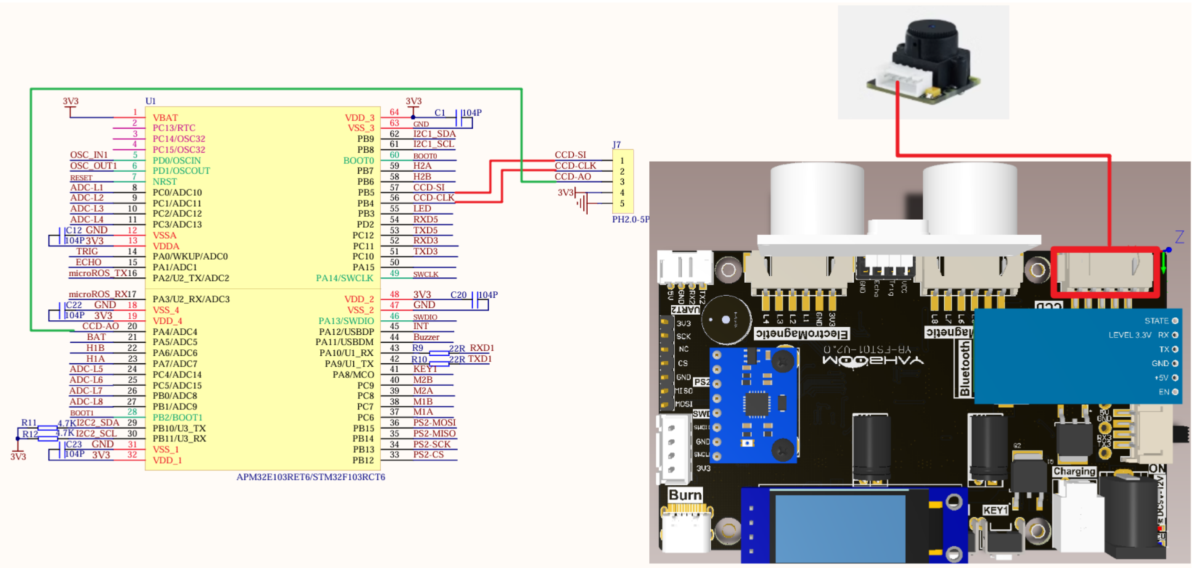
CCD module-Reading data (ADC)

The tutorial combines OLED and serial port to display the data output by CCD module.

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

Hardware connection



Since we have configured a special connection line, we only need to install it to the corresponding interface:

Peripherals	Development board
CCD: VCC	3.3V
CCD: AO	PA4
CCD: SLK	PB4
CCD: SI	PB5
CCD: GND	GND

Control principle

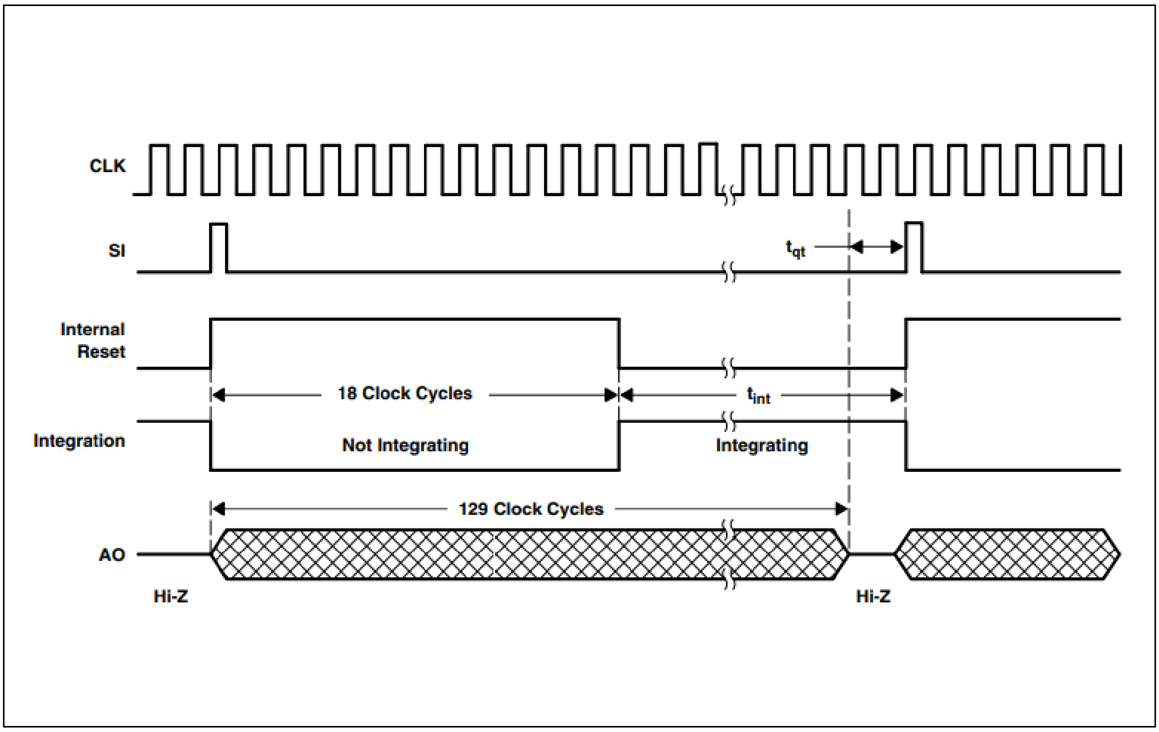
- CCD module

Peripherals	Description
CCD: VCC	Power supply pin: 3.3V-5V
CCD: AO	Gray value output pin: analog output
CCD: CLK	Clock pin, determines the exposure time and controls the output of pixel gray value.
CCD: SI	Controls the acquisition and output of pixel gray value.
CCD: GND	Power supply pin: GND

Working principle

Acquisition timing diagram:

Timing Waveforms



- Every 129 clock cycles of TSL1401 is an output acquisition cycle, and the clock cycle is provided by the CLK pin.

- When the SI pin receives a high-level signal, the TSL1401 gray value acquisition task and gray value output task start at the same time.
- CCD grayscale value acquisition task: perform reset work in the 1st to 18th clock cycles (corresponding to the Internal Reset timing in the figure), perform ambient light sensing in the 19th to 129th clock cycles (corresponding to the Integration timing in the figure), and convert it into an electrical signal. The brighter the environment, the stronger the electrical signal. At the same time, if the clock cycle is longer, the longer the light sensing time, the stronger the electrical signal. The signal collected in the current acquisition cycle is allowed to be read in the next cycle.
- CCD grayscale value output task: After each falling edge between the 2nd and 129th cycles, the AO pin outputs a grayscale value once, representing the grayscale value of the 1st to 128th pixels from the left. The value can be read through the microcontroller ADC. Similarly, the signal output in the current output cycle belongs to the signal collected in the previous cycle.

> **Black line detected**

The corresponding grayscale value is low;

> **White line detected**

The corresponding grayscale value is high.

Software configuration

Pin definition

Main control chip	Pin	Main function (after reset)	Default multiplexing function	Redefine function
STM32F103RCT6	PA4	PA4	SPI1_NSS/USART2_CK/DAC_OUT1/ADC12_IN4	
STM32F103RCT6	PB4	NJTRST	SPI3_MISO	PB4/TIM3_CH1/SPI1_MISO
STM32F103RCT6	PB5	PB5	I2C1_SMBA/SPI3_MOSI/I2S3_SD	TIM3_CH2/SPI1_MOSI

Software code

We need to configure the pins differently according to the function of the CCD pins.

```
Product supporting materials source code path: Attachment → Source code summary → 2.Extended_Course → 9.CCD
```

Control function

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

> **ccd_Init**

```
void  ccd_Init(void)
{
    ADC_InitTypeDef ADC_InitStructure;
    GPIO_InitTypeDef GPIO_InitStructure;
```

```
    RCC_APB2PeriphClockCmd( CCD_AO_CLK | CCD_ADC_CLK , ENABLE ); //Enable ADC3
channel clock
    RCC_ADCCLKConfig(RCC_PCLK2_Div6); //Set ADC division factor 6 72M/6=12, ADC
maximum time cannot exceed 14M

    //Set analog channel input pin
    GPIO_InitStructure.GPIO_Pin = CCD_AO_PIN;
    GPIO_InitStructure.GPIO_Mode = GPIO_Mode_AIN; //Analog input pin
    GPIO_Init(CCD_AO_PORT, &GPIO_InitStructure);

    //Initialize SI interface
    RCC_APB2PeriphClockCmd( CCD_SI_CLK , ENABLE ); GPIO_InitStructure.GPIO_Mode =
GPIO_Mode_Out_PP; //Push-pull output GPIO_InitStructure.GPIO_Pin = CCD_SI_PIN;
GPIO_InitStructure.GPIO_Speed ••= GPIO_Speed_10MHz;
GPIO_Init(CCD_SI_PORT,&GPIO_InitStructure); //Initialize CLK interface
RCC_APB2Per iphClockCmd( CCD_CLK_CLK , ENABLE ); GPIO_InitStructure.GPIO_Mode =
GPIO_Mode_Out_PP; //Push-pull output GPIO_InitStructure.GPIO_Pin = CCD_CLK_PIN;
GPIO_InitStructure.GPIO_Speed ••= GPIO_Speed_10MHz;
GPIO_Init(CCD_CLK_PORT,&GPIO_InitStructure);

    ADC_DeInit(CCD_ADC); //Reset ADC2 and reset all registers of peripheral ADC2
to default values
    ADC_InitStructure.ADC_Mode = ADC_Mode_Independent; //ADC working mode: ADC1
and ADC2 work in independent mode
    ADC_InitStructure.ADC_ScanConvMode = DISABLE; //Analog-to-digital conversion
works in single-channel mode
    ADC_InitStructure.ADC_ContinuousConvMode = DISABLE; //Analog-to-digital
conversion works in 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-
aligned
    ADC_InitStructure.ADC_NbrOfChannel = 1; //Number of ADC channels for
sequential regular conversion
    ADC_Init(CCD_ADC, &ADC_InitStructure); //Initialize the registers of the
peripheral ADCx according to the parameters specified in ADC_InitStruct
    ADC_Cmd(CCD_ADC, ENABLE); //Enable the specified ADC1

    ADC_ResetCalibration(CCD_ADC); //Enable reset calibration
    while(ADC_GetResetCalibrationStatus(CCD_ADC)); //Wait for reset calibration
to end
    ADC_StartCalibration(CCD_ADC); //Start AD calibration
    while(ADC_GetCalibrationStatus(CCD_ADC)); //Wait for calibration to end
}
```

Get_Adc_CCD

```
u16 Get_Adc_CCD(u8 ch)
{
    //Sets the specified ADC rule group channel, one sequence, and sampling time
    //Sets the specified ADC rule group channel, one sequence, and sampling time
    //ADC1, ADC channel, sampling time is 480 cycles
    ADC_RegularChannelConfig(CCD_ADC, ch, 1, ADC_SampleTime_239Cycles5 ); //ADC1,
ADC channel, sampling time is 239.5 cycles
    //Enable the specified ADC1 software transformation startup function
```

```
    //Enable the specified ADC1 software conversion startup function
    ADC_SoftwareStartConvCmd(CCD_ADC, ENABLE);
    //Wait for the conversion to finish
    //Wait for the conversion to finish
    while(!ADC_GetFlagStatus(CCD_ADC, ADC_FLAG_EOC ));
    //Returns the result of the last ADC1 rule group conversion
    //Returns the most recent conversion result of the ADC1 rule group
    return ADC_GetConversionValue(CCD_ADC);
}
```

RD_TSL

```
 void RD_TSL(void)
{
  u8 i=0,tslp=0;
  TSL_CLK=1;
  TSL_SI=0;
  Dly_us();

  TSL_SI=1;
  TSL_CLK=0;
  Dly_us();

  TSL_CLK=1;
  TSL_SI=0;
  Dly_us();
  for(i=0;i<128;i++)
  {
    TSL_CLK=0;
    Dly_us();
    Dly_us();

    ADV[tslp]=(Get_Adc_CCD(CCD_ADC_CH))>>4;
    ++tslp;
    TSL_CLK=1;
    Dly_us();
  }
}
```

Find_CCD_Zhongzhi

```
void  Find_CCD_Zhongzhi(void)
{
        static u16 i,j,Left,Right;
    static u16 value1_max,value1_min;

    value1_max=ADV[0]; //Dynamic threshold algorithm, read the maximum and minimum values
    for(i=5;i<123;i++) //Remove 5 points on each side
    {
    if(value1_max<=ADV[i])
    value1_max=ADV[i];
    }
    value1_min=ADV[0]; //Minimum value
```

```
    for(i=5;i<123;i++)
    {
    if(value1_min>=ADV[i])
    value1_min=ADV[i];
    }
    CCD_Yuzhi=(value1_max+value1_min)/2; //Calculate the threshold for this
midline extraction
    for(i = 5;i<118; i++) //Find the left jump edge
    {
    if(ADV[i]>CCD_Yuzhi&&ADV[i+1]>CCD_Yuzhi&&ADV[i+2]>CCD_Yuzhi&&ADV[i+3]
<CCD_Yuzhi&&ADV[i+4]<CCD_Yuzhi&&ADV[i+5]<CCD_Yuzhi)
    {
        Left=i;
        break;
    }
    }
    for(j = 118;j>5; j--)
    {
    if(ADV[j]<CCD_Yuzhi&&ADV[j+1]<CCD_Yuzhi&&ADV[j+2]
<CCD_Yuzhi&&ADV[j+3]>CCD_Yuzhi&&ADV[j+4]>CCD_Yuzhi&&ADV[j+5]>CCD_Yuzhi)
    {
      Right=j;
      break;
    }
    }
    CCD_Zhongzhi=(Right+Left)/2;
}
```

CCD_Get_ADC_128X32

```
uint8_t* CCD_Get_ADC_128X32(void)
{
    RD_TSL();
    for (int i = 0; i < 128; i++)
    {
        ADC_128X32[i] = ADV[i] >> 3;
    }
    return ADC_128X32;
}
```

OLED_Show_CCD_Image

```
void OLED_Show_CCD_Image(uint8_t* p_img)
{
    OLED_Clear();
    for (int i = 0; i < 128; i++)
    {
        if (p_img[i] < 32)
        {
            SSD1306_DrawPixel(i, p_img[i], SSD1306_COLOR_WHITE);
        }
    }
    OLED_Refresh();
}
```

Experimental phenomenon

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

After the program is successfully downloaded: OLED and serial port display the data output by the CCD module, and OLED displays the CCD module data in the form of a curve.

```
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.
```