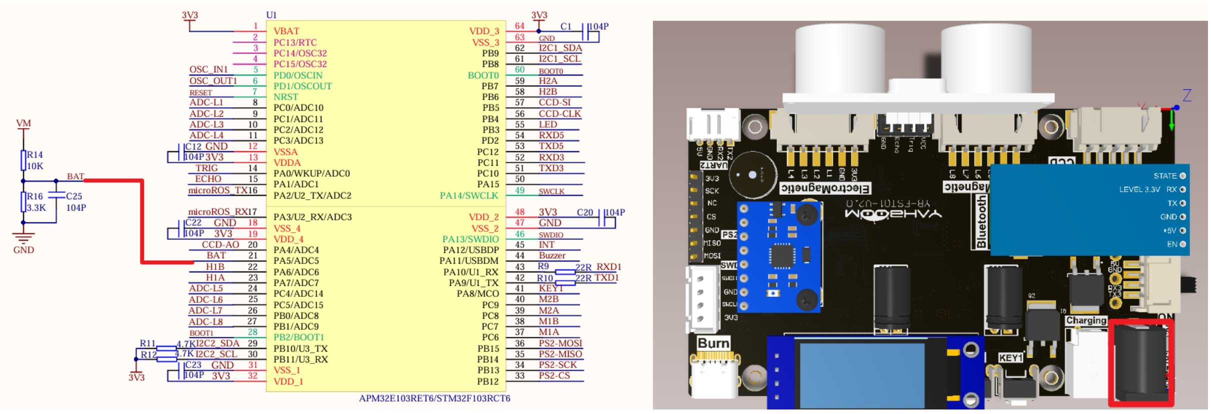
Voltage detection

The tutorial demonstrates ADC (ADC12_IN5) to obtain the real-time voltage of the battery pack and print the voltage value through the serial port.

```
The tutorial only introduces the standard library project code
```

Hardware connection



Peripherals	Development board	Description
Battery pack	PA5	The battery pack DC interface needs to be connected to the development board

Control principle

The converted value of the battery BAT pin is obtained through a single ADC, and the value is converted into actual voltage information and printed out through USART1.

- **ADC**

STM32F103RCT6 has three 12-bit analog-to-digital converters embedded, and each ADC controller has up to 16 channels.

- **ADC channel**

Only introduce the ADC channel corresponding to the battery pack interface.

Main control chip	Pin	Main function (after reset)	Default multiplexing function	Redefine function
STM32F103RCT6	PA5	PA5	SPI1_SCK/DAC_OUT2/ADC12_IN5	

- **ADC conversion value**

The ADC of STM32F103RCT6 is a 12-bit successive approximation analog-to-digital converter with 12-bit resolution;

$$ADCvaluerange = 0 - 2^{12} = 0 - 4095$$

The converted value of ADC can be stored in 16-bit data register in left-aligned or right-aligned mode.

- **ADC conversion mode**

The A/D conversion of each ADC channel can be performed in single, continuous, scan or intermittent mode.

Mode	Function
Single conversion mode	ADC performs only one conversion
Continuous conversion mode	Starts another conversion as soon as the previous ADC conversion is completed
Scan mode	Used to scan a group of ADC channels
Intermittent mode	Converts multiple ADC channels in groups until the entire sequence is converted

```
Regular channel: Perform channel conversion in a certain order
Injection channel: The injection channel can interrupt the conversion of the regular
channel to execute the injection channel, and then continue to execute the regular
channel conversion after the injection channel is completed
```

- **ADC conversion time**

The input clock of the ADC must not exceed 14MHz, which is generated by the frequency division of PCLK2.

$$Totalconversiontime = T_{CONV} = samplingtime + 12.5clockcycles$$

Conversion time in this tutorial: ADC clock frequency 12MHz, sampling time 239.5 clock cycles

$$Totalconversiontime = T_{CONV} = samplingtime + 12.5clockcycles = (239.5 + 12.5) * \frac{1}{12000000} = 21us$$

- **Actual voltage conversion**: ADC internal reference voltage 3.3V

$$V_{BAT} = \frac{Value_{ADCconvertedvalue} * （3.3）}{4096}$$

Referring to the hardware schematic diagram, we can see: **Current equality principle**

$$I_{current} = \frac{V_{BAT}}{R16} = \frac{V_M}{R16 + R14} \Longrightarrow \frac{V_{BAT}}{3.3} = \frac{V_M}{10 + 3.3} \Longrightarrow V_M = \frac{V_{BAT} * （10 + 3.3）}{3.3}$$

$$Thatis, theactualvoltage = V_M = \frac{V_{BAT} * （10 + 3.3）}{3.3}$$

Pin definition

Main control chip	Pin	Main function (after reset)	Default multiplexing function	Redefine function
STM32F103RCT6	PA5	PA5	SPI1_SCK/DAC_OUT2/ADC12_IN5	

Software code

Since the default function of the PA5 pin is a normal IO pin function, we need to use the multiplexing function.

```
Product supporting data source code path: Attachment → Source code summary →
1.Base_Course → 6.ADC
```

Control function

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

> **Battery_init**

```
//Battery power detection initialization
void Battery_init(void)
{
    ADC_InitTypeDef ADC_InitStructure;
    GPIO_InitTypeDef GPIO_InitStructure;
    RCC_APB2PeriphClockCmd(BAT_GPIO_CLK | BAT_ADC_CLK, ENABLE); //Enable BAT_ADC channel
clock
    RCC_ADCCLKConfig(RCC_PCLK2_Div6); //Set ADC division factor 6

    //72M/6=12, ADC maximum input clock cannot exceed 14M
    //PA5 as analog channel input pin
    GPIO_InitStructure.GPIO_Pin = BAT_GPIO_PIN;
    GPIO_InitStructure.GPIO_Mode = GPIO_Mode_AIN; //Analog input
    GPIO_Init(BAT_GPIO_PORT, &GPIO_InitStructure); //Initialization GPIOA.5

    ADC_DeInit(BAT_ADC); //Reset BAT_ADC and reset all registers of the peripheral
BAT_ADC to default values
    ADC_InitStructure.ADC_Mode = ADC_Mode_Independent; //ADC independent mode
    ADC_InitStructure.ADC_ScanConvMode = DISABLE; //Single channel mode
    ADC_InitStructure.ADC_ContinuousConvMode = DISABLE; //Single conversion mode
    ADC_InitStructure.ADC_ExternalTrigConv = ADC_ExternalTrigConv_None; //Conversion is
started by software instead of external trigger
    ADC_InitStructure.ADC_DataAlign = ADC_DataAlign_Right; //ADC data right alignment
    ADC_InitStructure.ADC_NbrOfChannel = 1; //Number of ADC channels for regular
conversion in sequence
    ADC_Init(BAT_ADC, &ADC_InitStructure); //Initialize peripheral ADCx according to
specified parameters
    ADC_Cmd(BAT_ADC, ENABLE); //Enable specified BAT_ADC
    ADC_ResetCalibration(BAT_ADC); //Start reset calibration
    while (ADC_GetResetCalibrationStatus(BAT_ADC)); //Wait for reset calibration to end
    ADC_StartCalibration(BAT_ADC); //Start AD calibration
    while (ADC_GetCalibrationStatus(BAT_ADC)); //Wait for calibration to end
}
```

> **Battery_Get**

```c
// Get ADC value, ch: channel value
static uint16_t Battery_Get(uint8_t ch)
{
    uint16_t timeout = 1000;
    // Set the specified ADC rule group channel, set their conversion order and sampling time
    ADC_RegularChannelConfig(BAT_ADC, ch, 1, ADC_SampleTime_239Cycles5);
    // Channel 1, the regular sampling order value is 1, and the sampling time is 239.5 cycles
    ADC_SoftwareStartConvCmd(BAT_ADC, ENABLE); // Enable software conversion function
    while (!ADC_GetFlagStatus(BAT_ADC, ADC_FLAG_EOC) && timeout--); // Wait for the conversion to end
    return ADC_GetConversionValue(BAT_ADC); // Return the most recent conversion result of the BAT_ADC rule group
}
```

> **Battery_Get_Average**

```c
uint16_t Battery_Get_Average(uint8_t ch, uint8_t times)
{
    uint16_t temp_val = 0;
    uint8_t t;
    for (t = 0; t < times; t++)
    {
        temp_val += Battery_Get(ch);
    }
    if (times == 4)
    {
        temp_val = temp_val >> 2;
    }
    else
    {
        temp_val = temp_val / times;
    }
    return temp_val;
}
```

> **Get_Measure_Volotage**

```c
// Get the measured raw voltage value
float Get_Measure_Volotage(void)
{
    uint16_t adcx;
    float temp;
    adcx = Battery_Get(BAT_ADC_CH); // Battery channel 5 is measured once
    temp = (float)adcx * (3.30f / 4096);
    return temp;
}
```

> **Get_Battery_Volotage**

```
// Get the actual battery voltage before voltage division
float Get_Battery_Volotage(void)
{
    float temp;
    temp = Get_Measure_Volotage();
    // The actual measured value is a little lower than the calculated value.
    temp = temp * 4.03f; //temp*(10+3.3)/3.3;
    return temp;
}
```

Experimental phenomenon

The ADC.hex file generated by the project compilation is located in the OBJ folder of the ADC project. Find the ADC.hex file corresponding to the project and use the FlyMcu software to download the program to the development board.

After the program is successfully downloaded: the LED switches on and off every 500ms; using the serial port debugging assistant, you can see the serial port returns the battery pack voltage information.

```
When using the serial port debugging assistant, you need to pay attention to the serial port settings. If the settings are wrong, the phenomenon may be inconsistent
```