11、Nine-axis attitude sensor to obtain data-ICM20948

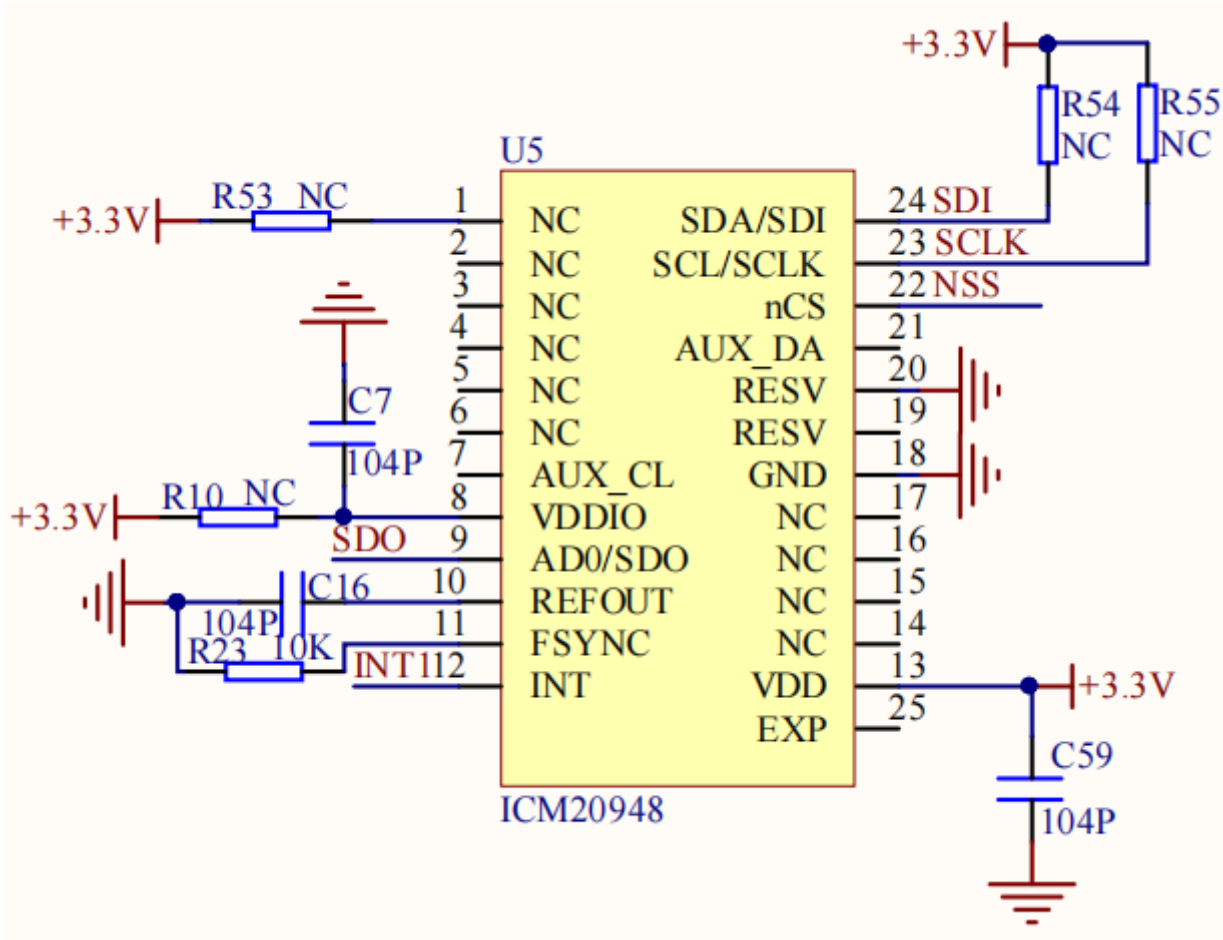
11.1、Experimental purpose

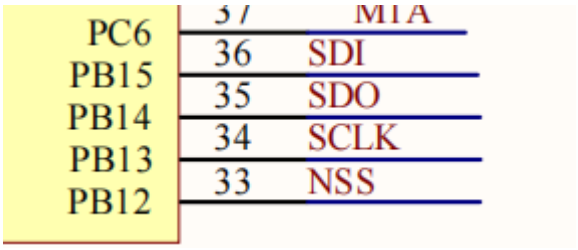
Use the SPI communication of STM32 to read the raw data of the nine-axis attitude sensor ICM20948 and print it out through the serial port assistant.

11.2、Configuration pin information

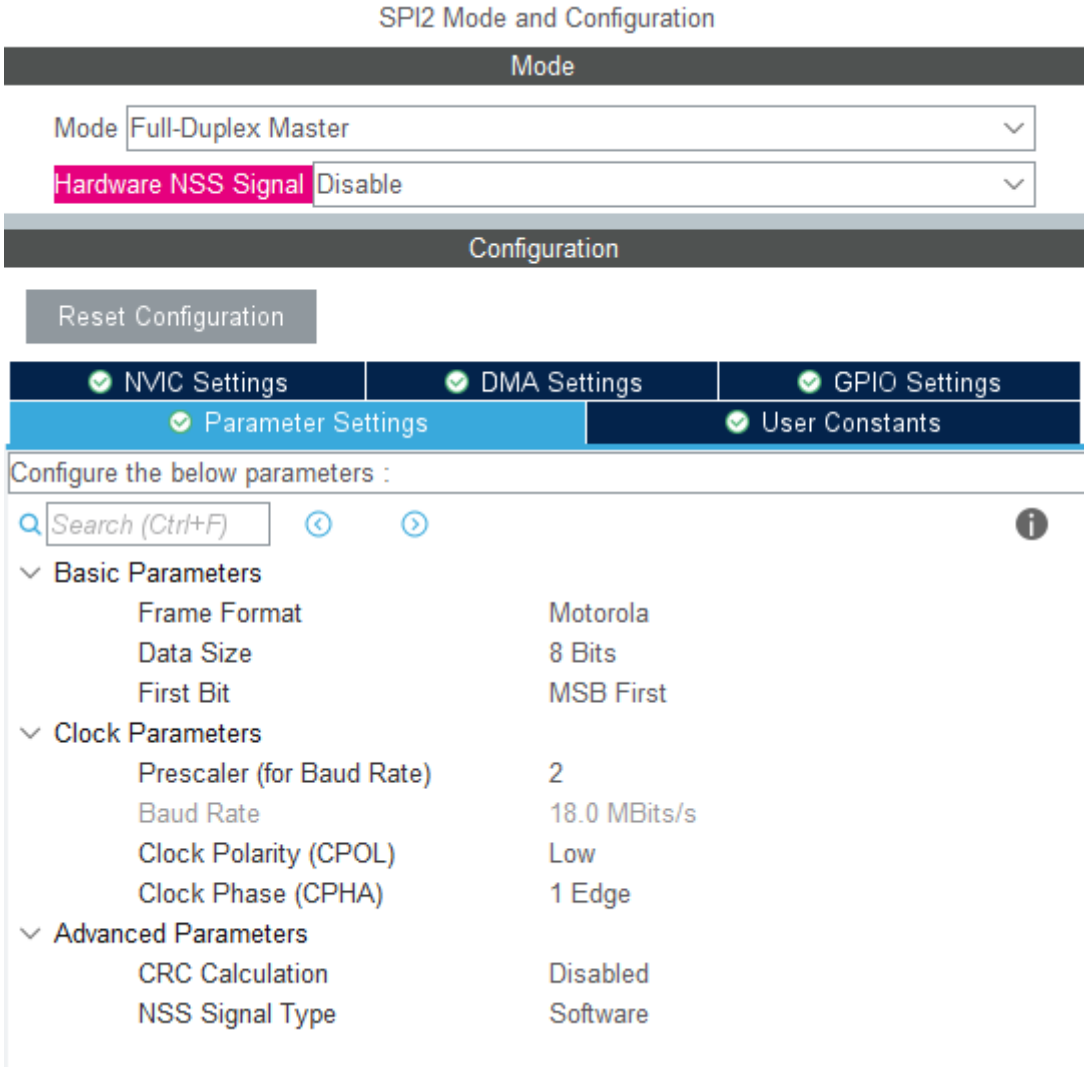
1.Import the ioc file from the Serial project and name it Read_ICM20948.

According to the schematic diagram, the SDA/SDI pin of the nine-axis attitude sensor is connected to PB15, the SCL/SCLK pin is connected to PB13, the AD0/SDO pin is connected to PB14, and the NSS pin is connected to PB12.

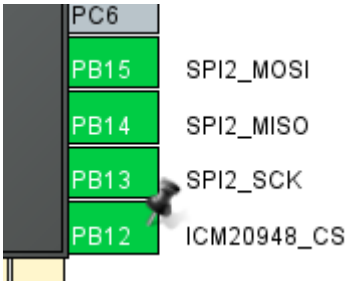




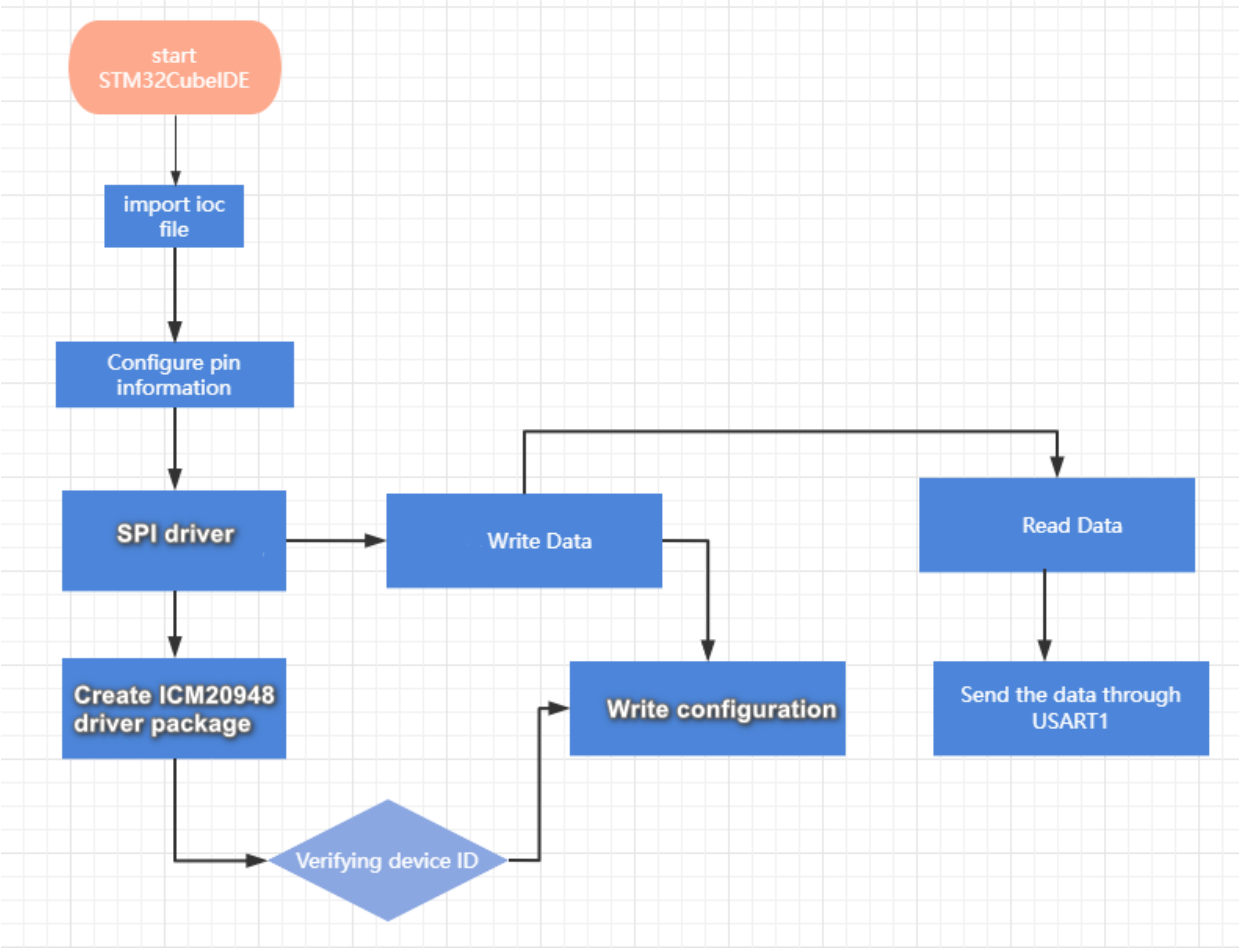
2.Enable the SPI2 interface, set PB13, PB14, and PB15 as SPI2 pins, and use the PB12 software control method for the NSS chip select pin. The specific parameters are shown in the figure below:



Then set PB12 to output mode and rename it ICM20948_CS.



11.3、Experimental flow chart analysis



11.4、Core code explanation

1.Create new bsp_icm20948.h and bsp_icm20948.c, and add the following content in bsp_icm20948.h.

```
void ICM20948_init();
void AK09916_init();

// read raw data.
void ICM20948_gyro_read(raw_data_t* data);
void ICM20948_accel_read(raw_data_t* data);
bool AK09916_mag_read(raw_data_t* data);

// Convert 16 bits ADC value to their unit.
void ICM20948_gyro_read_dps(axises_t* data);
void ICM20948_accel_read_g(axises_t* data);
bool AK09916_mag_read_uT(axises_t* data);

bool ICM20948_who_am_i();
bool AK09916_who_am_i();

void ICM20948_Read_Data_Handle(void);
```

2..Create the following content in the bsp_icm20948.c file:

Start initializing the ICM20948. First, reset and wake up the ICM20948, set the clock source, magnetometer access method and filtering configuration, then calibrate the gyroscope and accelerometer, and set the scaling ratio.

```
void ICM20948_init()
{
    while(!ICM20948_who_am_i());

    ICM20948_device_reset();
    ICM20948_wakeup();

    ICM20948_clock_source(1);
    ICM20948_odr_align_enable();

    ICM20948_spi_slave_enable();

    ICM20948_gyro_low_pass_filter(0);
    ICM20948_accel_low_pass_filter(0);

    ICM20948_gyro_sample_rate_divider(0);
    ICM20948_accel_sample_rate_divider(0);

    ICM20948_gyro_calibration();
    ICM20948_accel_calibration();

    ICM20948_gyro_full_scale_select(_2000dps);
    ICM20948_accel_full_scale_select(_16g);
}
```

3.Initialize the AK09916 magnetometer.

```
void AK09916_init()
{
    ICM20948_i2c_master_reset();
    ICM20948_i2c_master_enable();
    ICM20948_i2c_master_clk_frq(7);
    while(!AK09916_who_am_i());
    AK09916_soft_reset();
    AK09916_operation_mode_setting(continuous_measurement_100hz);
}
```

4.Enables and disables SPI communication of ICM20948.

```
static void ICM20948_NoActive()
{
    HAL_GPIO_WritePin(ICM20948_CS_GPIO_Port, ICM20948_CS_Pin, SET);
}
static void ICM20948_Active()
{
    HAL_GPIO_WritePin(ICM20948_CS_GPIO_Port, ICM20948_CS_Pin, RESET);
}
```

5.The SPI method of reading data, read_single_reg is to read one byte of data from a register, and read_multiple_reg is to read multiple bytes of data from a register.

```
static uint8_t read_single_reg(userbank_t ub, uint8_t reg)
{
    uint8_t read_reg = READ | reg;
    uint8_t reg_val;
    select_user_bank(ub);
    ICM20948_Active();
    HAL_SPI_Transmit(ICM20948_SPI, &read_reg, 1, 1000);
    HAL_SPI_Receive(ICM20948_SPI, &reg_val, 1, 1000);
    ICM20948_NoActive();
    return reg_val;
}
static uint8_t* read_multiple_reg(userbank_t ub, uint8_t reg, uint8_t len)
{
    uint8_t read_reg = READ | reg;
    static uint8_t reg_val[6];
    select_user_bank(ub);
    ICM20948_Active();
    HAL_SPI_Transmit(ICM20948_SPI, &read_reg, 1, 1000);
    HAL_SPI_Receive(ICM20948_SPI, reg_val, len, 1000);
    ICM20948_NoActive();
    return reg_val;
}
```

6.The SPI method of writing data, write_single_reg is to write one byte of data to a register, and write_multiple_reg is to write multiple bytes of data to a register.

```
static void write_single_reg(userbank_t ub, uint8_t reg, uint8_t val)
{
    uint8_t write_reg[2];
    write_reg[0] = WRITE | reg;
    write_reg[1] = val;
    select_user_bank(ub);
    ICM20948_Active();
    HAL_SPI_Transmit(ICM20948_SPI, write_reg, 2, 1000);
    ICM20948_NoActive();
}
static void write_multiple_reg(userbank_t ub, uint8_t reg, uint8_t* val, uint8_t
len)
```

```
{
    uint8_t write_reg = WRITE | reg;
    select_user_bank(ub);
    ICM20948_Active();
    HAL_SPI_Transmit(ICM20948_SPI, &write_reg, 1, 1000);
    HAL_SPI_Transmit(ICM20948_SPI, val, len, 1000);
    ICM20948_NoActive();
}
```

7.Read accelerometer raw data. Because the calibration function cancels out the acceleration due to gravity, adding a scaling factor to the Z-axis brings the reading back to normal.

```
void ICM20948_accel_read(raw_data_t* data)
{
    uint8_t* temp = read_multiple_reg(ub_0, B0_ACCEL_XOUT_H, 6);
    data->x = (int16_t)(temp[0] << 8 | temp[1]);
    data->y = (int16_t)(temp[2] << 8 | temp[3]);
    // data->z = (int16_t)(temp[4] << 8 | temp[5]);
    data->z = (int16_t)(temp[4] << 8 | temp[5]) + g_scale_accel;
    // Add scale factor because calibraiton function offset gravity acceleration.
}
```

Combine the accelerometer raw data and the scale factor to convert the unit to g.

```
void ICM20948_accel_read_g(axises_t* data)
{
    ICM20948_accel_read(&g_raw_accel);
    data->x = (float)(g_raw_accel.x / g_scale_accel);
    data->y = (float)(g_raw_accel.y / g_scale_accel);
    data->z = (float)(g_raw_accel.z / g_scale_accel);
}
```

8.Read gyroscope raw data.

```
void ICM20948_gyro_read(raw_data_t* data)
{
    uint8_t* temp = read_multiple_reg(ub_0, B0_GYRO_XOUT_H, 6);
    data->x = (int16_t)(temp[0] << 8 | temp[1]);
    data->y = (int16_t)(temp[2] << 8 | temp[3]);
    data->z = (int16_t)(temp[4] << 8 | temp[5]);
}
```

Combine the gyroscope raw data and the scale factor to convert the unit to dps.

```
void ICM20948_gyro_read_dps(axises_t* data)
{
    ICM20948_gyro_read(&g_raw_gyro);
    data->x = (float)(g_raw_gyro.x / g_scale_gyro);
    data->y = (float)(g_raw_gyro.y / g_scale_gyro);
    data->z = (float)(g_raw_gyro.z / g_scale_gyro);
}
```

9.Read magnetometer raw data.

```
bool AK09916_mag_read(raw_data_t* data)
{
    uint8_t* temp;
    uint8_t drdy, hofl;
    drdy = read_single_mag_reg(MAG_ST1) & 0x01;
    if(!drdy)   return false;
    temp = read_multiple_mag_reg(MAG_HXL, 6);
    hofl = read_single_mag_reg(MAG_ST2) & 0x08;
    if(hofl)    return false;
    data->x = (int16_t)(temp[1] << 8 | temp[0]);
    data->y = (int16_t)(temp[3] << 8 | temp[2]);
    data->z = (int16_t)(temp[5] << 8 | temp[4]);
    return true;
}
```

Convert the magnetometer raw data into uT units.

```
bool AK09916_mag_read_uT(axises_t* data)
{
    bool new_data = AK09916_mag_read(&g_raw_mag);
    if(!new_data)   return false;
    data->x = (float)(g_raw_mag.x * 0.15);
    data->y = (float)(g_raw_mag.y * 0.15);
    data->z = (float)(g_raw_mag.z * 0.15);
    return true;
}
```

10.Add content to initialize ICM20948 and AK09916 in the Bsp_Init() function.

```
void Bsp_Init(void)
{
    USART1_Init();
    ICM20948_init();
    AK09916_init();
    Beep_On_Time(50);
}
```

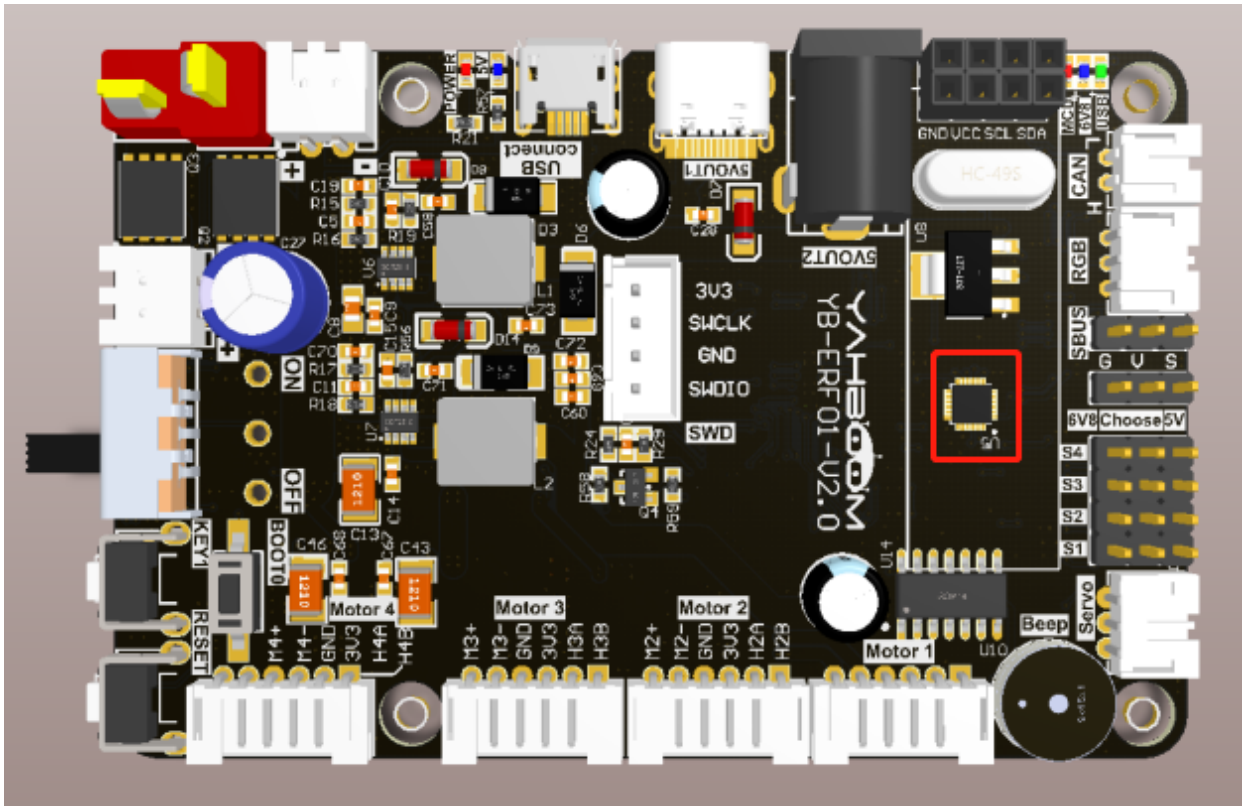
8.Add the function of reading ICM20948 data in the Bsp_Loop() function.

```
void Bsp_Loop(void)
{
    // Detect button down events
    if (Key1_State(KEY_MODE_ONE_TIME))
    {
        Beep_On_Time(50);
        static int press = 0;
        press++;
        printf("press:%d\n", press);
    }
    ICM20948_Read_Data_Handle();

    Bsp_Led_Show_State_Handle();
    // The buzzer automatically shuts down when times out
    Beep_Timeout_Close_Handle();
    HAL_Delay(10);
}
```

11.5、Hardware connection

The ICM20948 nine-axis attitude sensor is already soldered on the expansion board, so there is no need to manually connect the device.



11.6、Experimental effect

After burning the program, the LED light flashes every 200 milliseconds. Open the serial port assistant (the parameters are shown in the figure below), and you can see that the serial port assistant keeps printing the data of the accelerometer accel, gyroscope gyro, and magnetometer mag of ICM20948.