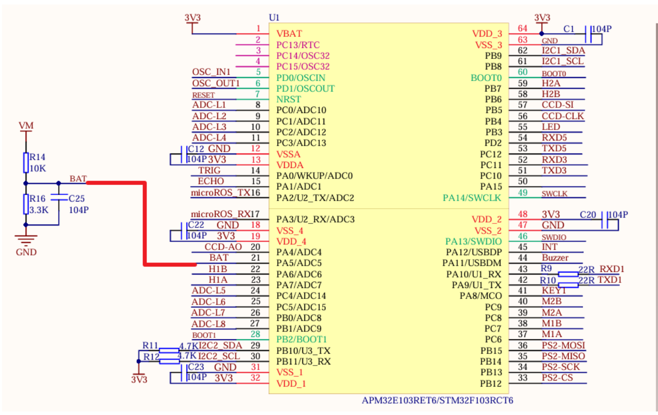
Battery voltage detection (ADC)

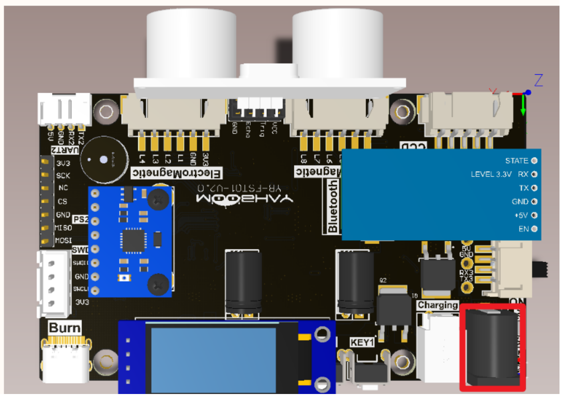
The tutorial demonstrates the low voltage alarm function of the development board.

```
ADC collects the actual voltage of the battery pack, and determines whether to issue an
alarm and the LED status through the obtained voltage value!

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.

- **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 →
2.Extended_Course → 1.Battery
```

Control function

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

> **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); //Initialize 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**

```
// Get ADC value, ch: channel value
static uint16_t Battery_Get(uint8_t ch)
{
    uint16_t timeout = 1000;
    //Set the regular group channel of the specified ADC, set their conversion order and
sampling time
    ADC_RegularChannelConfig(BAT_ADC, ch, 1, ADC_SampleTime_239Cycles5);
    //Channel 1, rule sampling order value is 1, 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
conversion to end
    return ADC_GetConversionValue(BAT_ADC); //Return the most recent conversion result
of the BAT_ADC rule group
}
```

Battery_Get_Average

```
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

```
// Get the measured original 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 Battery.hex file generated by the project compilation is located in the OBJ folder of the Battery project. Find the Battery.hex file corresponding to the project and use the FlyMcu software to download the program to the development board.

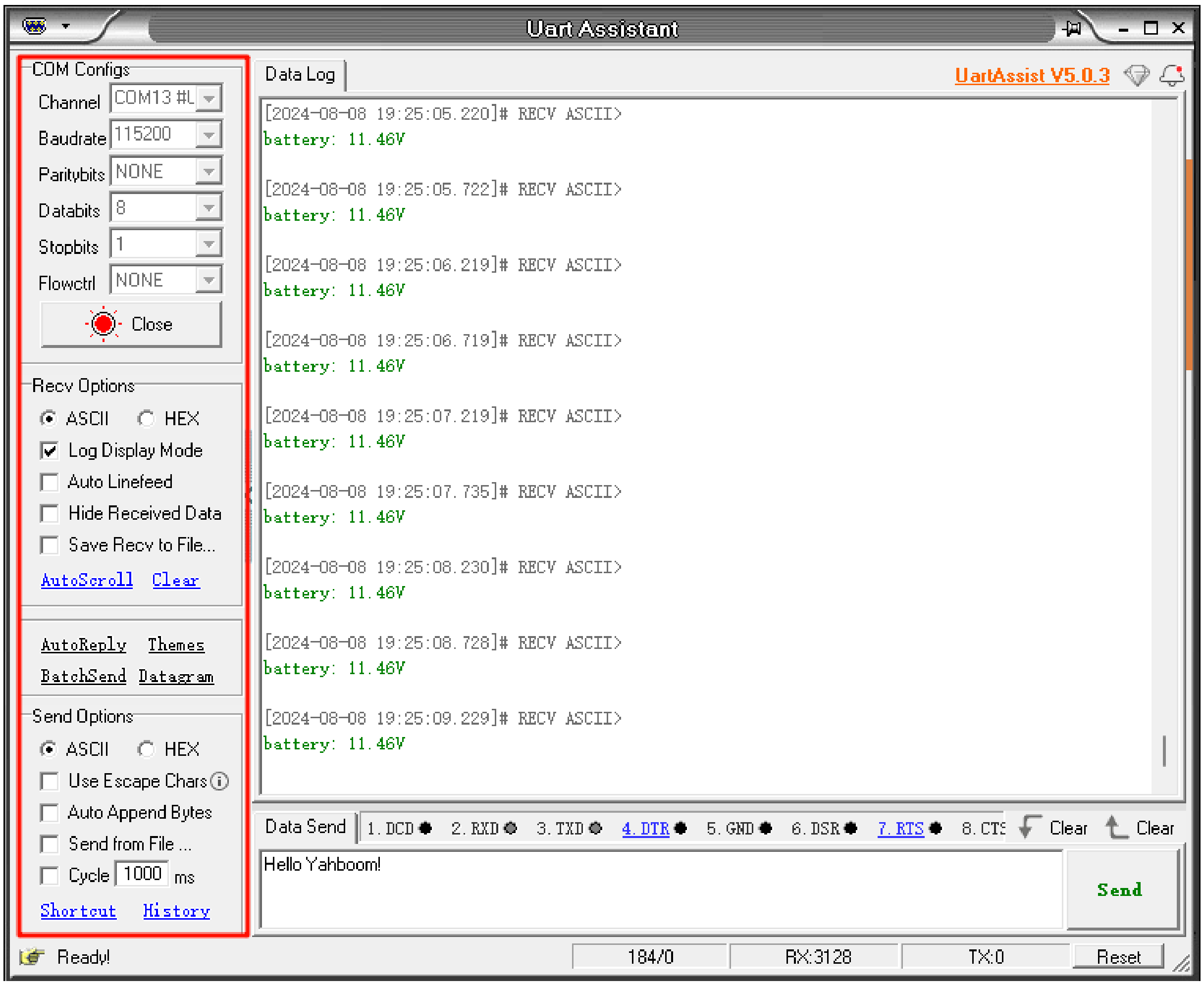
After the program is successfully downloaded:

The program will enter the corresponding state according to the obtained voltage and print the real-time battery voltage information on the serial port:

Voltage is less than 9.6V: The buzzer keeps beeping and the LED is off;

Voltage is greater than or equal to 9.6V: The LED flashes

```
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
```



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 19:25:05.220]# RECV ASCII>
battery: 11.46V

[2024-08-08 19:25:05.722]# RECV ASCII>
battery: 11.46V

[2024-08-08 19:25:06.219]# RECV ASCII>
battery: 11.46V

[2024-08-08 19:25:06.719]# RECV ASCII>
battery: 11.46V

[2024-08-08 19:25:07.219]# RECV ASCII>
battery: 11.46V

[2024-08-08 19:25:07.735]# RECV ASCII>
battery: 11.46V

[2024-08-08 19:25:08.230]# RECV ASCII>
battery: 11.46V

[2024-08-08 19:25:08.728]# RECV ASCII>
battery: 11.46V

[2024-08-08 19:25:09.229]# RECV ASCII>
battery: 11.46V
```

Hello Yahboom!

Ready! 184/0 RX:3128 TX:0