9. Timer interrupt control PWM servos

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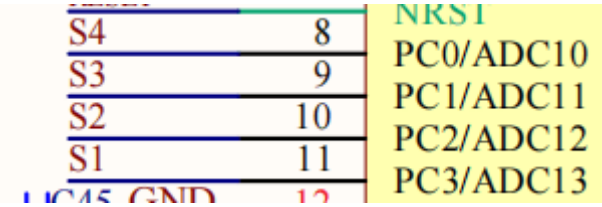
9.1. Purpose of experiment

Use the basic timer interrupt function of STM32 to simulate the output of PWM signal to control the PWM servo.

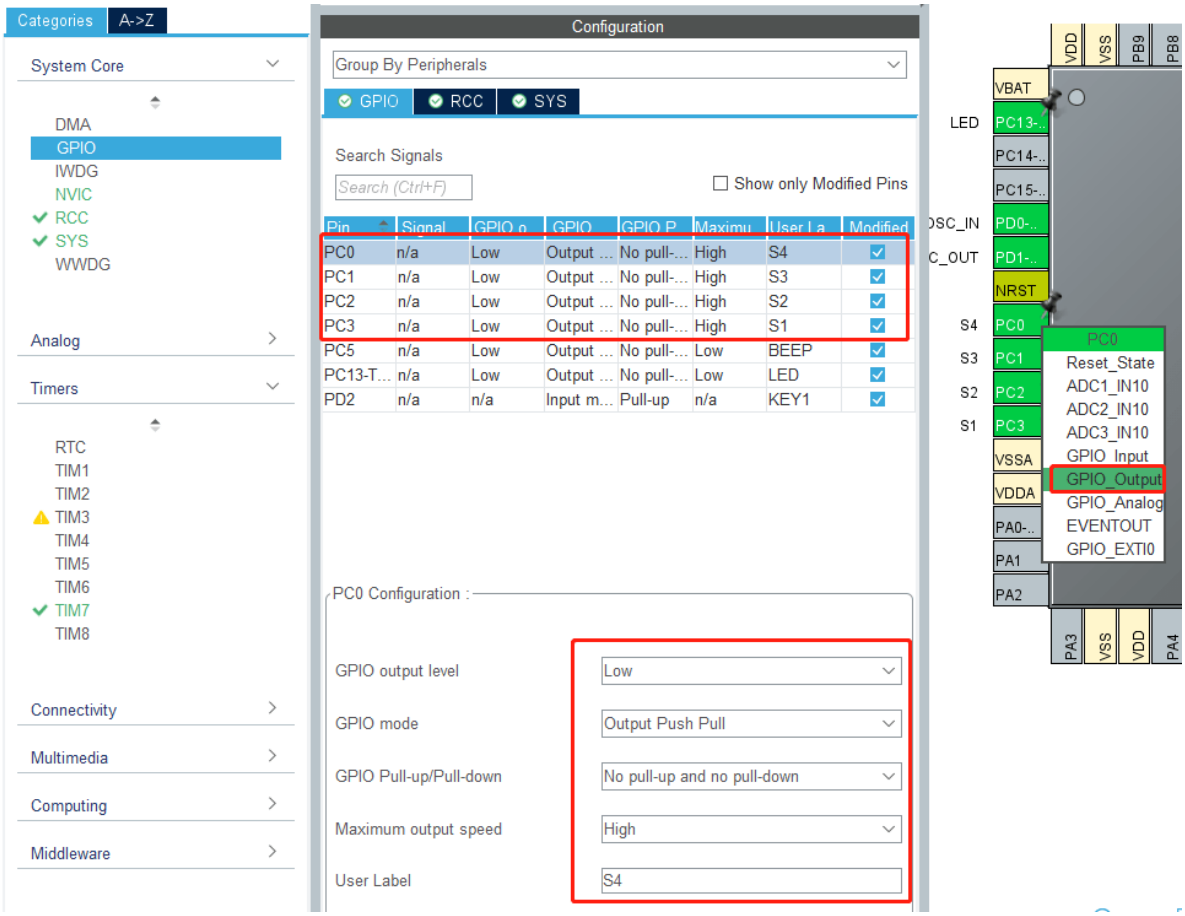
9.2 Configuring Pin Information

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

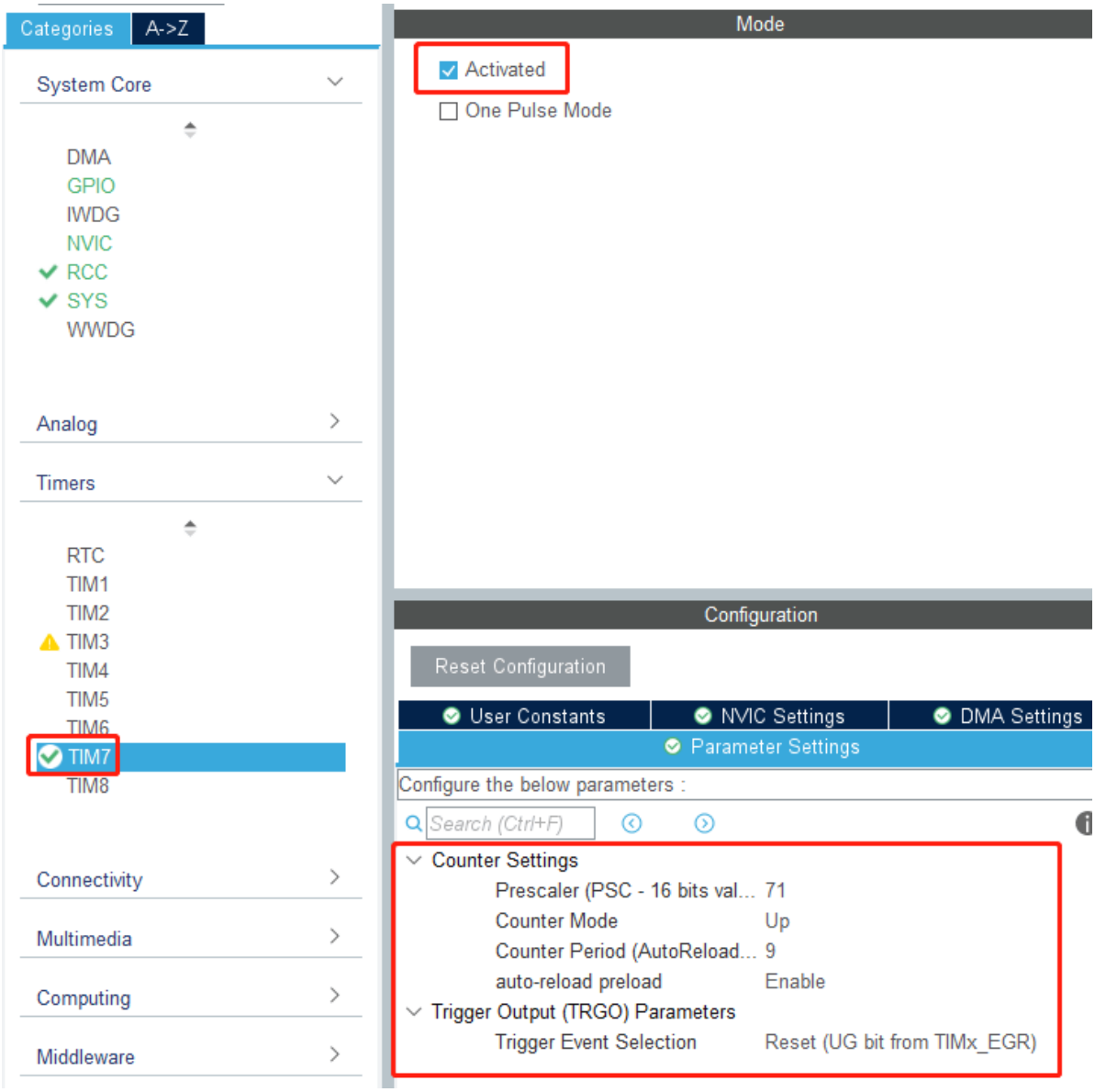
According to the schematic diagram, it can be seen that servo S1 S2 S3 S4 are connected to the PC3 PC2 PC1 PC0 pins of STM32 respectively.



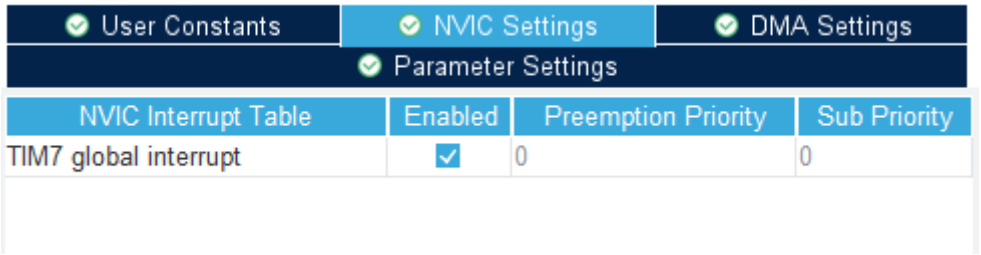
Set PC0 PC1 PC2 PC3 pins to output mode with the parameters shown below:



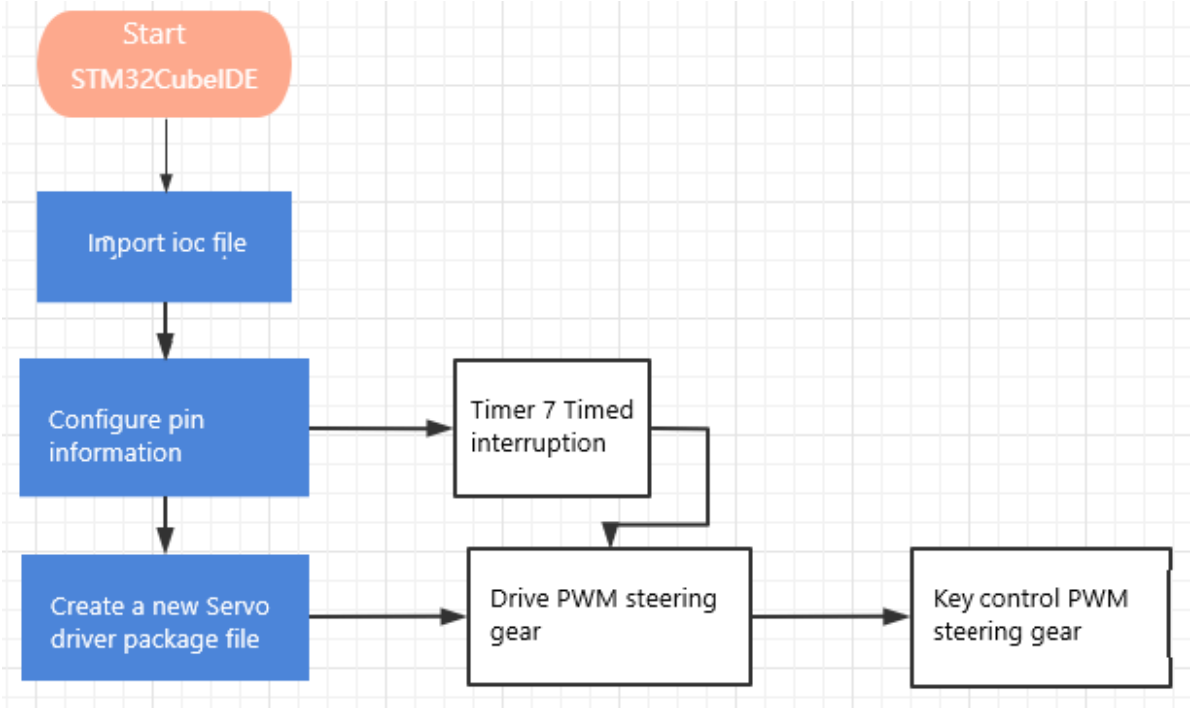
2. Next we need to configure Timer 7, the specific configuration parameters are shown below.



Turns on the timer global interrupt setting.



9.3. Experimental flow chart analysis



9.4. Core Code Explanation

1. Create a new bsp_pwmServo.h and bsp_pwmServo.c, and add the following to pwmServo.h:

```
#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);
```

Among them, SERVO_X_HIGH() means output high level, SERVO_X_LOW() means output low level.

2. In the bsp_pwmServo.c file, create the following new content:

PwmServo_Init() function initializes the PWM position to 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 a PWM duty cycle value.

```
// 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.PwmServo_Set_Angle() function sets the pwm servo angle, index=0~3, angle is 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.PwmServo_Set_Angle_All() function sets the angle of all pwm servos, angle_s1 corresponds to the angle of S1, the range is 1-180, and the other three parameters correspond to the angle values 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. PwmServo_Handle() function needs to be called in the interrupt of the timer to simulate the output PWM signal to control the servo according to the servo 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. New HAL_TIM_PeriodElapsedCallback() function, this function can not change the name, otherwise this function will be found. Call PwmServo_Handle() function at timer 7 interrupt to generate 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 to the Bsp_Loop() function button to control the PWM servo.

```
// 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

Because PWM servo has different voltage drive value, so the expansion board added the function of voltage switching, according to the jumper cap on the expansion board, you can modify the PWM output voltage to 5V or 6.8 V. To use PWM servo, you must use the jumper cap to select the corresponding voltage, to avoid burning the servo. If you don't insert the jumper cap, you can't control the PWM servo.The pins of PWM servo are: yellow->signal, red->power positive, black->power negative.

Due to the relatively large power of the PWM servo, the expansion board should not use USB5V power supply directly, but need to use DC 12V power supply.

9.6. Experimental Effect

After burning the program, the LED flashes every 200 milliseconds. Pressing the key several times, the PWM servo will go back and forth between 50 degrees and 150 degrees.