear Clear
Send
41/0 RX:3400 TX:0 Reset