9. Timer interrupt controls PWM steering gear

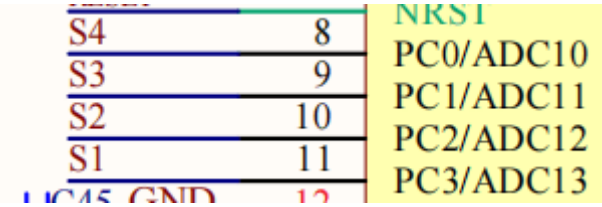
9.1. Experimental purpose

Using STM32 basic timer interrupt function, analog output PWM signal, control PWM steering gear.

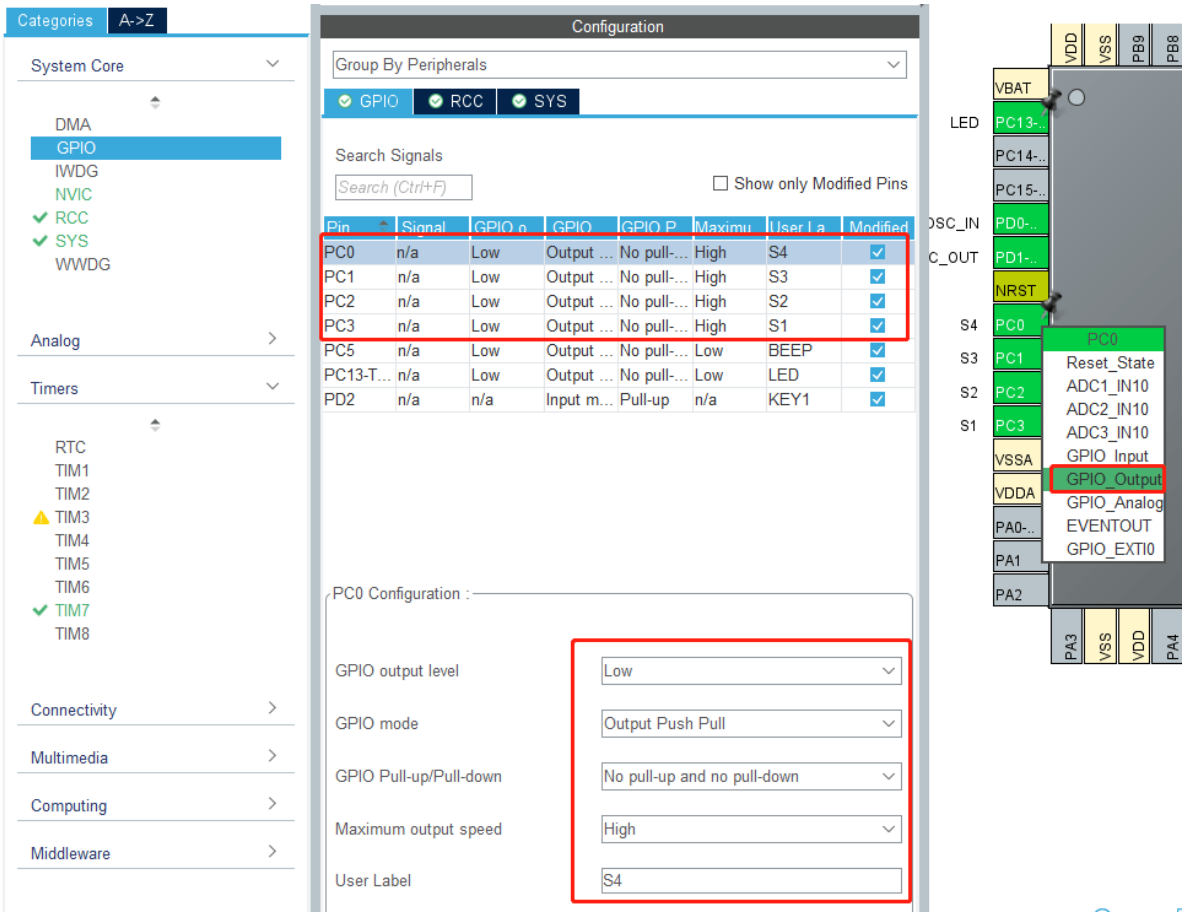
9.2. Configure pin information

1. Import ioc file from Beep project and name it PwmServo.

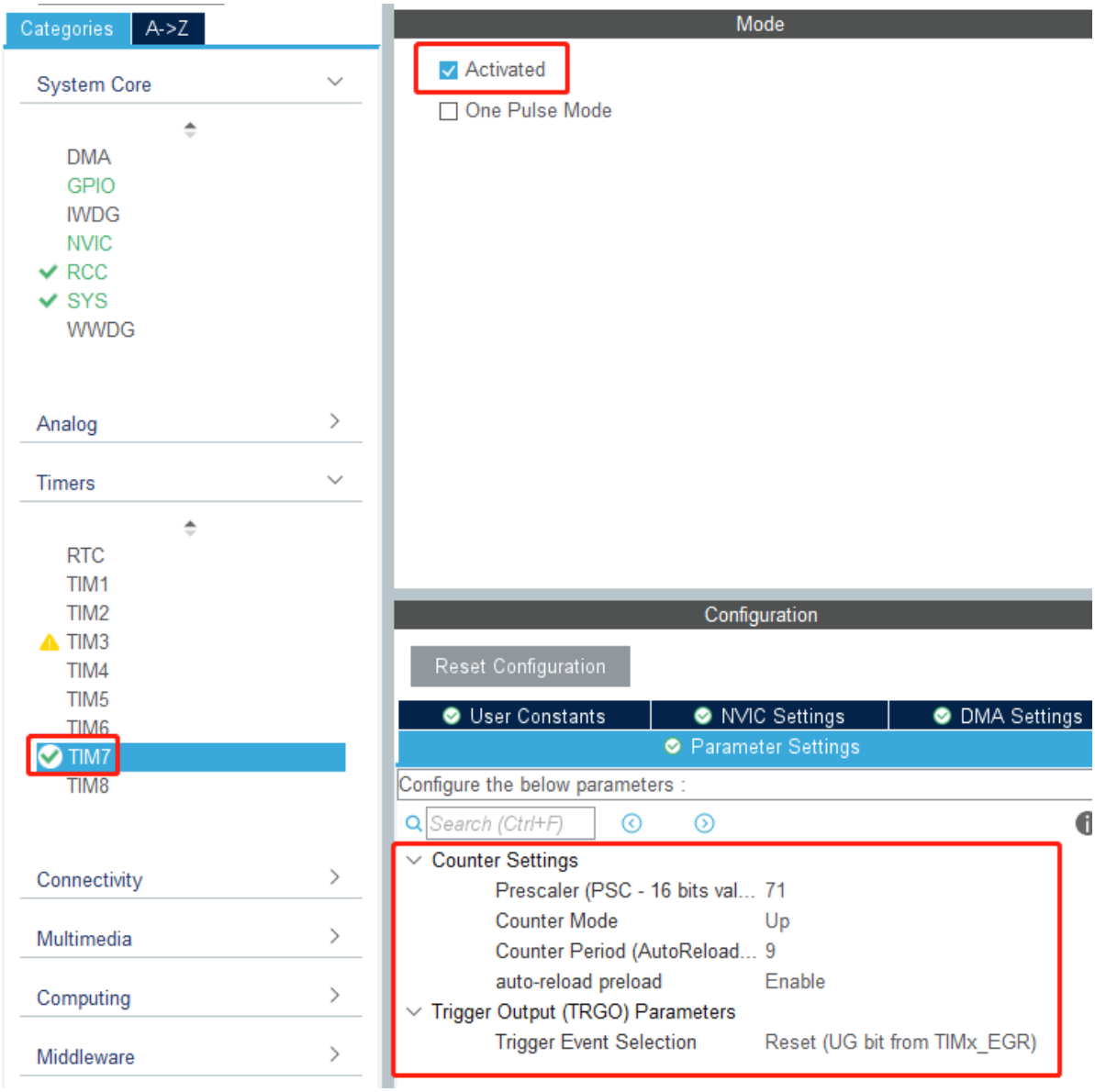
According to the schematic diagram, the steering gear S1, S2, S3, S4 is respectively connected to the PC3, PC2, PC1, PC0 pins of the STM32.



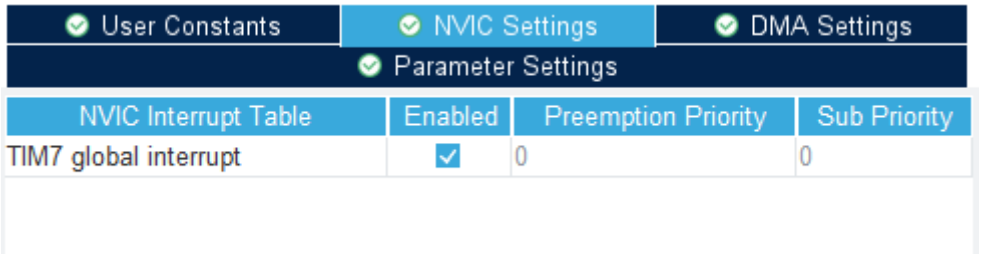
Set PC0 PC1 PC2 PC3 pin to output mode, specific parameters are shown as follows:



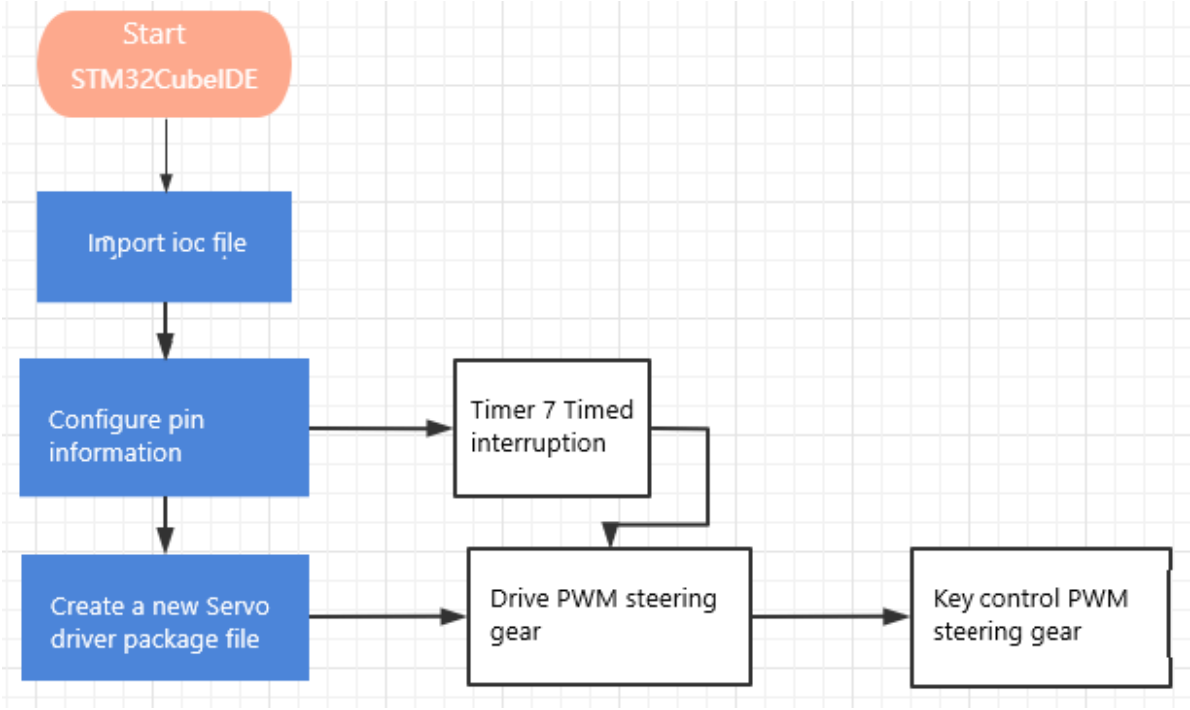
2. Next, we need to configure timer 7. The specific configuration parameters are shown in the following figure.



The timer global interrupt setting is enabled.



9.3. Analysis of experimental flow chart



9.4. Core code interpretation

1. Create bsp_pwmServo.h and bsp_pwmServo.c, and add the following contents to pwmServo.

```
#define SERVO_1_HIGH()   HAL_GPIO_WritePin(S1_GPIO_Port, S1_Pin, GPIO_PIN_SET)
#define SERVO_1_LOW()    HAL_GPIO_WritePin(S1_GPIO_Port, S1_Pin, GPIO_PIN_RESET)

#define SERVO_2_HIGH()   HAL_GPIO_WritePin(S2_GPIO_Port, S2_Pin, GPIO_PIN_SET)
#define SERVO_2_LOW()    HAL_GPIO_WritePin(S2_GPIO_Port, S2_Pin, GPIO_PIN_RESET)

#define SERVO_3_HIGH()   HAL_GPIO_WritePin(S3_GPIO_Port, S3_Pin, GPIO_PIN_SET)
#define SERVO_3_LOW()    HAL_GPIO_WritePin(S3_GPIO_Port, S3_Pin, GPIO_PIN_RESET)

#define SERVO_4_HIGH()   HAL_GPIO_WritePin(S4_GPIO_Port, S4_Pin, GPIO_PIN_SET)
#define SERVO_4_LOW()    HAL_GPIO_WritePin(S4_GPIO_Port, S4_Pin, GPIO_PIN_RESET)


void PwmServo_Init(void);
void PwmServo_Set_Angle(uint8_t index, uint8_t angle);
void PwmServo_Set_Angle_All(uint8_t angle_s1, uint8_t angle_s2, uint8_t angle_s3, uint8_t angle_s4);
void PwmServo_Handle(void);
```

SERVO_X_HIGH() indicates the output high level, and SERVO_X_LOW() indicates the output low level.

2. Create the following content in the bsp_pwmServo.c file:

The PwmServo_Init() function initializes the position of the PWM at 90 degrees.

```
// Initialize the steering gear  舵机初始化
void PwmServo_Init(void)
{
    for (int i = 0; i < MAX_PWM_SERVO; i++)
    {
        g_pwm_angle[i] = 90;
        g_angle_num[i] = PwmServo_Angle_To_Pulse(g_pwm_angle[i]);
    }
}
```

The PwmServo_Angle_To_Pulse() function converts the Angle into the duty cycle value of the PWM.

```
// 角度转化为脉冲数, angle= [0, 180]
// The Angle is converted to the number of pulses, angle= [0, 180]
static uint16_t PwmServo_Angle_To_Pulse(uint8_t angle)
{
    uint16_t pulse = (angle * 11 + 500) / 10;
    return pulse;
}
```

3. The PwmServo_Set_Angle() function sets the pwm steering gear angle, index=0~3, angle= 0-180.

```
// 设置pwm舵机角度，index=0~MAX_PWM_SERVO-1，angle为0-180
// Set the PWM servo Angle, index=0~MAX_PWM_SERVO, Angle to 0-180
void PwmServo_Set_Angle(uint8_t index, uint8_t angle)
{
    if (index >= MAX_PWM_SERVO)
        return;
    if (angle > 180)
        return;
    g_pwm_angle[index] = angle;
    g_angle_num[index] = PwmServo_Angle_To_Pulse(angle);
}
```

4. The PwmServo_Set_Angle_All() function sets the angles of all pwm steering engines. angle_s1 corresponds to the angles of S1, ranging from 1 to 180, and the other three parameters correspond to the angles of S2 S3 S4 respectively.

```
// 设置全部pwm舵机的角度
// Set the Angle of all PWM steering gear
void PwmServo_Set_Angle_All(uint8_t angle_s1, uint8_t angle_s2, uint8_t angle_s3, uint8_t angle_s4)
{
    if (angle_s1 <= 180)
    {
        g_pwm_angle[0] = angle_s1;
        g_angle_num[0] = PwmServo_Angle_To_Pulse(angle_s1);
    }

    if (angle_s2 <= 180)
    {
        g_pwm_angle[1] = angle_s2;
        g_angle_num[1] = PwmServo_Angle_To_Pulse(angle_s2);
    }

    if (angle_s3 <= 180)
    {
        g_pwm_angle[2] = angle_s3;
        g_angle_num[2] = PwmServo_Angle_To_Pulse(angle_s3);
    }

    if (angle_s4 <= 180)
    {
        g_pwm_angle[3] = angle_s4;
        g_angle_num[3] = PwmServo_Angle_To_Pulse(angle_s4);
    }
}
```

5. The PwmServo_Handle() function needs to be called during the interrupt of the timer to simulate the output PWM signal and control the steering gear according to the Angle value set above.

```
// PWM舵机控制，在定时器中调用，模拟输出PWM信号
// PWM steering gear control, in the timer call, analog output PWM signal
void PwmServo_Handle(void)
{
    g_pwm_pulse++;

#ifdef USE_SERVO_J1
    if (g_pwm_pulse <= g_angle_num[0])
        SERVO_1_HIGH();
    else
        SERVO_1_LOW();
#endif

#ifdef USE_SERVO_J2
    if (g_pwm_pulse <= g_angle_num[1])
        SERVO_2_HIGH();
    else
        SERVO_2_LOW();
#endif

#ifdef USE_SERVO_J3
    if (g_pwm_pulse <= g_angle_num[2])
        SERVO_3_HIGH();
    else
        SERVO_3_LOW();
#endif

#ifdef USE_SERVO_J4
    if (g_pwm_pulse <= g_angle_num[3])
        SERVO_4_HIGH();
    else
        SERVO_4_LOW();
#endif

    if (g_pwm_pulse >= 2000)
        g_pwm_pulse = 0;
}
```

6. Create a new HAL_TIM_PeriodElapsedCallback() function. This function cannot change its name, otherwise it will be found. The PwmServo_Handle() function is interrupted on timer 7 to generate a PWM signal.

```
// Timer interrupts the callback function  定时器中断回调函数
void HAL_TIM_PeriodElapsedCallback(TIM_HandleTypeDef *htim)
{
    if (htim->Instance == htim7.Instance)
    {
        PwmServo_Handle();
    }
}
```

7. Add the following content to the Bsp_Loop() function to control PWM steering gear.

```
// main.c中循环调用此函数，避免多次修改main.c文件。
// This function is called in a loop in main.c to avoid multiple modifications to the main.c file
void Bsp_Loop(void)
{
    static uint8_t key_state = 0;
    // Detect button down events   检测按键按下事件
    if (Key1_State(KEY_MODE_ONE_TIME))
    {
        Beep_On_Time(50);
        if (key_state)
        {
            key_state = 0;
            PwmServo_Set_Angle_All(50, 50, 50, 50);
        }
        else
        {
            key_state = 1;
            PwmServo_Set_Angle_All(150, 150, 150, 150);
        }
    }

    Bsp_Led_Show_State_Handle();
    // The buzzer automatically shuts down when times out   蜂鸣器超时自动关闭
    Beep_Timeout_Close_Handle();
    HAL_Delay(10);
}
```

9.5. Hardware connection

Since the PWM actuator has different voltage driving values, the voltage switching function is added to the expansion board. According to the jumper cap on the expansion board, the PWM output voltage can be modified to 5V or 6.8V. To use PWM steering gear, the corresponding voltage must be selected with jumper cap to avoid burning out the steering gear. If the jumper cap is not inserted, the PWM steering engine cannot be controlled. The pins of PWM steering gear are: yellow -> signal, red -> positive power supply, black -> negative power supply.

Because the power of the PWM actuator is relatively large, do not use the USB5V power supply directly on the expansion board, and use the battery power supply.

9.6. Experimental effect

After burning the program, the LED light flashes every 200 milliseconds. By pressing the key several times, the PWM steering machine will go back and forth between 50 degrees and 150 degrees.