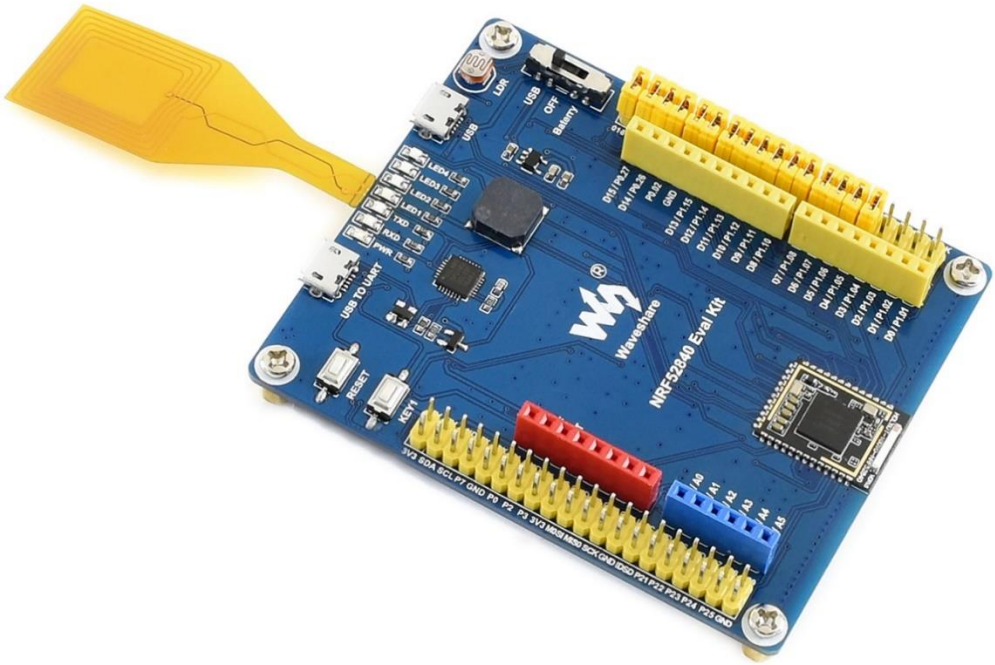
NRF52840 Eval Kit

User Manual



CONTENT

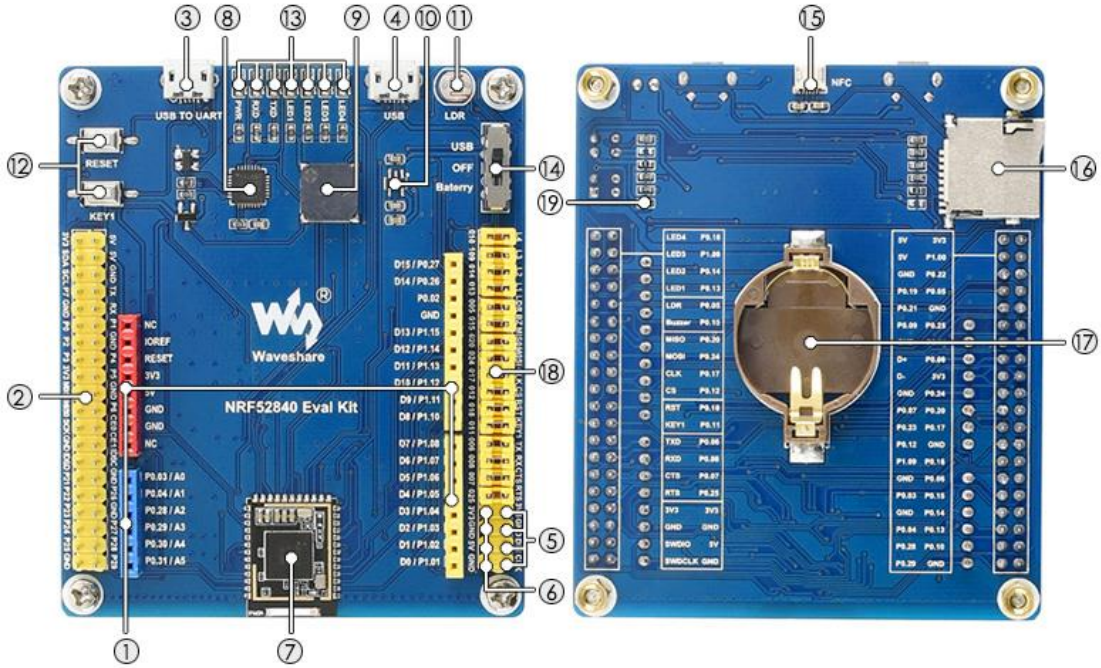
CHAPTER 1. OVERVIEW

NRF52840 Eval Kit is a development/evaluation kit based on nRF52840, features Arduino / Raspberry Pi connectivity, and several common peripherals.

It supports the new generation Bluetooth 5.0, compared to Bluetooth 4.0, the data rate is twice, up to 2Mbps, the transfer distance is quadruple. Based on the ARM Cortex-M4F architecture, the CPU frequency achieves up to 64MHz. Bluetooth MESH[1] and 2.4GHz radio are also available, that means higher performance, and more suitable applications.

Thanks to the onboard Arduino / Raspberry Pi compatible headers, both Arduino shields and Raspberry Pi HATs can be attached at the same time, make it easy to use more expansion resources.

WHAT' S ON BOARD



[1] At least three NRF52849 modules are required for Bluetooth MESH networking

1. **Arduino headers:** for connecting Arduino shields
2. **Raspberry Pi GPIO header:** for connecting Raspberry Pi HATs
3. **USB TO UART interface**
4. **USB port:** the USB port of nRF52840
5. **4PIN SWD debugging interface:** for connecting ARM Debugger to program / debug
6. **3.3V/5V power input/output:** provides power output OR powered from external power supply
7. **Core52840:** nRF52840 core module
8. **CP2102:** USB TO UART converter
9. **Buzzer**
10. **RT9193-33:** 3.3V voltage regulator
11. **Optical sensor**
12. **Keys:** RESET and USER KEY
13. **LEDs**

    PWR: power indicator

    RXD/TXD: nRF52840 UART RX/TX indicator

    LED1~LED4: USER LEDs
14. **Power switch**

    USB: powered from USB connection

    Battery: powered from CR2032 battery
15. **NFC antenna connector**
16. **TF card slot**
17. **CR2032 battery holder**
18. **Jumpers**

    Short the jumpers: connect the onboard peripherals to I/Os in example code

    Open the jumpers: connect to custom I/Os via jumper wires
19. **Current testing pads:** 0Ω resistor is soldered by default, remove the resistor to test current of the board

CHAPTER 2. SETUP DEVELOPING ENVIRONMENT

Generally, we use nRFgo Studio software to programming NRF52840, however, because of the compatibility of JLink driver, which is the driver of programmer of nRF series. Herein we use CLI to setup developing environment for nRF52840 instead of nRFgo Studio.

INSTALL KEIL AND RELATED PACK

Download Keil from its website and install. Note that Keil requires license, otherwise it can only be used to compile codes which is smaller than 256kB.

After installing, you should also install related Packs. The NRF52840 pack was already included in resources[2], run NordicSemiconductor.nRF_DeviceFamilyPack.8.17.0 to install it.

INSTALL SEGGER EMBEDDED STUDIO FOR ARM 4.10A

This tool is only required for Bluetooth MESH examples. You can skip this part if you do not use MESH.

You can download the package from resources and install it without license.

SERIAL DRIVER INSTALL

The Evaluation board has integrated CP2102 module, which is used for TTL to USB converting. To properly use serial port, you need to install CP2102 driver in your PC. If you have installed it before, skip this part.

The CP2102 driver is included in resources, choose one according to your OS.

[2] You can find them on Waveshare Wiki: https://www.waveshare.com/wiki/NRF52840_Eval_Kit

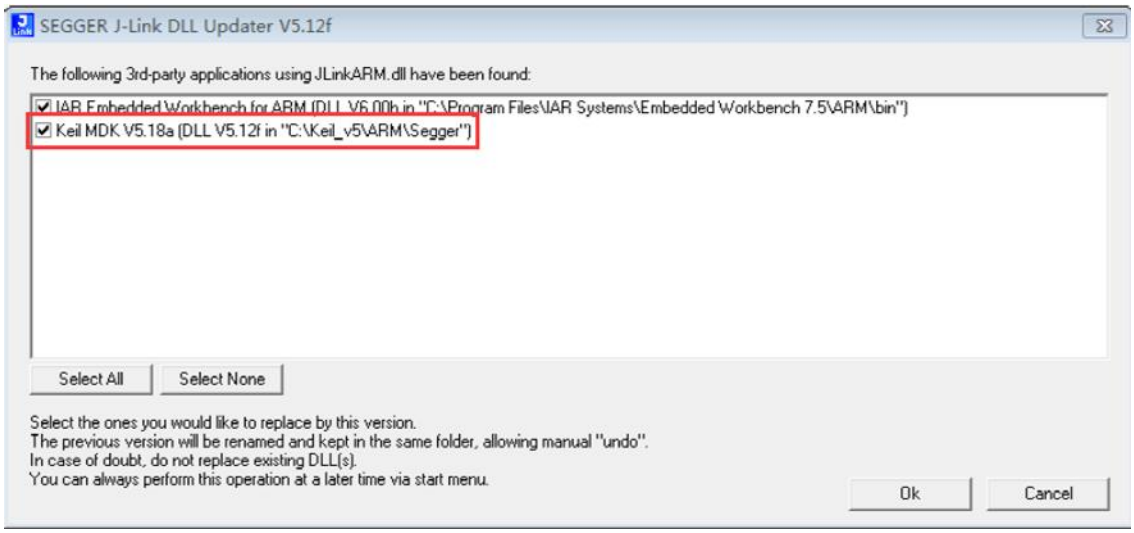
- Double-click installer “CPCP210xVCPInstaller_xxx” to run it
- Clock next to finish installing

  After installing, you can find that a new serial device is recognized under Computer->Manager->Devices Manager-> COM and LPT after you connect the evaluation board to PC.

INSTALL JLINK DRIVER

JLink programmer is used to programming NRF52840. It can also be used to erase NRF52840Flash and upload Bluetooth Softdevices[3] with nRF5x-Command-Line-Tools. We recommend you use V6.22 version or above, otherwise, the driver may cannot be recognized. The JLink driver is included in resources, you can search and download it.

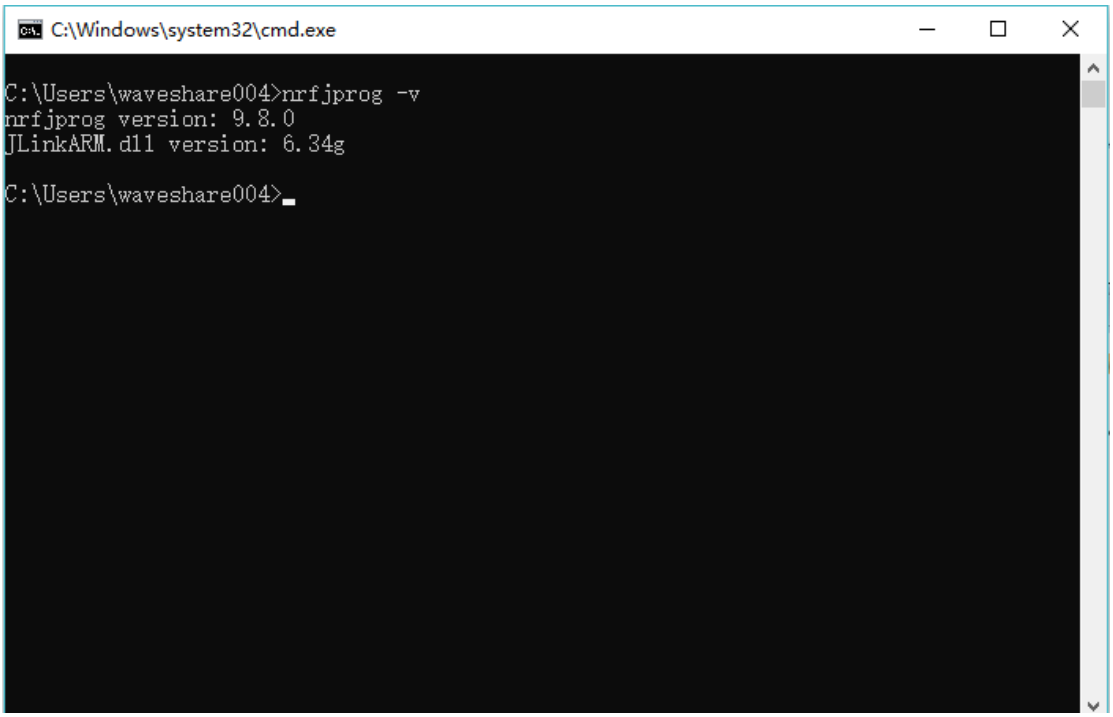
If you have installed Keil before JLink driver, don’t forget to check the option to cover it as below:



[3] Softdevices are protocol stacks for nRF series

INSTALL NRFX-COMMAND-LINE-TOOLS

The tool can be downloaded from resources. Download and install it. After installing, open console, and input nrfjprog -v to check the tools. It should be as below if you install the tool successfully.



INSTALL APP

App should be installed in mobile phones for debugging.

nRF Connect: Common debugging tool of mobile phone. With this APP, use can get the original data. nRF Connect can display RSSI curve, supports multiply slave devices, has high compatibility and is commonly used.

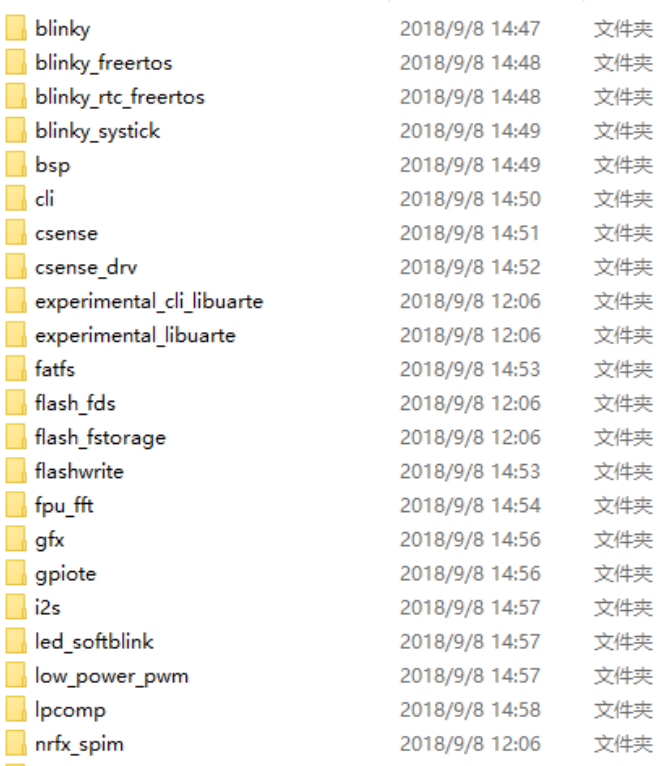
nRF Toolbox: BLE tool. Toolbox is generally used for part of experiments, it has GUI like thermometer, cardiotachometer. However, it can only be used for some of experiments and it is not much stable.

PERIPHERALS DEMO

Finish the developing environment setup, you now can try with some demo. Herein using the newest SDK(SDK 15.2), which support Bluetooth 5.0

There are examples in SDK, which can be divided to two kinds, one of them can run without Softdevice and another are based on Softdevice. The demo which does not need Softdevice generally located in

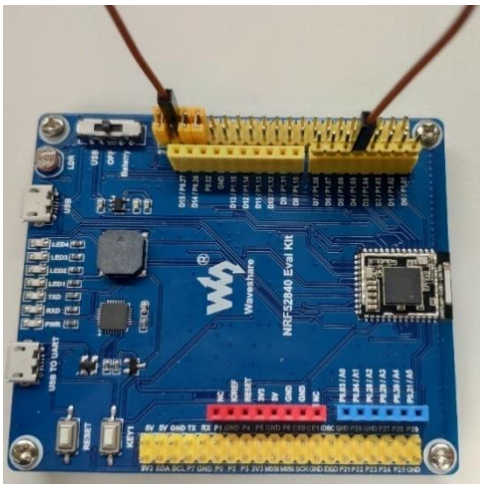
nRF5_SDK_15.2.0_9412b96\examples\peripheral\



HARDWARE CONNECTION

- Connect J-Link programmer to NRF52840 Eval kit and PC
- Connect NRF52840 Eval Kit to PC or other external power adapter
- Pull the jumper of LED3, and wire L3 to P1.05[4]

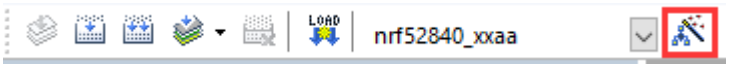
[4] LED3 isn't compatible with official SDK, so we should re-connect it when test Blinky sample



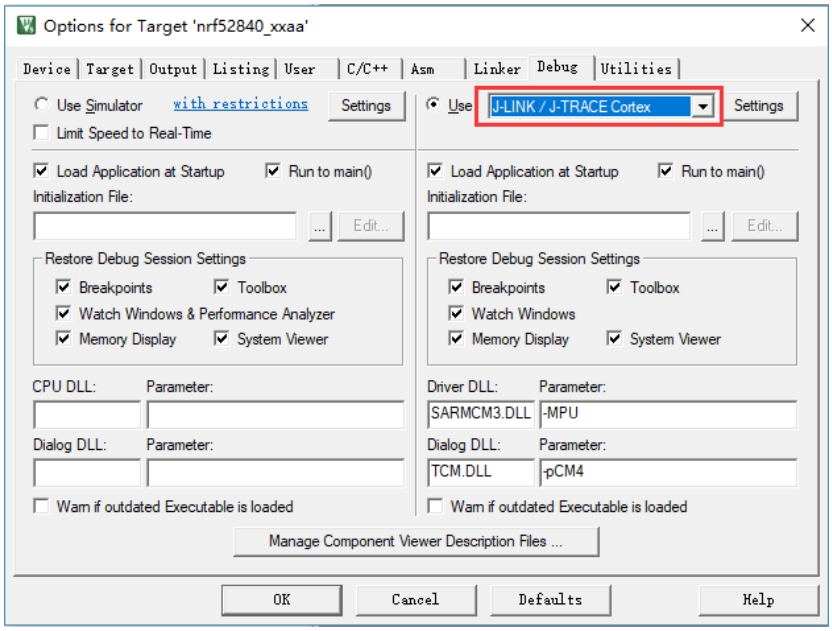
DOWNLOAD SAMPLES WITHOUT SOFTDEVICE

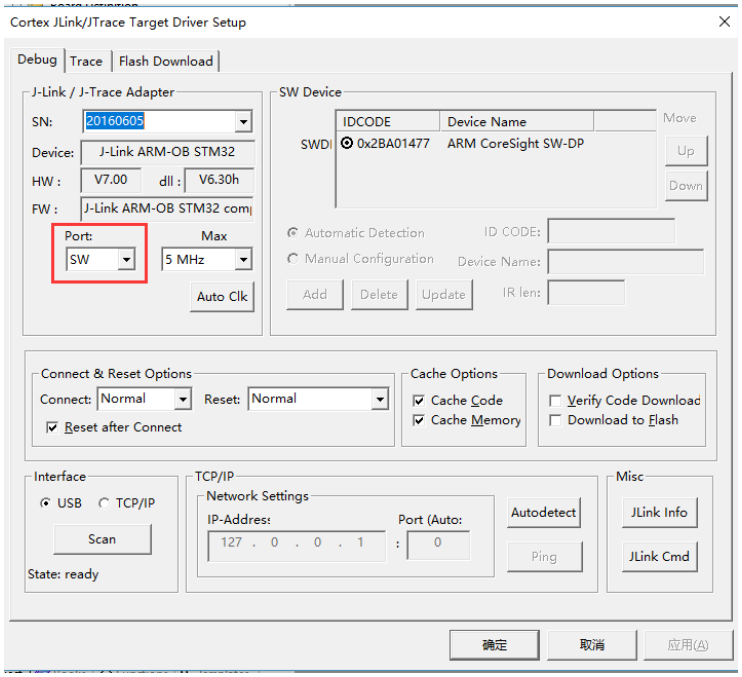
We take Blinky as example, learn how to use peripherals examples of SDK. Click blinky->pca10056->blank->arm5_no_packs->blink_pca10056.uvoptx to open the project. Compiling it:

Generally, it can be compiled successfully without error or warning. After compiling, you should configure it:

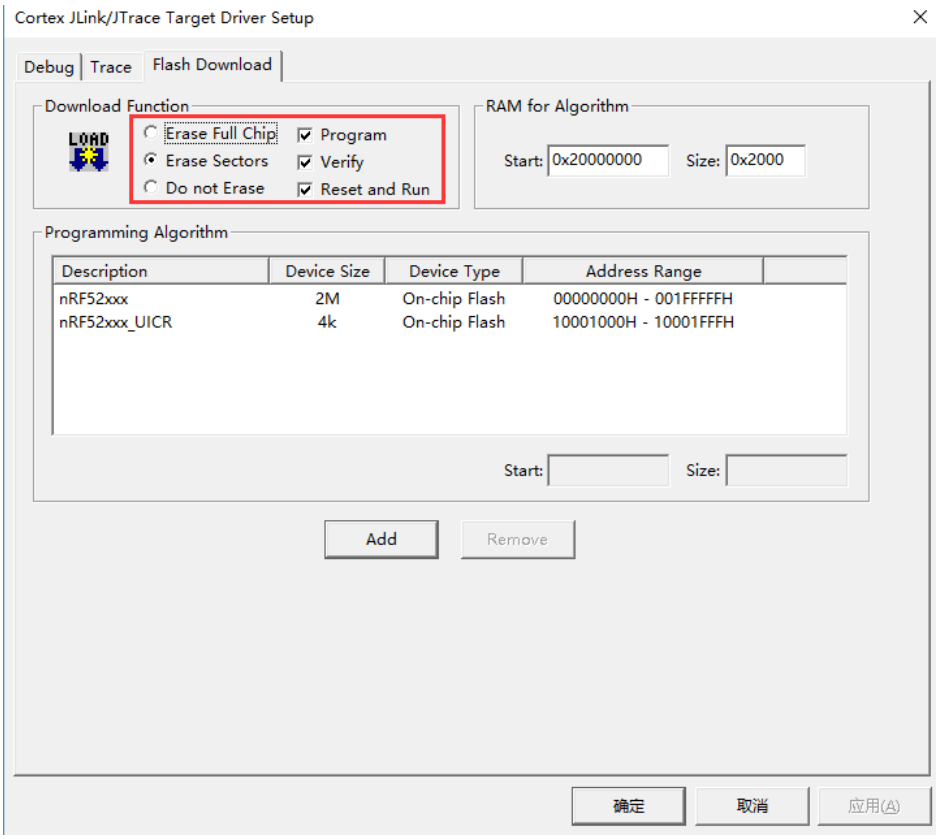


Click Debug, choose J-Links/J-Trace Cortex as debugger. Debug->Settings set Port to SW





Then click Flash Download, check the options as below and confirm by clicking OK.

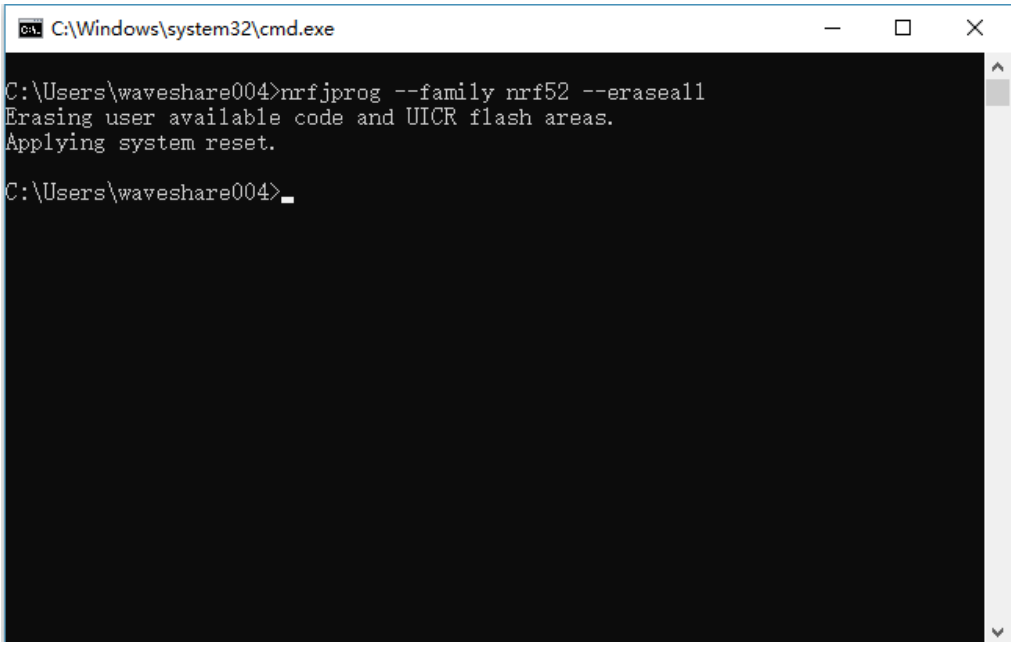


DOWNLOAD SAMPLES WITH SOFTDEVOCE

Different with samples like the blinky, you should first download softdevices, which Bluetooth demo codes are based on. Herein we take app_uart as example to show you how to program such demos.

- First, we need to erase NRF52840 flash: Open CMD, connect NRF52840 to PC and using ARM Debugger(JLink) for programming. Type command to erase NRF52840

as below:

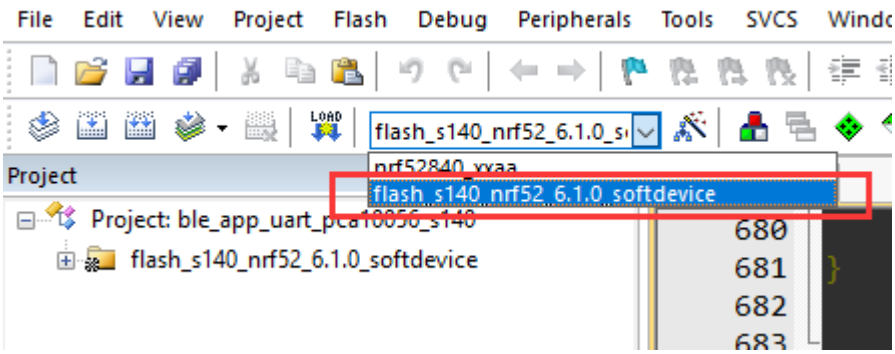


- Download Softdevice. Click

  nRF5_SDK_15.2.0_9412b96->examples->ble_peripheral->ble_app_uart->pca10056

  ->s140->arm5_no_packs-> ble_app_uart_pca10056_s140.uvprojx to open the

  project. Choose flash_s140_nrf52_6.1.0_softdevice:



- Download the application code like blinky sample.

CHAPTER 3. CREATING NEW PROJECT

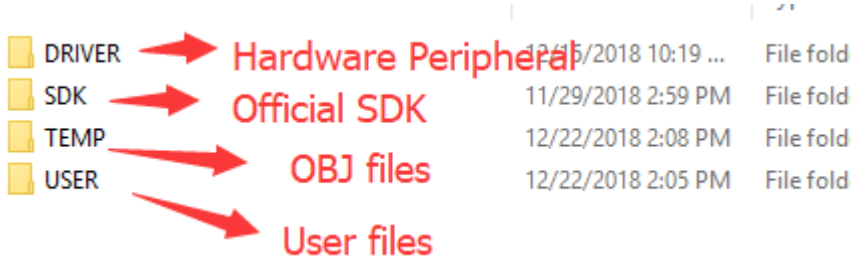
SDK should be used for NRF52840 developing, we take common SDK[5] as example to show you how to create a project.

The SDK used herein is SDK V15.2, there is also template for reference:

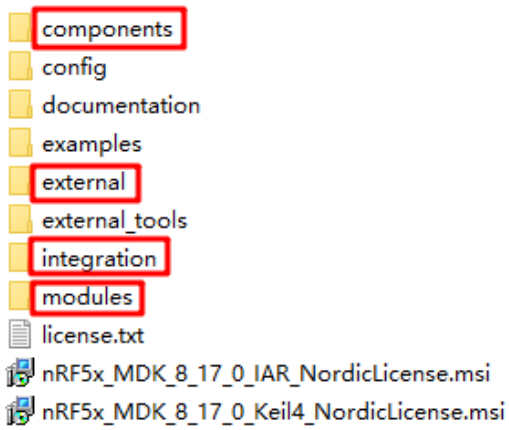
nRF5_SDK_15.2.0_9412b96\examples\ble_peripheral\ble_app_template\pca10056\s140\arm5_no_packs\ble_app_template_pca10056_s140.uvprojx

PROJECT TEMPLATE

Generally, the project should include:



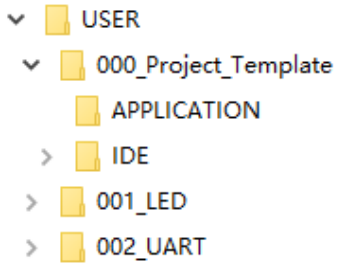
- DRIVER: Drivers of hardware peripherals are saved in this directory, like driver of MPU6050 created by users
- SDK: SDK files copied from official SDK, like:



[5] There are specific SDK used for Zigbee, Thread and Mesh sevices

There are so many files included in SDK, and we only use some of them for certain project. Most of libraries are included in components, external contains third party libraries like freertos library and so on. Old drivers are saved to folder integration and modules contains the new drivers.

- TEMP: Intermediate files generated while compiling. The files in this folder can be deleted.
- USER: User files



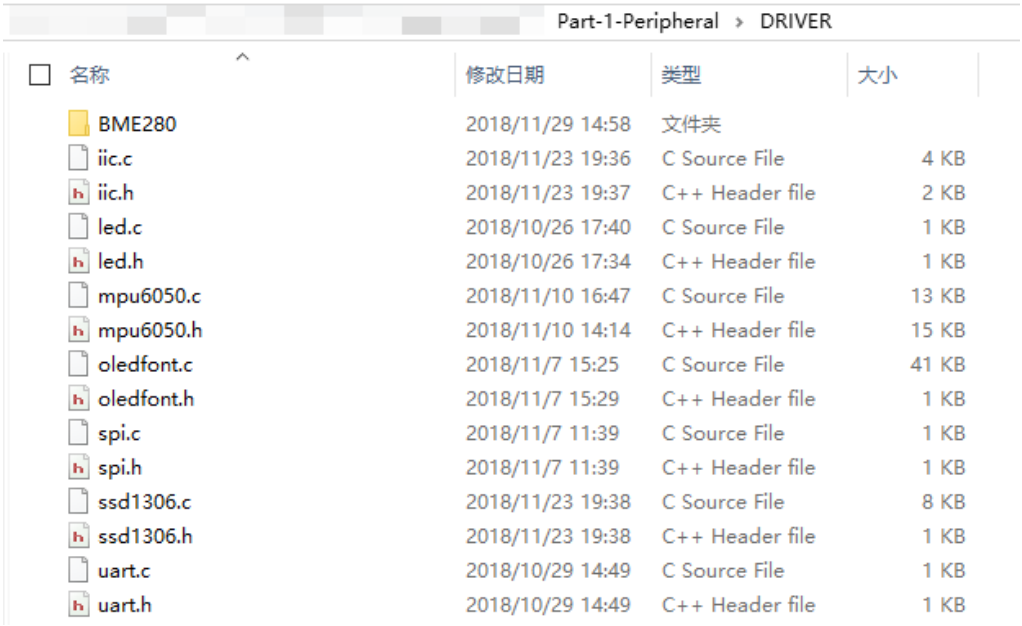
Generally, files in folders SDK, DRIVER and TEMP are same for different project, what we need to do is create user files and save them to USER.

CREATE A NEW PROJECT

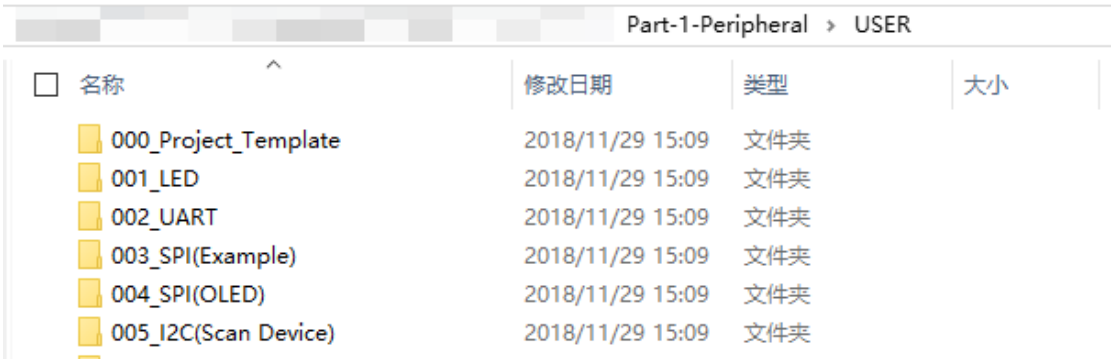
Create a directory to save project files and copy libraries files to it.

You can google about how to create a new Keil project. Herein we take about some notices when creating new project.

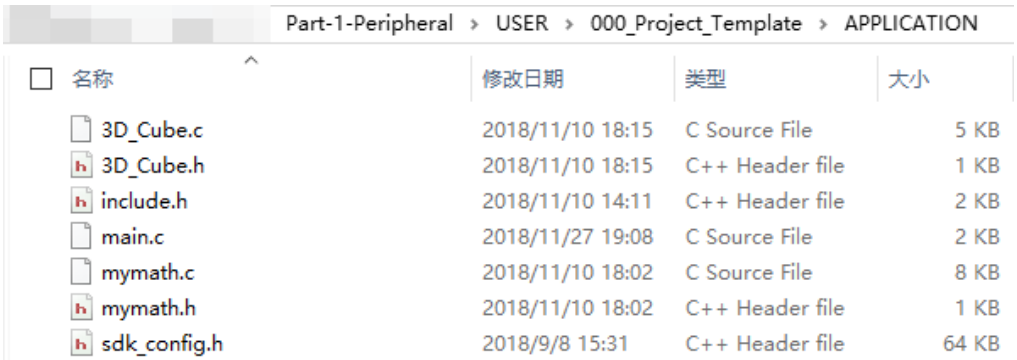
- The drivers of user peripherals should be saved in DRIVER folder



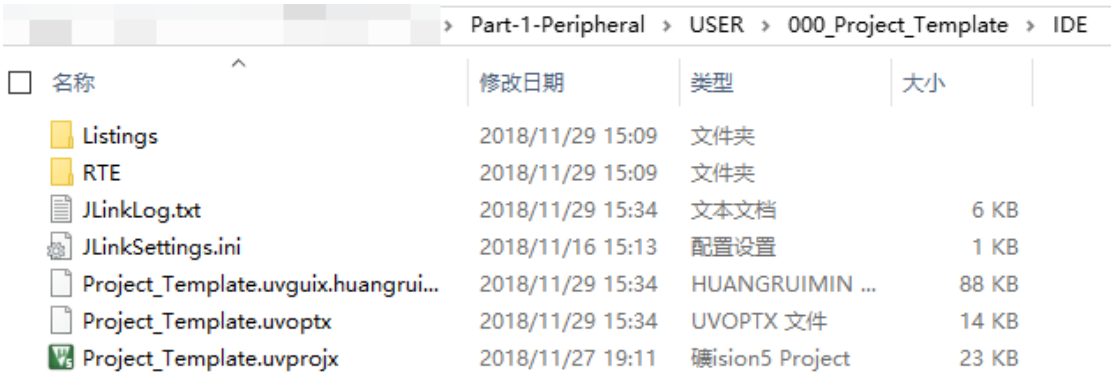
- The projects created should be saved under USER, and please notice the project name



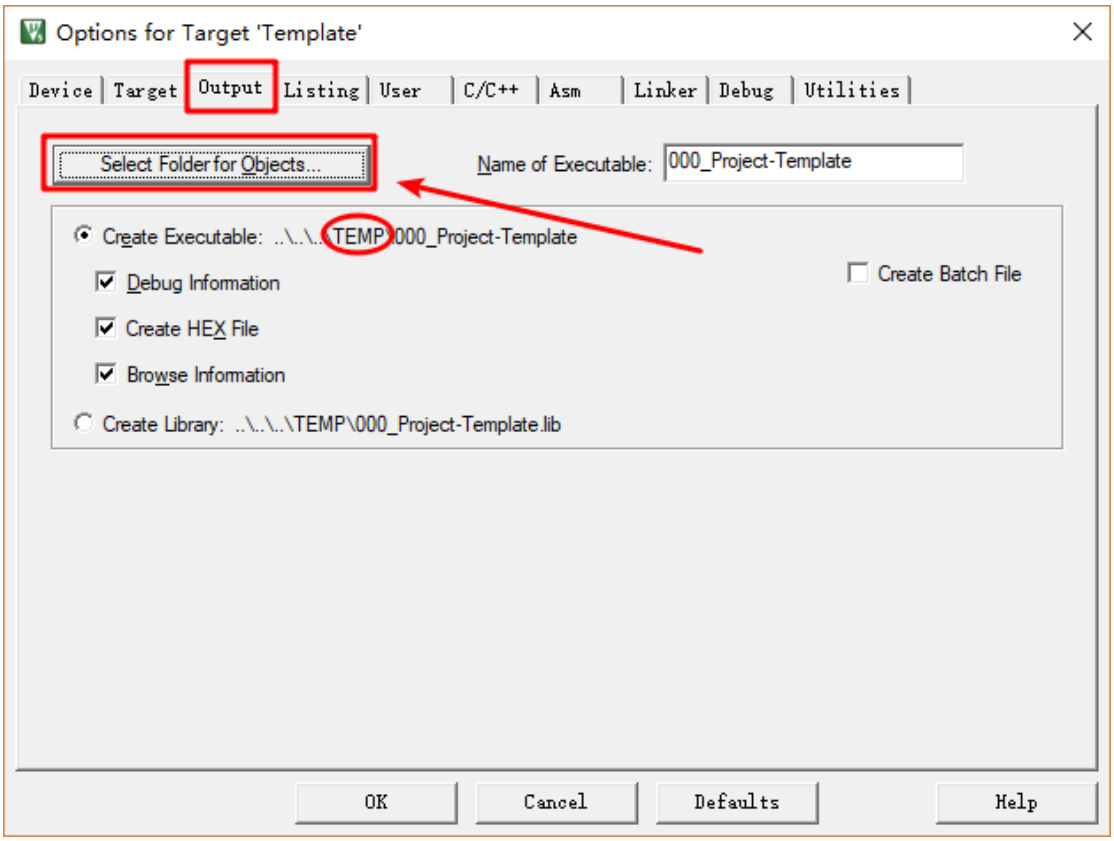
- The application files are usually saved under the path: USER/[Project file]/APPLICATION/



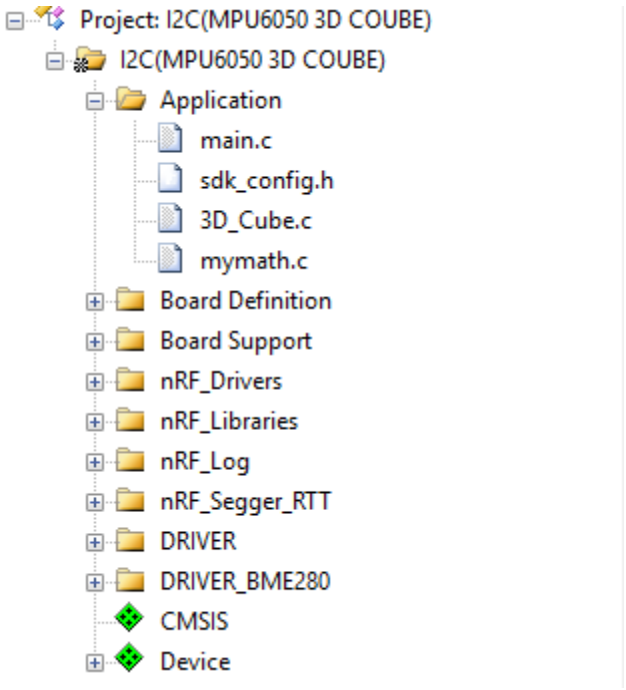
- The Keil project file is saved in IDE folder



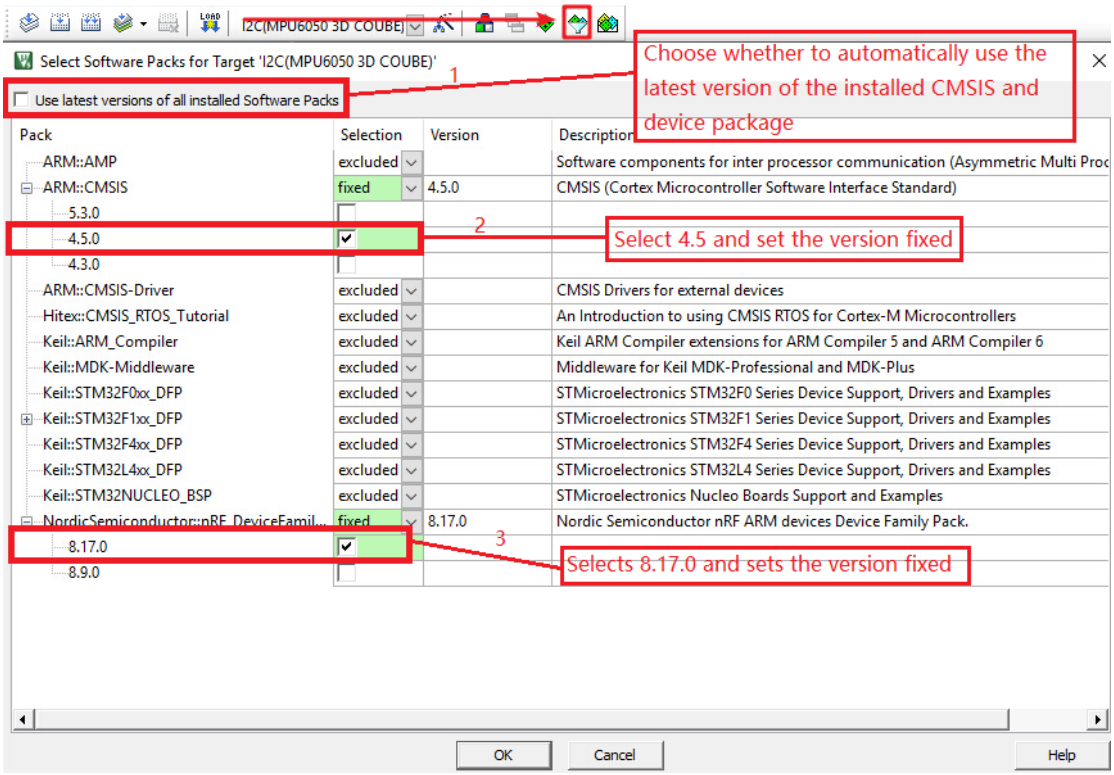
- Save OBJ files to TEMP folder



- You had better set the project tree same as official projects.



- Notice the PACK version you use, make sure it is same as official examples



For more details, please refer to official examples.

CHAPTER 4. CONTROLING LED

In this chapter, we will instruct how to configure GPIO and control LED. The examples used herein is 001_LED.

CODES

Open led.h files, you can find that the GPIO and related control functions are defined in this header file:

```
#ifndef __LED_H__
#define __LED_H__

#include "nrf.h"
#include "nrf_gpio.h"

#define LED0  NRF_GPIO_PIN_MAP(0,13)
#define LED1  NRF_GPIO_PIN_MAP(0,14)
#define LED2  NRF_GPIO_PIN_MAP(0,19)
#define LED3  NRF_GPIO_PIN_MAP(0,16)

void LED_On(uint32_t led_number);
void LED_Off(uint32_t led_number);

#endif
```

Functions defined in header file will be realized in led.c file:

```
#include "led.h"
void LED_On(uint32_t led_number)
{
    nrf_gpio_cfg_output(led_number);
    nrf_gpio_pin_clear(led_number);
}
void LED_Off(uint32_t led_number)
{
    nrf_gpio_cfg_output(led_number);
    nrf_gpio_pin_set(led_number);
}
```

LED_On(led_number): Turn the LED on

LED_Off(led_number): Turn the LED off

And finally, the functions are called in main file to keep turning four LEDs on for 500ms then turning them off for 500ms.

```
int main(void)
{
    while (true)
    {
        LED_On(LED0);
        LED_On(LED1);
        LED_On(LED2);
        LED_On(LED3);
        nrf_delay_ms(500);

        LED_Off(LED0);
        LED_Off(LED1);
        LED_Off(LED2);
        LED_Off(LED3);
        nrf_delay_ms(500);
    }
}
```

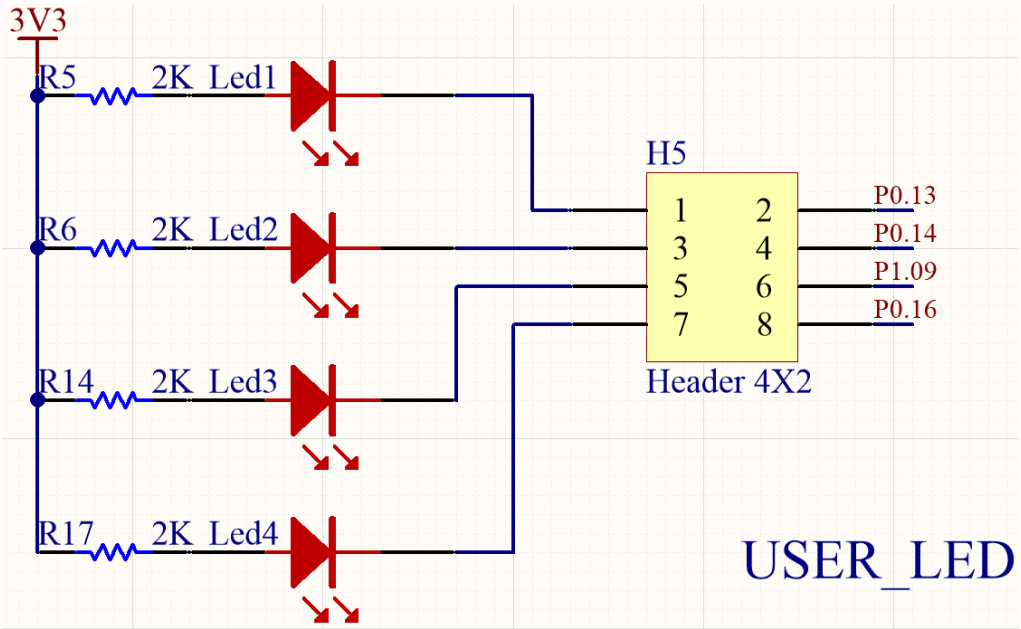
HARDWARE CONNECTION

According to the codes above we know that, the four LEDs controlled should be connected to P0.13, P0, 14, P0.19, P0.16 separately as table:

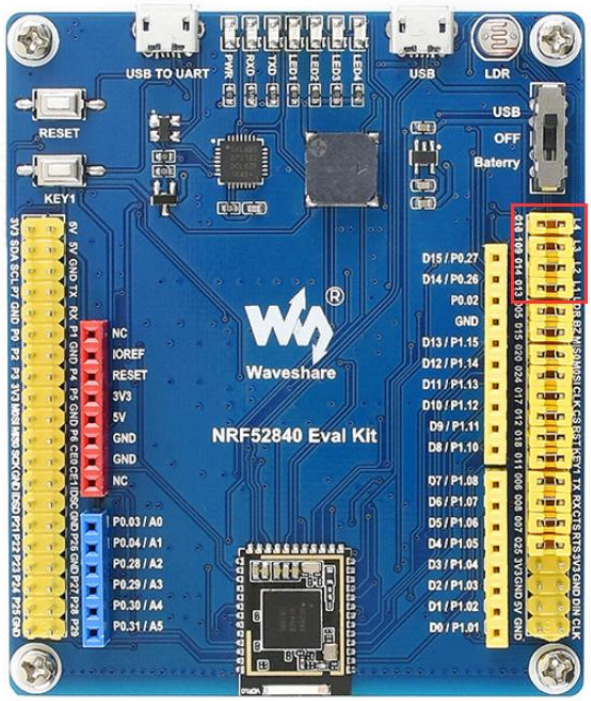
UART	GPIO
LED1	P0.13
LED2	P0.14
LED3	P1.09
LED4	P0.16

In official SDK, LED3 is connected to P0.15 which is not compatible with official examples. If you want to use the official SDK and LED3, you need to change it to P1.09.

The schematic of Eval board is as below:



Header 4x2 are jumpers on board:



If you use official SDK, don’ t forget to pull L3 jumper and wire it to P0.15 (Do not require if you use 001_LED).

CHAPTER 5. UART

In this chapter, we describe about how to use UART interface of NRF52840. The example used herein is 003_UART. With the example, data can be sent from NRF52840 to UART interface, and LED on eval board will turn on/off when receive corresponding data from UART interface.

CODES

uart.h

```
#ifndef _UART_H_
#define _UART_H_

#include "nrf.h"
#include "nrf_gpio.h"
#include "app_uart.h"
#include "nrf_uart.h"

#define RX_PIN_NUMBER  NRF_GPIO_PIN_MAP(0,8)
#define TX_PIN_NUMBER  NRF_GPIO_PIN_MAP(0,6)
#define CTS_PIN_NUMBER  NRF_GPIO_PIN_MAP(0,7)
#define RTS_PIN_NUMBER  NRF_GPIO_PIN_MAP(0,5)

#define UART_HWFC APP_UART_FLOW_CONTROL_DISABLED

#define MAX_TEST_DATA_BYTES     (15U)
#define UART_TX_BUF_SIZE 256
#define UART_RX_BUF_SIZE 256

extern app_uart_comm_params_t comm_params;

void uart_error_handle(app_uart_evt_t * p_event);

#endif
```

uart.c:

```
#include "uart.h"
```

```
app_uart_comm_params_t comm_params =
{
    RX_PIN_NUMBER,
    TX_PIN_NUMBER,
    RTS_PIN_NUMBER,
    CTS_PIN_NUMBER,
    UART_HWFC,
    false,
    NRF_UART_BAUDRATE_115200
};

void uart_error_handle(app_uart_evt_t * p_event)
{
    if (p_event->evt_type == APP_UART_COMMUNICATION_ERROR)
    {
        APP_ERROR_HANDLER(p_event->data.error_communication);
    }
    else if (p_event->evt_type == APP_UART_FIFO_ERROR)
    {
        APP_ERROR_HANDLER(p_event->data.error_code);
    }
}
```

main.c:

```
#include "nrf.h"

#include <stdio.h>
#include <stdint.h>
#include <stdbool.h>

#include "app_uart.h"
#include "app_error.h"
#include "nrf_delay.h"

#include "nrf_uart.h"
#include "nrf_uarte.h"

#include "led.h"
#include "uart.h"

/**
 * @brief Function for main application entry.
 */
int main(void)
{
```

```
    uint32_t err_code;


    APP_UART_FIFO_INIT(&comm_params,UART_RX_BUF_SIZE,UART_TX_BUF_SI
    ZE,uart_error_handle,APP_IRQ_PRIORITY_LOWEST,err_code);

    APP_ERROR_CHECK(err_code);

    printf("\r\nUART example started.\r\n");

    while (true)
    {
        uint8_t cr;
        //Get Data from the port!
        while (app_uart_get(&cr) != NRF_SUCCESS);
        //Then put data to the port
        while (app_uart_put(cr) != NRF_SUCCESS);
        switch (cr)
        {
            case '1':
            {
                printf("\r\n LED0 ON \r\n");
                LED_On(LED0);
                break;
            }
            case '2':
            {
                printf("\r\n LED0 OFF \r\n");
                LED_Off(LED0);
                break;
            }
            case '3':
            {
                printf("\r\n LED1 ON \r\n");
                LED_On(LED1);
                break;
            }
            case '4':
            {
                printf("\r\n LED1 OFF \r\n");
                LED_Off(LED1);
                break;
            }
            case '5':
```

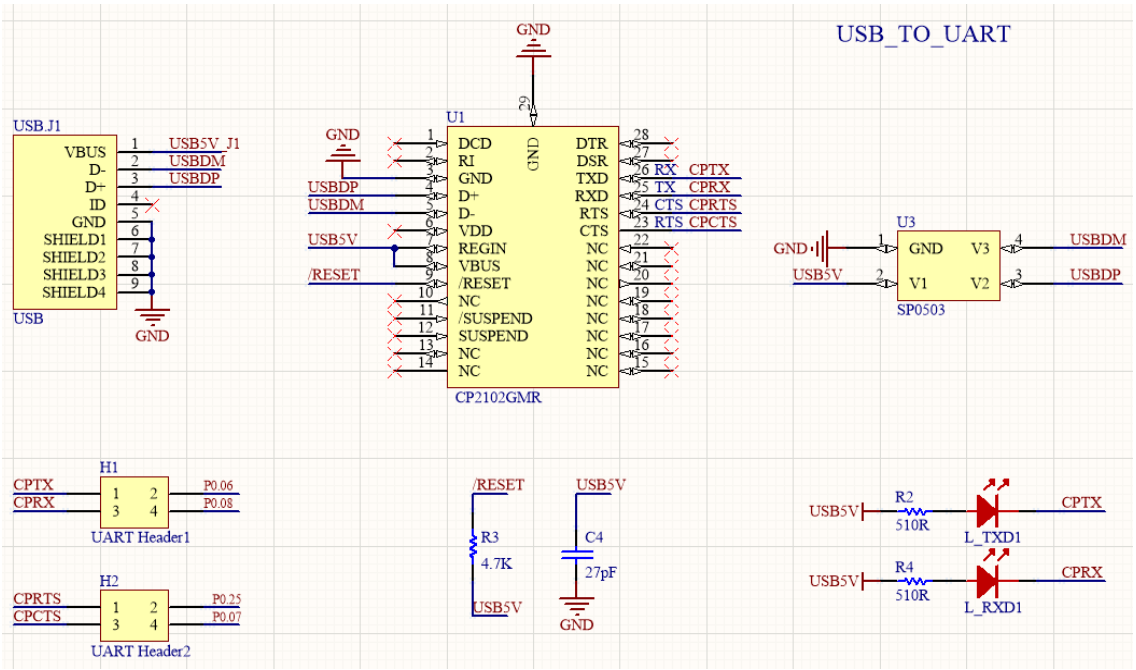
```
            {
                printf("\r\n LED2 ON \r\n");
                LED_On(LED2);
                break;
            }
            case '6':
            {
                printf("\r\n LED2 OFF \r\n");
                LED_Off(LED2);
                break;
            }
            case '7':
            {
                printf("\r\n LED3 ON \r\n");
                LED_On(LED3);
                break;
            }
            case '8':
            {
                printf("\r\n LED3 OFF \r\n");
                LED_Off(LED3);
                break;
            }
            case 'q':
            {
                printf("\r\n Exit! \r\n");
                while (true);
            }
            case 'Q':
            {
                printf("\r\n Exit! \r\n");
                while (true);
            }
            default:
            {
                printf("\r\nPlease input correct command\r\n");
                break;
            }
        }
    }
}
```

The serial is redirected in the codes, for using printf function to print data to uart interface. In the main.c, serial port will keep receiving data, and if corresponding data are received, LEDs will behavior according to it.

When 1 is received, LED1 is on, and turned off if receiving 2. Turn LED2 on if 3 and turn off if 4 similarly.

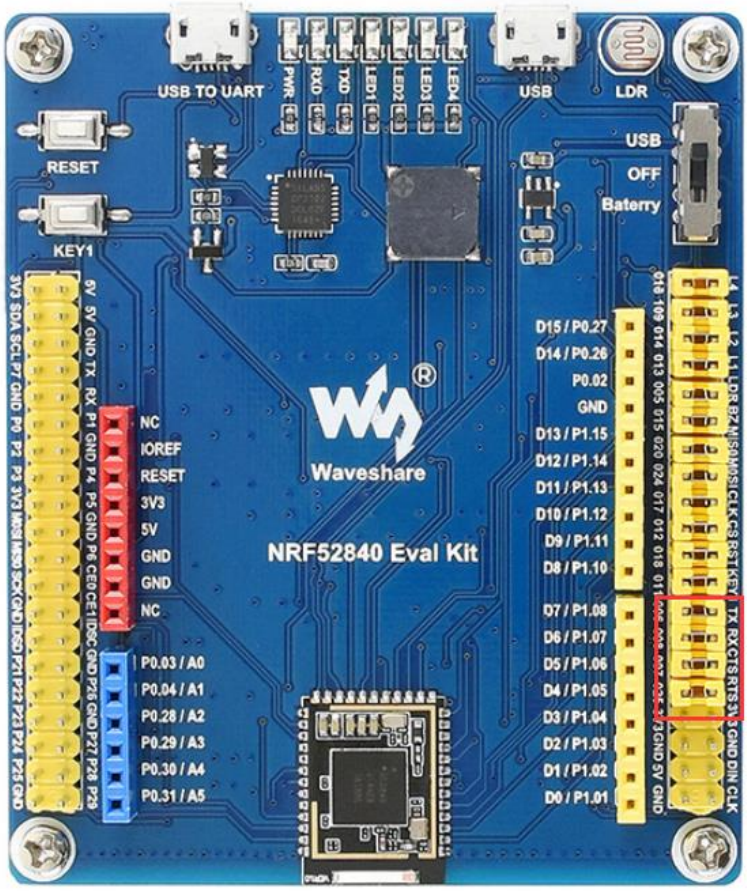
HARDWARE

The schematic of serial part is as below:



H1 and H2 are jumpers of UART pins. CP2102 is accessed to NRF52840 only when jumpers H1 and H2 are inserted.

UART	GPIO
CPTX	P0.06
CPRX	P0.08
CPRTS	P0.25
CPCTS	P0.07



【Note】In official SDK, CPRTS is defined as P0.05, however, CPRTS is connected to P0.25 on NRF52840 Eval kit. You need to modify the definition to P0.25 when using.

CHAPTER 6. SPI

Examples used in this chapter: 004_SPI(Example), 005_SPI(OLED)

In this chapter, we will describe about how to use SPI interface of NRF52840, do loopback testing and try to drive a 0.96inch OLED module.

LOOPBACK TESTING

main.c

```
#include "nrf_drv_spi.h"
#include "nrf_gpio.h"
#include "app_util_platform.h"
#include "nrf_delay.h"
#include "app_error.h"
#include <string.h>
#include "nrf_log.h"
#include "nrf_log_ctrl.h"
#include "nrf_log_default_backends.h"
#include "spi.h"
int main(void)
{
    APP_ERROR_CHECK(NRF_LOG_INIT(NULL));
    NRF_LOG_DEFAULT_BACKENDS_INIT();
    nrf_drv_spi_config_t spi_config = NRF_DRV_SPI_DEFAULT_CONFIG;
    spi_config.ss_pin   = CS_PIN;
    spi_config.miso_pin = MISO_PIN;
    spi_config.mosi_pin = MOSI_PIN;
    spi_config.sck_pin  = SCK_PIN;
    /*
    Doesn't print what to send or what received in SPI
    */
    //APP_ERROR_CHECK(nrf_drv_spi_init(&spi, &spi_config, NULL,
NULL));

    /*
    Print what to send or what received in SPI
    */
    APP_ERROR_CHECK(nrf_drv_spi_init(&spi, &spi_config,
spi_event_handler, NULL));
```

```
    NRF_LOG_INFO("SPI example started.");
    NRF_LOG_FLUSH();
    while (1)
    {
        memset(m_rx_buf, 0, m_length);
        spi_xfer_done = false;
        APP_ERROR_CHECK(nrf_drv_spi_transfer(&spi, m_tx_buf,
m_length, m_rx_buf, m_length));
        while (!spi_xfer_done)
        {
            __WFE();
        }
        NRF_LOG_FLUSH();
        nrf_delay_ms(500);
    }
}
```

DRIVE OLED

When you drive OLED via SPI interface, you should notice that:

1. Do not use interrupt callback function when initializing SPI

```
/*
Doesn't print what to send or what received in SPI
*/
//APP_ERROR_CHECK(nrf_drv_spi_init(&spi, &spi_config, NULL,
NULL));

/*
Print what to send or what received in SPI
*/
APP_ERROR_CHECK(nrf_drv_spi_init(&spi, &spi_config,
spi_event_handler, NULL));
```

2. If you must to add interrupt codes, add delay to it.

```
void Single_Command(unsigned char cmd)
{
    nrf_gpio_pin_clear(DC);
    //if SPI is busy Frequently,delay here
    nrf_delay_us(30);
    spi_write(&cmd, sizeof(cmd));
}
```

3. The most basic function of OLED driver is written and read functions as below:

write

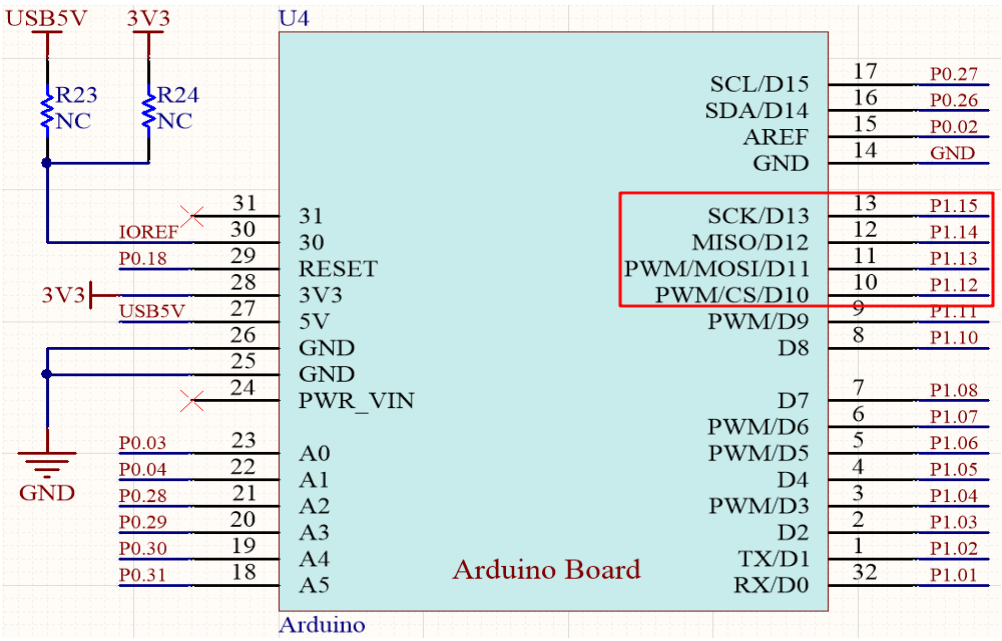
```
void Single_Command(unsigned char cmd)
{
    nrf_gpio_pin_clear(DC);
    //if SPI is busy Frequently,delay here
    //nrf_delay_us(30);
    spi_write(&cmd, sizeof(cmd));
}
```

read

```
void Single_Data(unsigned char dt)
{
    nrf_gpio_pin_set(DC);
    //if SPI is busy Frequently,delay here
    //nrf_delay_us(30);
    spi_write(&dt, sizeof(dt));
}
```

HARDWARE

In hardware, the SPI interface of NRF52840 are pinout to Arduino compatible interface.

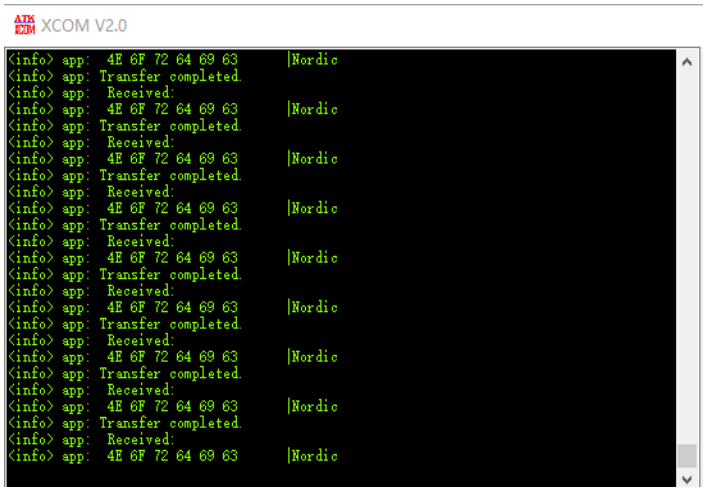


【Note】The pins used in example herein are different with official SDK, if you use official SDK with NRF52840 Eval Kit, don’ t forget to modify the pins

SPI	GPIO
SPI_CS	P1.12
SPI_MOSI	P1.13
SPI_MISO	P1.14
SPI_SCK	P1.15

Loopback testing

Data will be sent from MOSI and back from the MISO.



Drive OLED

The OLED will display image as below:

CHAPTER 7. I2C

In this chapter, we will learn about how to use the I2C interface of NRF52840. There are three examples, which are used here: 006_I2C(Scan Device), 007_I2C(BME280), 008_I2C(MPU6050 3D COUBE)

SCANNING SLAVE DEVICES

It keeps scanning the slave device address of those devices which are connected to I2C bus.

```
for(address=1; address<=TWI_ADDRESSES; address++)
{
    err_code = nrf_drv_twi_rx(&m_twi, address, &sample_data,
sizeof(sample_data));
    if (err_code == NRF_SUCCESS)
    {
        detected_device = true;

        device_address = address;

        NRF_LOG_INFO("TWI device detected at address 0x%x.",
address);

        NRF_LOG_FLUSH();
    }
}
```

The code will scan slave devices address connected and print them.

READ DATA FROM BME280

BME280 is a module from Bosch that supports sense environmental temperature, humidity and barometric pressure.

Write/read function from Bosch: https://github.com/BoschSensortec/BME280_driver

```
int8_t user_i2c_read(uint8_t dev_id, uint8_t reg_addr, uint8_t
*reg_data, uint16_t len)
```

```
{
    int8_t rslt = 0; /* Return 0 for Success, non-zero for failure
*/
    /*
     * The parameter dev_id can be used as a variable to store the
I2C address of the device
     */
    /*
     * Data on the bus should be like
     * |------------+---------------------|
     * | I2C action | Data                |
     * |------------+---------------------|
     * | Start      | -                   |
     * | Write      | (reg_addr)          |
     * | Stop       | -                   |
     * | Start      | -                   |
     * | Read       | (reg_data[0])       |
     * | Read       | (....)              |
     * | Read       | (reg_data[len - 1]) |
     * | Stop       | -                   |
     * |------------+---------------------|
     */
    return rslt;
}
int8_t user_i2c_write(uint8_t dev_id, uint8_t reg_addr, uint8_t
*reg_data, uint16_t len)
{
    int8_t rslt = 0; /* Return 0 for Success, non-zero for failure
*/
    /*
     * The parameter dev_id can be used as a variable to store the
I2C address of the device
     */
    /*
     * Data on the bus should be like
     * |------------+---------------------|
     * | I2C action | Data                |
     * |------------+---------------------|
     * | Start      | -                   |
     * | Write      | (reg_addr)          |
     * | Write      | (reg_data[0])       |
     * | Write      | (....)              |
     * | Write      | (reg_data[len - 1]) |
     * | Stop       | -                   |
```

```
     * |-----------+--------------------|
     */
    return rslt;
}
```

Working with NRF52840, you can use its library to realize the write/read function:

```
int8_t user_i2c_read(u8 dev_id, u8 reg_addr, u8 *reg_data, u16 len)
{
    ret_code_t err_code =
nrf_drv_twi_tx(&m_twi,dev_id,&reg_addr,1,false);

    APP_ERROR_CHECK(err_code);

    err_code = nrf_drv_twi_rx(&m_twi,dev_id,reg_data,len);

    APP_ERROR_CHECK(err_code);

    return err_code;
}

#define MAX_WRITE_LENGTH  200
int8_t user_i2c_write(u8 dev_id, u8 reg_addr, u8 *reg_data, u16
len)
{
    ret_code_t err_code;

    uint8_t write_data[MAX_WRITE_LENGTH];

    if(len>MAX_WRITE_LENGTH-1)
    {
        err_code = 1;
        return err_code;
    }

    write_data[0] = reg_addr;

    memcpy(&write_data[1],reg_data,len);

    err_code =
nrf_drv_twi_tx(&m_twi,dev_id,write_data,len+1,false);

    APP_ERROR_CHECK(err_code);

    return err_code;
```

```
}
```

BME280 Initialization in main.c

```
struct bme280_dev dev;
int8_t rslt = BME280_OK;

dev.dev_id = BME280_I2C_ADDR_SEC;
dev.intf = BME280_I2C_INTF;
dev.read = user_i2c_read;
dev.write = user_i2c_write;
dev.delay_ms = user_delay_ms;

//before you init bme280, you can choose to do a selftest
rslt = bme280_crc_selftest(&dev);
if(rslt == 0)
{
    NRF_LOG_INFO("BME280 self test pass\r\n");
    NRF_LOG_FLUSH();
}

rslt = bme280_init(&dev);
if(rslt == 0)
{
    NRF_LOG_INFO("Init Success\r\n");
    NRF_LOG_FLUSH();
}
else
{
    NRF_LOG_INFO("Init Fail,Please Check your address or the wire
you connected!!!\r\n");
    NRF_LOG_FLUSH();
    while(1);
}
/*
    Using normal mode to read the data
*/
stream_sensor_data_normal_mode(&dev);
```

bme280_crc_selftest(): Self testing function

stream_sensor_data_normal_mode(&dev): Read data of bme280 and calculate. Use

bme280_get_sensor_data() and print_sensor_data() to read and print_sensor_data().

READ DATA FROM MPU6050

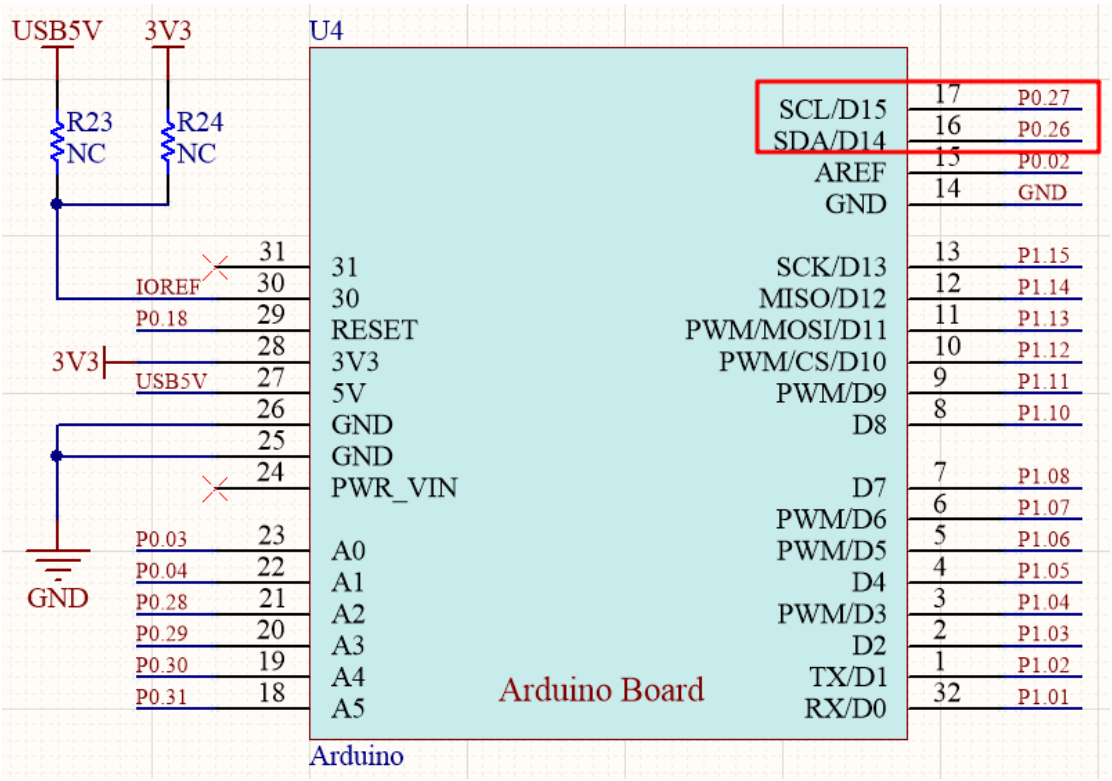
This example is run to read MPU6050 data via I2C bus.

```
u8 IIC_Write_1Byte(u8 SlaveAddress,u8 REG_Address,u8 REG_data)
{
    ret_code_t err_code = user_i2c_write(SlaveAddress, REG_Address,
&REG_data, 1);

    return err_code;
}

u8 IIC_Read_1Byte(u8 SlaveAddress,u8 REG_Address,u8 *REG_data)
{
    ret_code_t err_code = user_i2c_read(SlaveAddress, REG_Address,
REG_data, 1);

    return err_code;
}

u8 IIC_Write_nByte(u8 SlaveAddress, u8 REG_Address, u8 len, u8
*buf)
{
    ret_code_t err_code = user_i2c_write(SlaveAddress, REG_Address,
buf, len);

    return err_code;
}

u8 IIC_Read_nByte(u8 SlaveAddress, u8 REG_Address, u8 len, u8 *buf)
{
    ret_code_t err_code = user_i2c_read(SlaveAddress, REG_Address,
buf, len);

    return err_code;
}
```

The basic functions are user_i2c_read() and user_i2c_write().

HARDWARE

In hardware, the I2C interface are pinout to the Arduino compatible header.



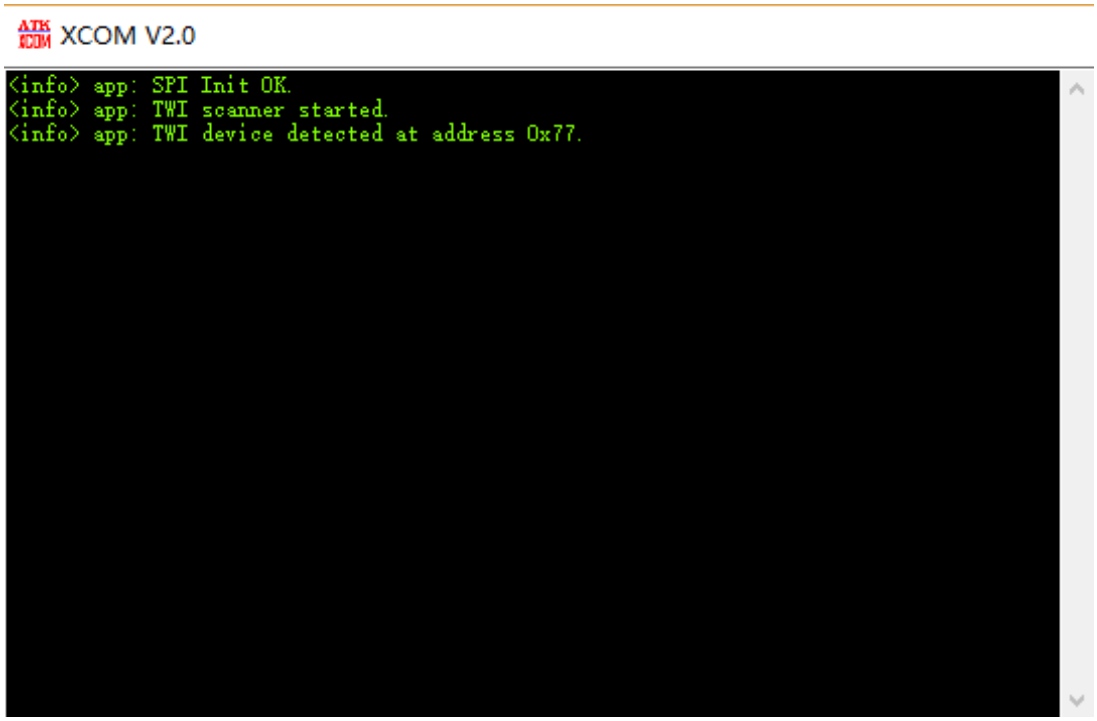
I2C	GPIO
SCL_PIN	P0.27
SDA_PIN	P0.26

The I2C pins can be re-configured to others by modifying the codes:

```
#define SDA_PIN    NRF_GPIO_PIN_MAP(0,26)
#define SCL_PIN    NRF_GPIO_PIN_MAP(0,27)
```

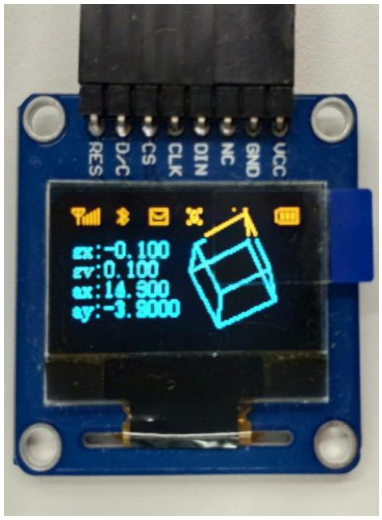
【Note】Don’t forget to change hardware connection if you re-configure the pins.

After running codes, the data will be printed to serial port and display the I2C address in OLED as below:



- Downloading 007_I2C(BME280) codes, data will be printed to OLED as below:

- Downloading 008_I2C(MPU6050 3D COUBE), Data will be printed as below(The 3D figure display is not stable):



CHAPTER 8. NFC

CODES

This example is used to starting mobile APP.

The name of Android Phone APP:

```
static const uint8_t m_android_package_name[] =
{'n', 'o', '.', 'n', 'o', 'r', 'd', 'i', 'c', 's',
'e', 'm', 'i', '.', 'a', 'n', 'd', 'r', 'o', 'i',
'd', '.', 'n', 'r', 'f', 't', 'o', 'o', 'l', 'b',
'o', 'x'};
```

The name of Windows Phone APP:

```
static const uint8_t m_windows_application_id[] =
{'{', 'e', '1', '2', 'd', '2', 'd', 'a', '7', '-',
'4', '8', '8', '5', '-', '4', '0', '0', 'f', '-',
'b', 'c', 'd', '4', '-', '6', 'c', 'b', 'd', '5',
'b', '8', 'c', 'f', '6', '2', 'c', '}'};
```

Initializing callback function, which will be execute when NFC objects are detected to turn on LED0.

```
static void nfc_callback(void * p_context, nfc_t2t_event_t event,
const uint8_t * p_data, size_t data_length)
{
    (void)p_context;

    switch (event)
    {
        case NFC_T2T_EVENT_FIELD_ON:
            bsp_board_led_on(BSP_BOARD_LED_0);
            break;
        case NFC_T2T_EVENT_FIELD_OFF:
            bsp_board_led_off(BSP_BOARD_LED_0);
            break;
        default:
            break;
    }
}
```

In main.c file, the process to start NFC are that:

1. Set interrupt callback function and initialize NFC:

2. Encode NFC information

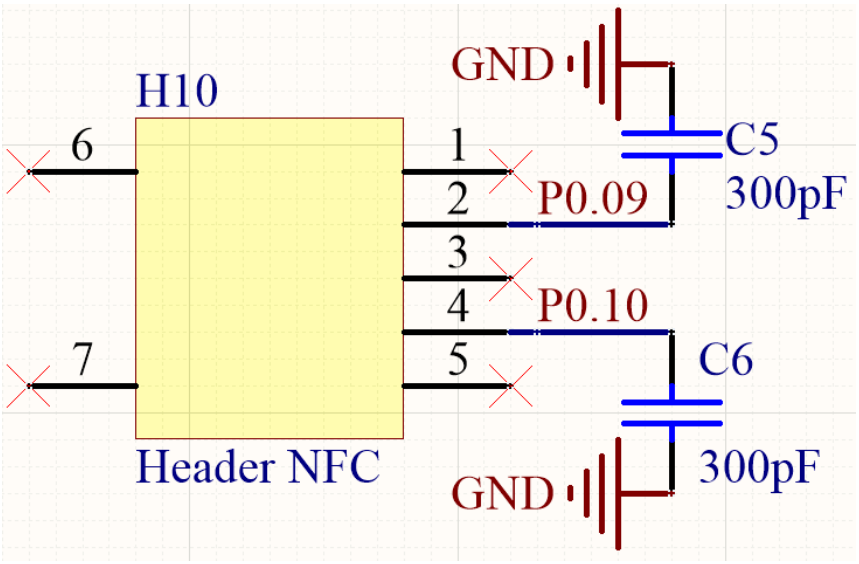
3. Load NFC information to NFC end

4. Start NRF

```
int main(void)
{
    uint32_t len;
    uint32_t err_code;
    //Init log
    log_init();
    //Init led
    bsp_board_init(BSP_INIT_LEDS);
    //set NFC with a callback
    err_code = nfc_t2t_setup(nfc_callback, NULL);
    APP_ERROR_CHECK(err_code);
    //provide available buffer size for encoding function
    len = sizeof(m_ndef_msg_buf);
    //Encode launchapp message into buffer
    err_code = nfc_launchapp_msg_encode(m_android_package_name,
                                        sizeof(m_android_package_name),
                                        m_windows_application_id,
                                        sizeof(m_windows_application_id),
                                        m_ndef_msg_buf,
                                        &len);
    APP_ERROR_CHECK(err_code);
    //Set created message as the NFC payload
    err_code = nfc_t2t_payload_set(m_ndef_msg_buf, len);
    APP_ERROR_CHECK(err_code);
    //Start sensing NFC field
    err_code = nfc_t2t_emulation_start();
    APP_ERROR_CHECK(err_code);
    while (1)
    {
        NRF_LOG_FLUSH();
        __WFE();
    }
}
```

HARDWARE

The pins for NFC are compatible with official[6] SDK



NFC	GPIO
NFC_1_PIN	P0.09
NFC_2_PIN	P0.10

Testing:

Install nRF Toolbox APP in your phone. Connect NFC coils and download the codes to eval board. LED1 will be on if you close NFC side of phone to the NFC coils, and turn off when taking away

[6] Nordic: https://www.nordicsemi.com/

CHAPTER 9. BLUETOOTH

The examples used in this chapter are: Part-2-Bluetooth-Slave-Device，Part-3-Bluetooth-Master-Device，Part-4-Bluetooth-Master&Slave-Device.

PREPARATION

The software required:

- MDK5.25
- Jlink driver
- nRFx-Command-Line-Tools
- nRF Toolbox (mobile APPP)
- Mobile phone which supports BLE

INSTALL SOFTDEVICE

To run the examples, you need to first install Softdevice.

- Erase Flash
- Install Softdevice

BLUETOOTH SERIAL TRANSPARENT

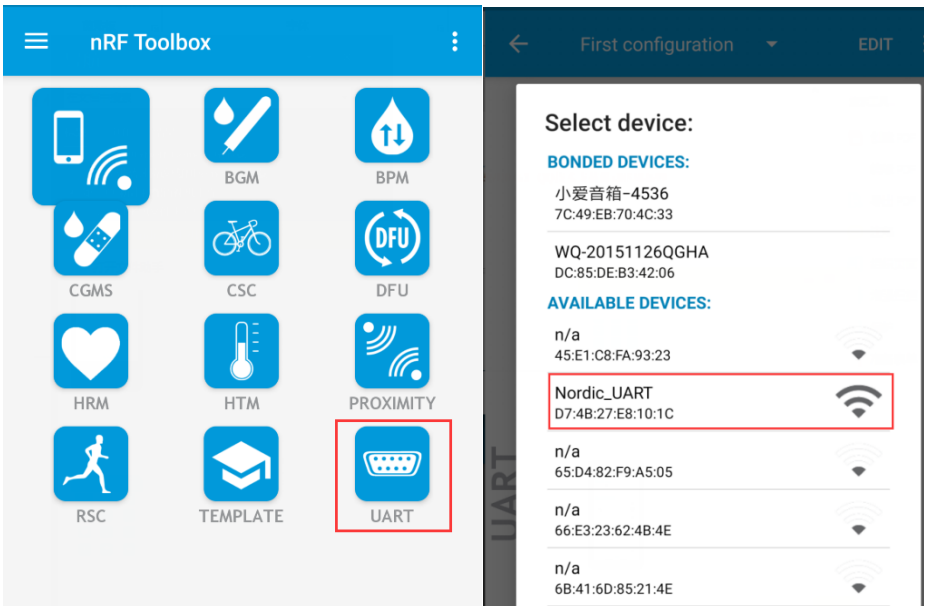
The example located in Bluetooth-Slave-Device\USER

- Open SlaveDevice-Bluetooth-To-UART(APP) example, compile and download to NRF52840 eval kit.

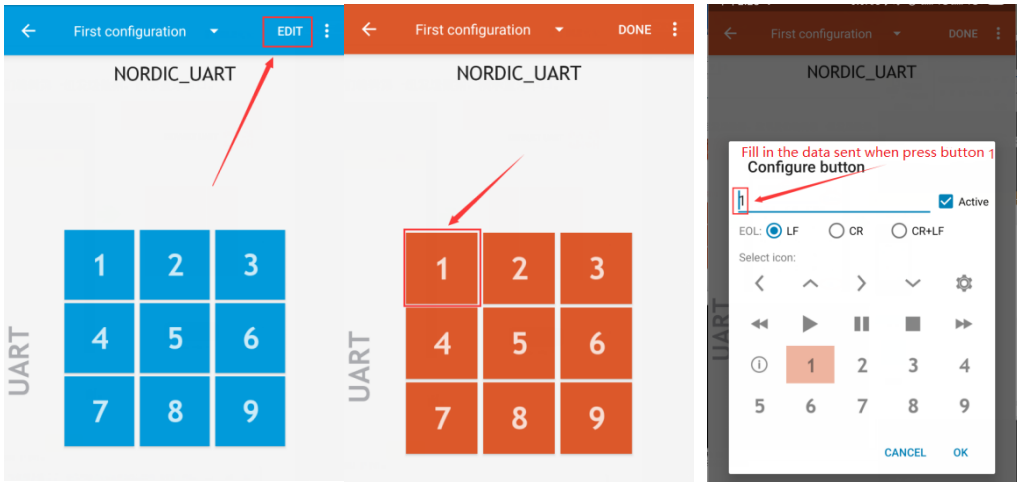
Expected Result:

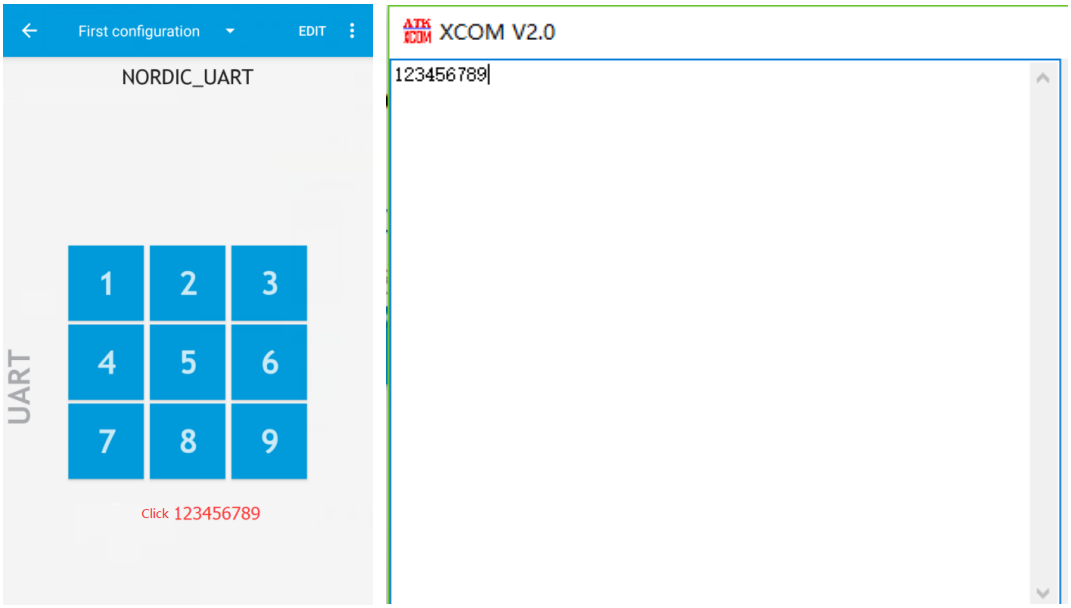
- LED1 is blinking when broadcast after downloading the code.

Open nRFToolbox software in your phone and enter UART, Connect Nodic_UART device

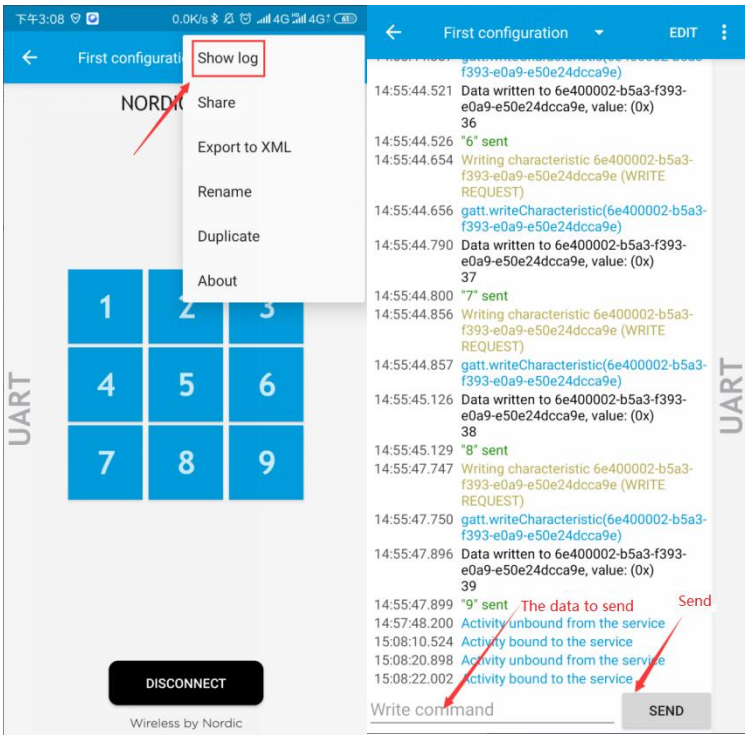


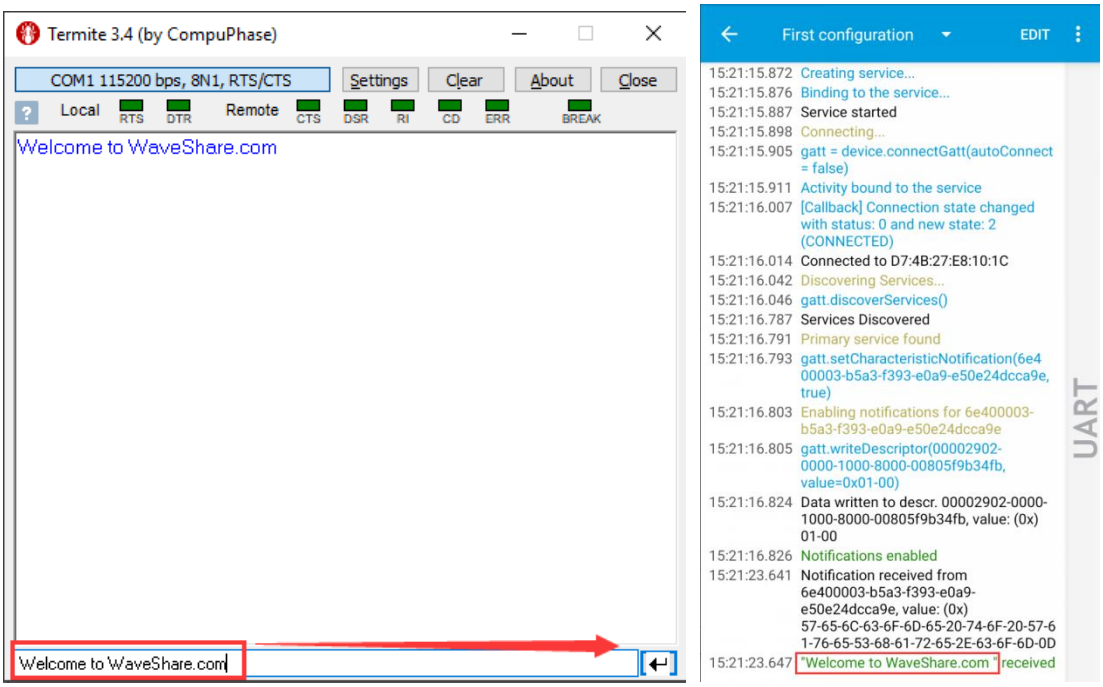
- After connecting, LED1 is on
- You can edit the figures and try to send:





- You can also send data directly on Show log:





BLUETOOTH AGAINST LOSING

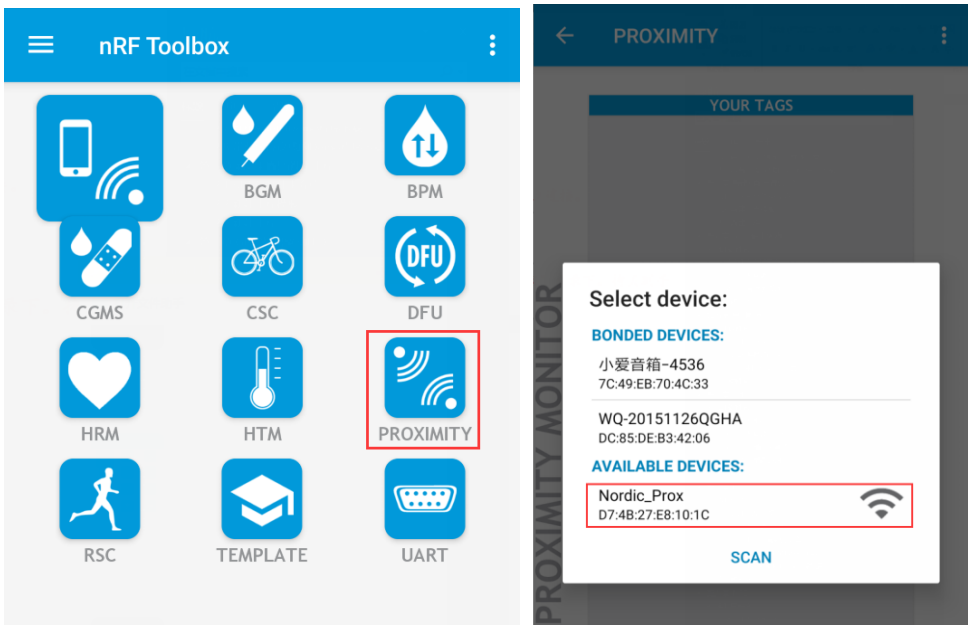
Download:

- Open the project SlaveDevice-Bluetooth-Proximity (APP), which located in Part-2-Bluetooth-Slave-Device\USER
- Compile and download to eval board

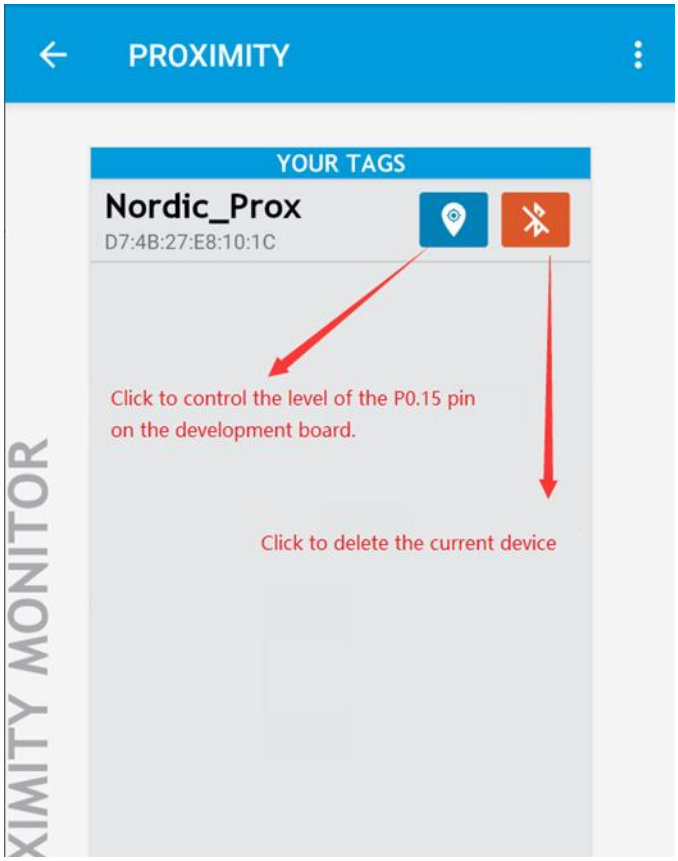
Expected result:

- LED1 is lighted in when broadcasting after downloading
- Turn on Bluetooth service of your phone

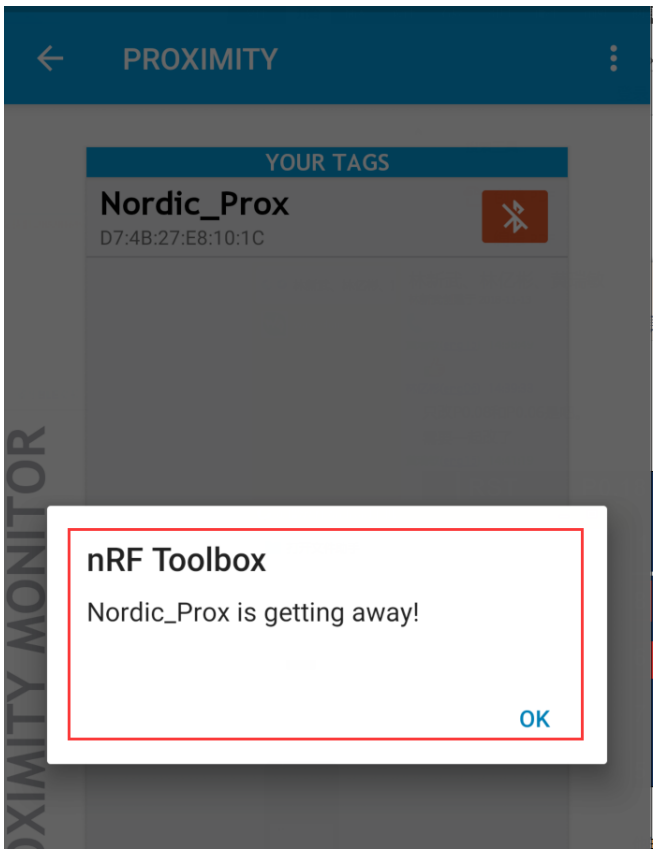
- Open nRF Toolbox and clock UART. Connect Nordic_UART device



- After connecting, LED1 will light on. The Toolbox will display as below:



- You can click the indicator button on APP to control P0.15 pin of Eval Kit board. When testing, you can connect P0.15 to one LED to check the status. Click Delete button to delete device.
- Press button S1 of Eval Kit board, music will be played in your phone, and stopped if S1 is pressed again.
- The software also prompt if you take the phone away from the Eval Kit board.



BLUETOOTH BEACON (SUPPORT WECHAT SHAKE)

Beacon is that build a small information base station by using BLE, it can be used in Indoor navigation, mobile payment, store shopping, Object tracking and so on.

Beacon is not a standard built by Bluetooth SIG

Download:

- Open the project SlaveDevice-Bluetooth-BEACON(WeChat) which located in Part-2-Bluetooth-Slave-Device\USER
- Compile and Download to Eval Kit Board

  【Note】The example is different with official examples(line 74-77)

  APP_COMPANY_IDENTIFER change to:0X004c

  APP_MAJOR_VALUE change to:0x00,0x0A

  APP_MINOR_VALUE change to:0x00,0x07

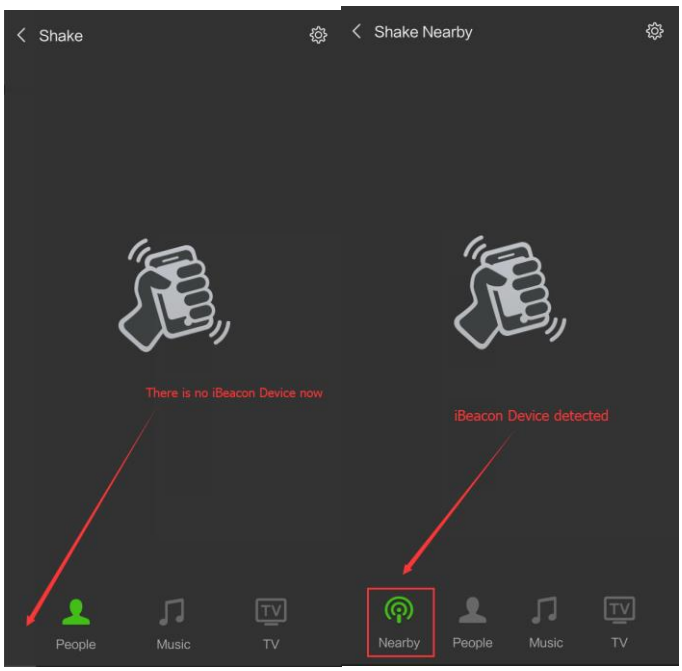
  APP_BEACON_UUID change to:0xFD,0xA5,0x06,0x93,\

  0xA4,0xE2,0x4F,0xB1,\

  0xAF,0xCF,0xC6,0xEB,\

Expected result:

- Open WeChat, and open Shake, there are not Nearby devices detect
- Download example and run it, LED1 will light on
- Open Shake again, Nearby device is detected



- Click Nearby and try to shake

【Note】The Web page detected is configurable, for more details about it you can refer to official guide of WeChat: https://zb.weixin.qq.com/intro.xhtml

The testing ID used in the example is the open ID of WeChat

Attributes	Value
UUID	FDA50693-A4E2-4FB1-AFCF-C6EB07647825
Major	10
Minor	7

WIRELESS MOUSE

HOGP profile (HID over GATT Profile) can be used to release wireless mouse function.

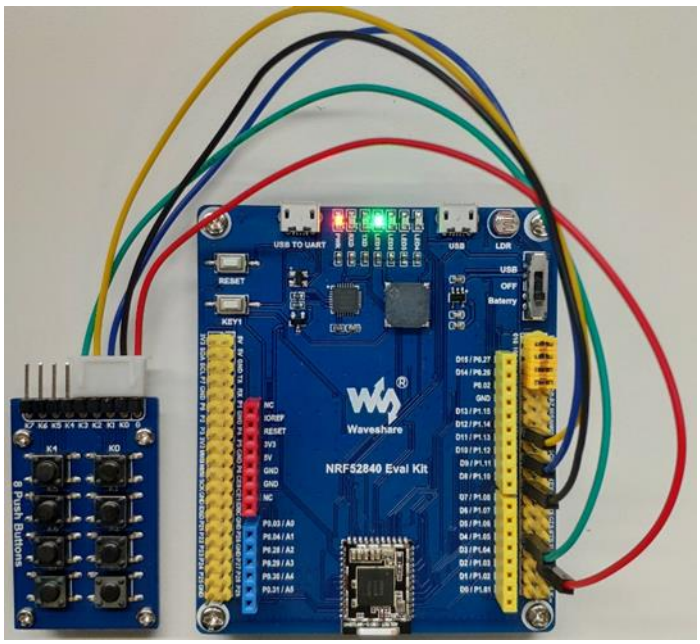
HOGP use basic protocol GATT of BLE to release interaction between HID host and Device.

Download:

- Open the project SlaveDevice_bluetooth-HIDS_MOUSE(APP),
- Compile and download to Eval Kit board.

Expected result:

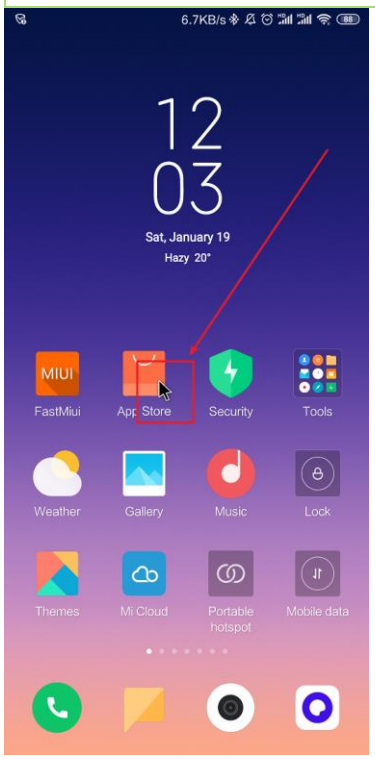
- Eval Kit board broadcast and LED1 lights on
- Connect P0.11，P0.12，P0.24，P0.25 to buttons



- Cursor will move when press buttons.

Pin	KEY	功能
P0.11	KEY1(left)	Mouse move left for 5 pixels

P0.12	KEY2(up)	Mouse move up for 5 pixels
P0.24	KEY3(right)	Mouse move right for 5 pixels
P0.25	KEY4(down)	Mouse move down for 5 pixels



- If your PC support BLE, you can also used to control cursor on PC
- If you want to use the joystick of Arduino Accessory Shield, you need to modify the definition of keys in pca10056.h

```
#define BUTTON_1        NRF_GPIO_PIN_MAP(0,29)
#define BUTTON_2        NRF_GPIO_PIN_MAP(0,4)
#define BUTTON_3        NRF_GPIO_PIN_MAP(0,28)
#define BUTTON_4        NRF_GPIO_PIN_MAP(0,31)
```

WIRELESS KEYBOARD

HOGP profile (HID over GATT Profile) can be used to release wireless keyboard function. HOGP use basic protocol GATT of BLE to release interaction between HID host and Device.

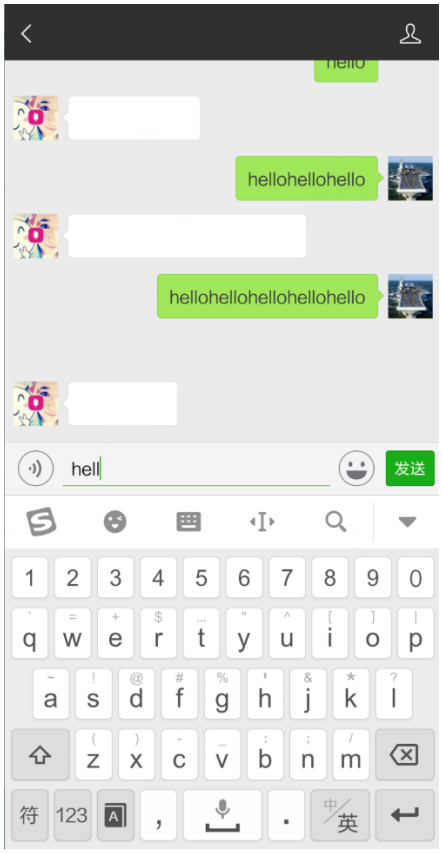
Download:

- Open the project SlaveDevice_bluetooth-HIDS_KEYBOARD(APP),
- Compile and download to Eval Kit board.

Expected result:

- Eval Kit board broadcast and LED1 is blinking.
- Open Bluetooth of your Phone, search and connect Nordic_keyboard device. After connecting, LED1 is on
- Then you can try to input text

  Press KEY1 on board to input string “hello”. Connect P0.15 to LED, and you can find that LED is turned off if Caps Lock is enabled, and the LED is turned on when Caps Lock is disabled.



CSCS

NRF52840 will send seed, rate, riding distance, total distance and gear ratio data to phone via BLE.

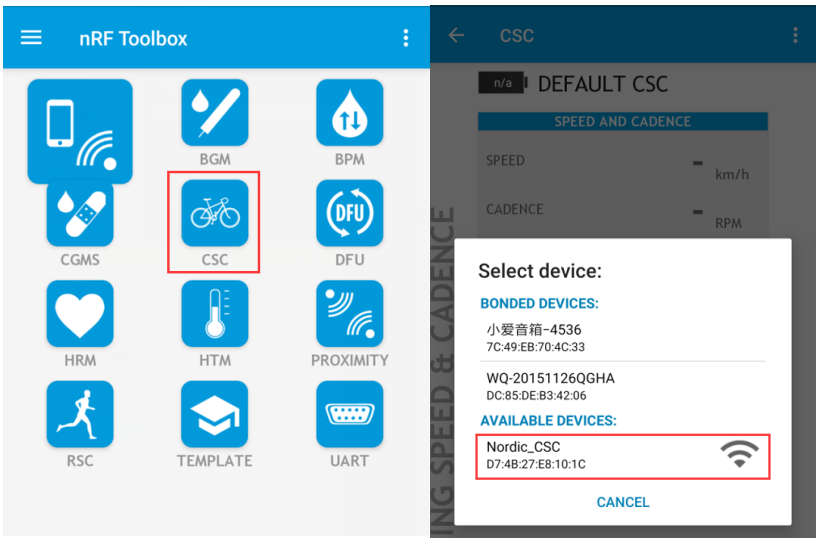
The data is generated by software (simulated), which is based on Cycling Speed and Cadence profile.

Download:

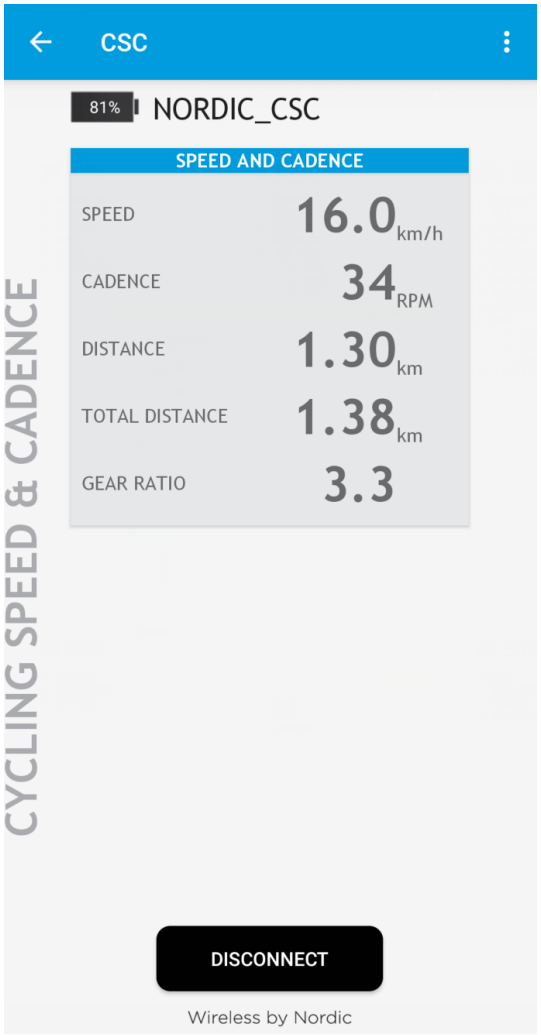
- Open the project Bluetooth-CSCS(APP),
- Compile and download to Eval Kit board.

Expected result:

- Eval Kit board is broadcasting and LED1 blinking
- Open nRF Toolbox APP, click CSC(Cycling Speed and Cadence)
- Click Connect to scan and connect to Nordic_CSC device



- After connecting, corresponding data are printed to APP



BLUETOOTH MASTER- CARDIOTACHOMETER

You need two NRF52840 Eval Kit for this example, one is used as master, and another is slaver.

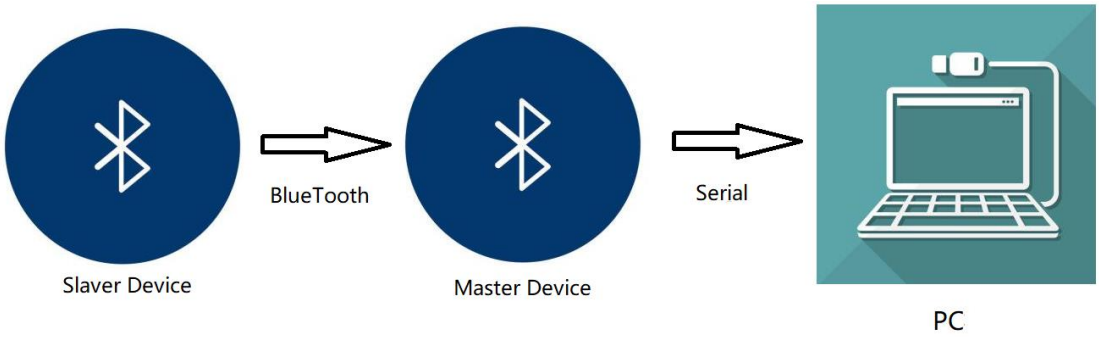
Download:

- Open project Master-Link-To-Slave-By-HRS(Master), compile and download it to one Eval Kit board.
- Open project Master-Link-To-Slave-By-HRS(Slaver), compile and download it to another Eval Kit board.

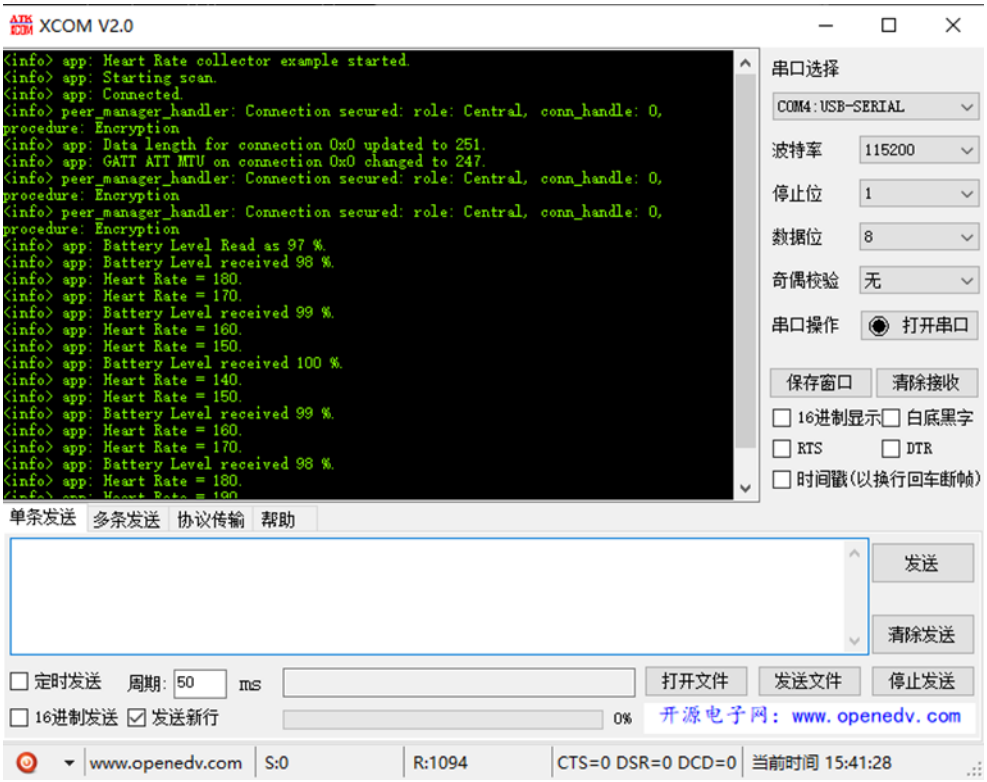
Both projects can be found in Part-3-Bluetooth-Master-Device\USER

Expected result:

- The communication between two Eval Kit boards is as below:



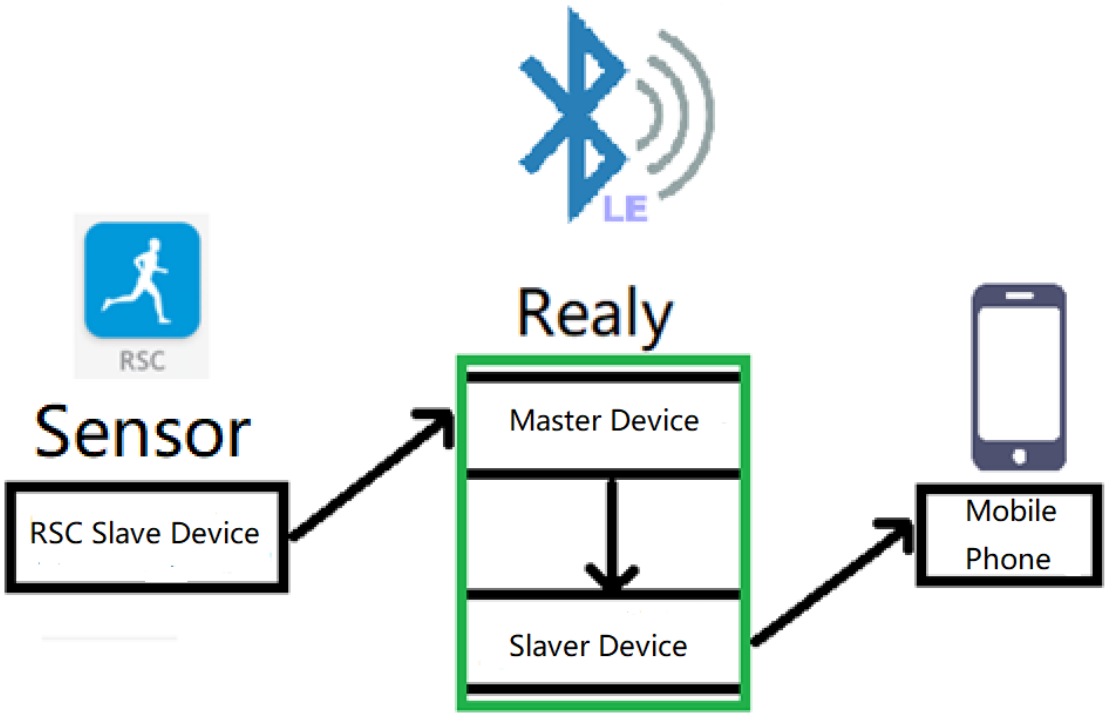
- After downloading, the master will auto-link to slaver, LED1 are on if they connect successfully.
- Slaver will send data to Master, which are transferred to serial port and printed in PC.



MASTER-SLAVER-BLE RELAY

With this example, Eval Kit board can work as master and slaver at the same time.

- Eval Kit board auto connect to another slaver (RSCS) when work as master
- Eval Kit board will connect to phone when work as slaver
- With BLE Relay example, Eval Kit can receiver data from RSCS slaver and send it to mobile phone as below:

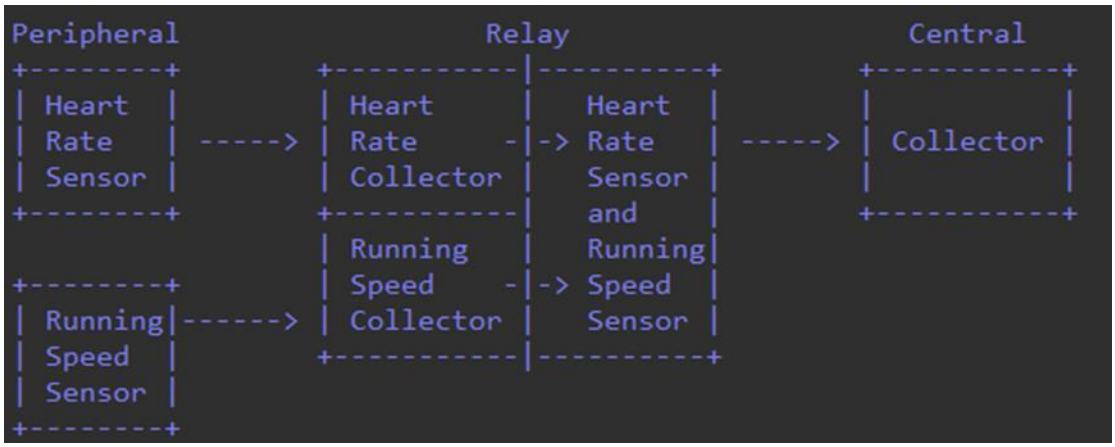


To complete this example, you require two Eval Kit boards, one is work as Sensor(RSCS slaver) and another is Relay (Master-Slaver)

Download:

- Open project Master&Slaver-Relay(Master), compile and download to Relay board.
- Open project Master&Slaver-Relay(Slaver), compile and download to Sensor board

【Note】 The slaver project is RSC project, it also can be HRM project



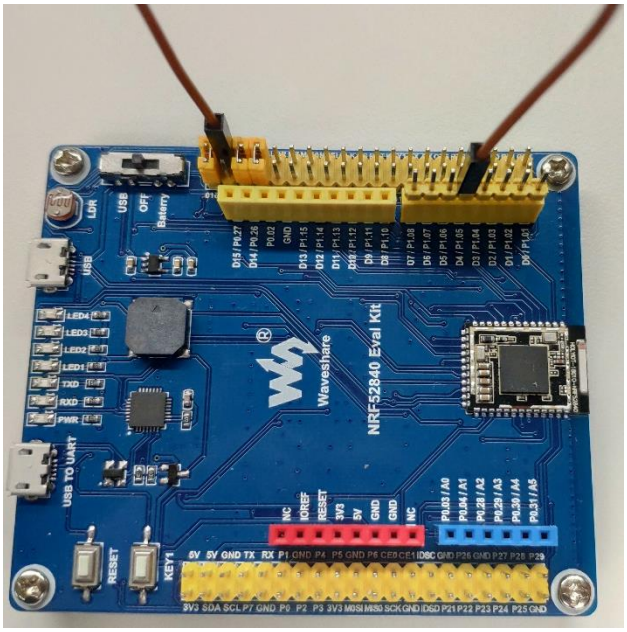
Expected result:

- Power on Relay board, it begins to scan devices(master) and broadcasts(slaver). LED1 and LED3 are on
- Power on Sensor board, it begin to broadcast and LED1 is blinking, LED1 stay on if Sensor board connected to Master successfully

Indicators of Relay Board

Indicators	Description
LED1	On: Master is scanning (it keeps scanning even Slaver is connected)
LED2	On: Master has connected to slaver (slaver: sensor board)常
LED3	On: Slaver is broadcasting
LED4	On: Slaver is connected master (master: mobile phone)

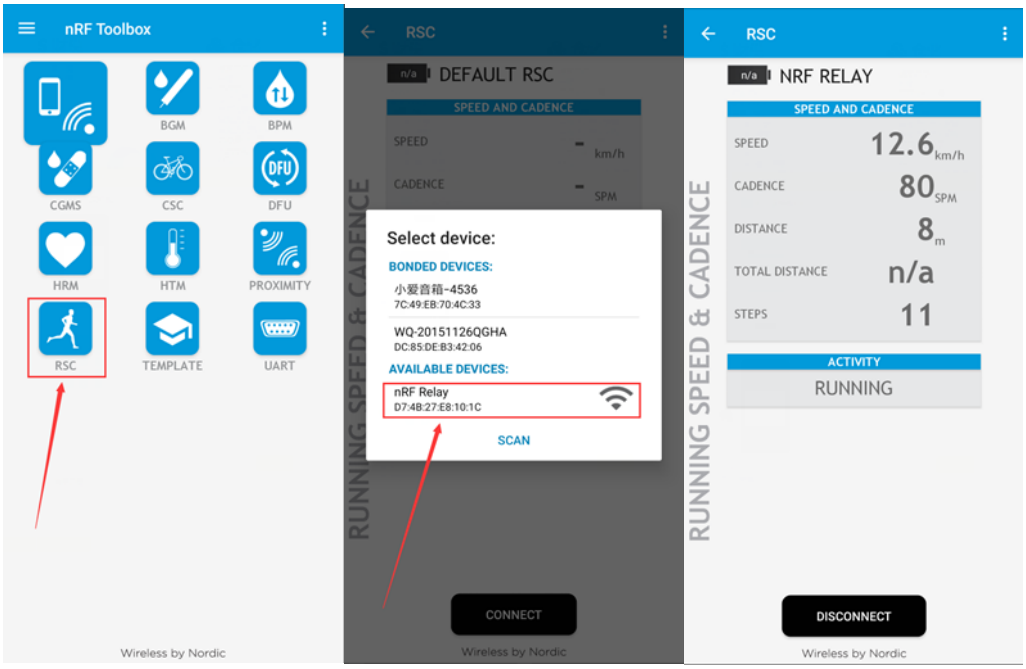
【Note】The pin of LED3 is not compatible with SDK， you need to wire it to P1.05 manually.



Indicator of Sensor board:

Indicator	Description
LED1	Blinking: Broadcasting On: Connected

- Open nRF Toolbox on phone, click RSC and Connect to nRF Relay device.
- After connecting, LED2 of Relay board is turned off and LED4 turns on. Data are sent to phone.



XCOM V2.0

```
<info> app: Relay example started.
<info> app: Fast advertising.
<info> app: Central connected
<info> app: Attempt to find HRS or RSC on conn_handle 0x0
<info> peer_manager_handler: Connection secured: role: Central, conn_handle: 0,
procedure: Encryption
<info> peer_manager_handler: Connection secured: role: Central, conn_handle: 0,
procedure: Encryption
<info> app: Running Speed and Cadence service discovered on conn_handle 0x0
<info> peer_manager_handler: Connection secured: role: Central, conn_handle: 0,
procedure: Encryption
<info> app: Speed      = 1280
<info> app: Speed      = 896
<info> app: Speed      = 512
<info> app: Speed      = 128
<info> app: Speed      = 512
<info> app: Speed      = 896
<info> app: Speed      = 1280
<info> app: Speed      = 1664
<info> app: Speed      = 1280
<info> app: Speed      = 896
<info> app: Speed      = 512
<info> app: Speed      = 128
<info> app: Speed      = 512
<info> app: Speed      = 896
<info> app: Speed      = 1280
```

CHAPTER 10. MESH[7]

This chapter we describe some of the basic concepts of the Bluetooth Mesh network using Nordic’ s nRF5 SDK for Mesh.

The project we used herein is light-switch example from Nordic’ s MESH SDK, for more details about it, you can refer to official Documents.

The light-switch example demonstrates the major parts of the mesh network ecosystem. it consists of three minor examples:

- Light switch server: a minimalistic server that implements a generic OnOff server model, which is used to receive the state data and control the state of LED1 on the board
- Light Switch Client: A minimalistic client that implements four instances of a Generic OnOff client model. When a user presses any of the buttons, an OnOff Set message is sent out to the configured destination address.
- Mesh Provisioner: A simple static provisioner implementation. This provisioner provisions all the nodes in one mesh network. Additionally, the provisioner also configures key bindings and publication and subscription settings of mesh model instances on these nodes to enable them to talk to each other.

These three examples will be referred to as the server, the client and the provisioner respectively.

The four buttons are used to initiate certain actions and four LEDs are used to reflect the status of actions as below:

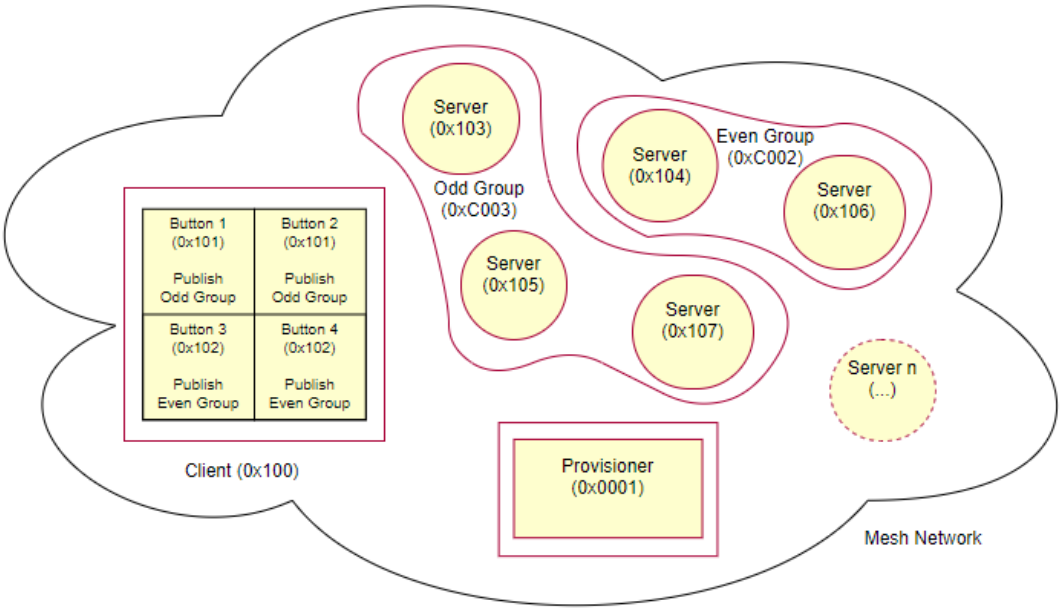
[7] You can directly refer to Nordic website:

- Server:
  - During provisioning process:
    - LED3 and 4 blinking: Device identification active
    - LED1 to 4: Blink four times to indicate provisioning process is completed
  - After provisioning and configuration is over:
    - LED1: Reflects the value of OnOff state on the server
      - LED ON: Value of the OnOff state is 1 (true)
      - LED OFF: Value of the OnOff state is 0 (false).
- Client:
  - During provisioning process:
    - LED3 and 4 blinking: Device identification active
    - LED1 to 4: Blink four times to indicate provisioning process is completed
  - After provisioning and configuration is over, buttons on the client are used to send OnOff Set message to the servers:
    - Button1: Send a message to the odd group(address: 0xC003) to turn on LED1
    - Button2: Send a message to the odd group (address: 0xC003) to turn off LED1
    - Button3: Send a message to the even group (address: 0xC002) to turn on LED1

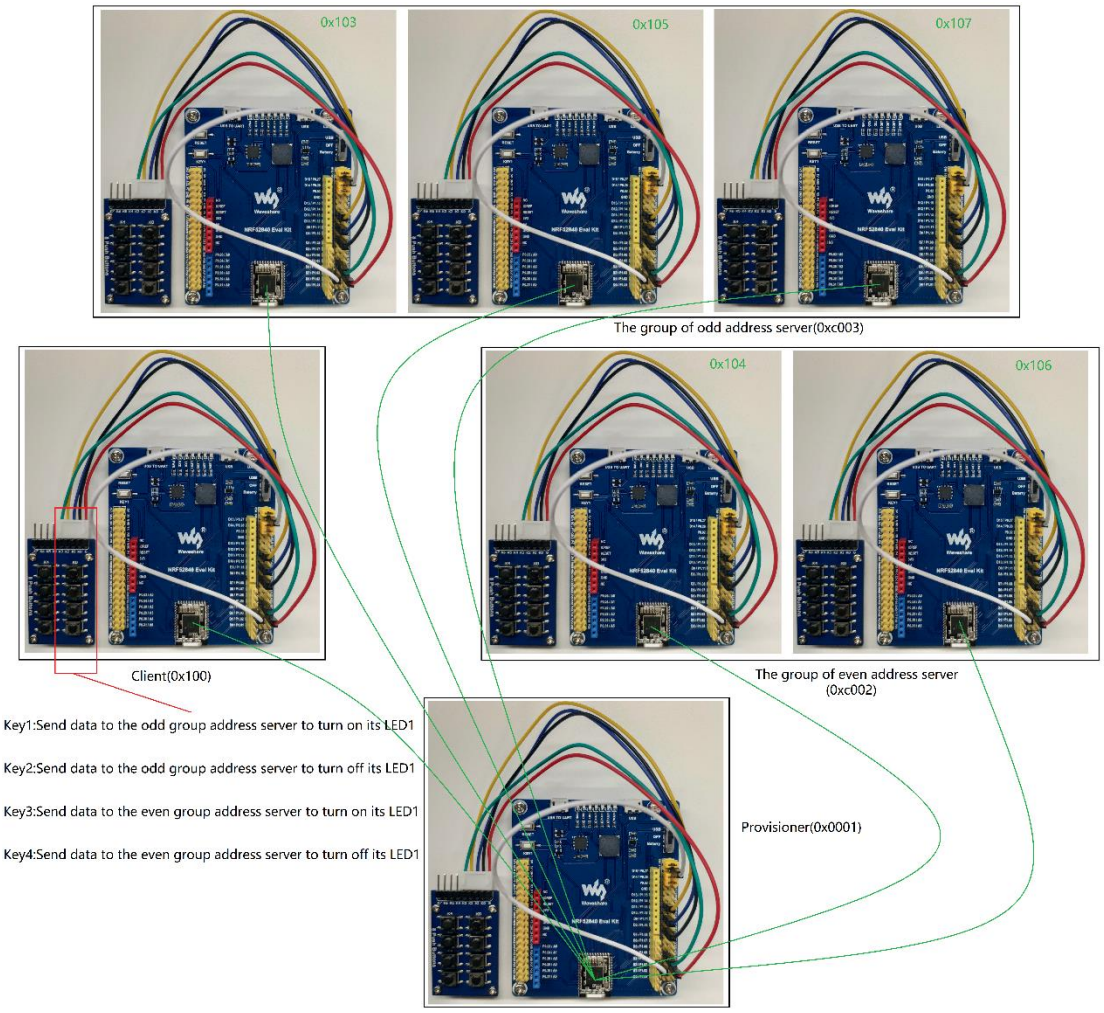
- Button 4: Send a message to the even group (address: 0xC002) to turn off LED1.

- Provisioner:
  - Button1: Start provisioning
  - LED1: Reflects the state of the provisioning.
    - LED ON: provisioning of the node is in progress
    - LED OFF: No ongoing provisioning process
  - LED2: Reflects the state of the configuration
    - LED ON: Configuration of the node is in process
    - LED OFF: No ongoing configuration process

The following figure gives the overall view of the mesh network that will be set up in this example. Numbers in parentheses indicate the addresses that are assigned to these nodes by the provisioner.



The Mesh is as below:



Hardware requirement:

it required at least three NRF52840 Eval Kit:

- One Eval Kit board for server
- One Eval Kit board for client
- One Eval Kit board for provisioner

Software requirement:

1. nRF Mesh SDK: nrf5_SDK_for_Mesh_v2.2.0_src, download and extract the SDK
2. BLE SDK: nRF5_SDK_15.0.0_a53641a, download and extract the SDK
3. nrfjprog: This tool is used to erase Flash, can be installed by nRFx Command Line Tools for Windows

4. SEGGER Embedded Studio for ARM 4.10a (The MESH project is built by this tool)

【Note】All the resources should be extracted to the same path, for linked by compiler. Otherwise, the project is failed to compile.

```
.
+— nrf5_sdk_for_mesh/
+— nRF5_SDK_15.0.0_a53641a/
```

Download:

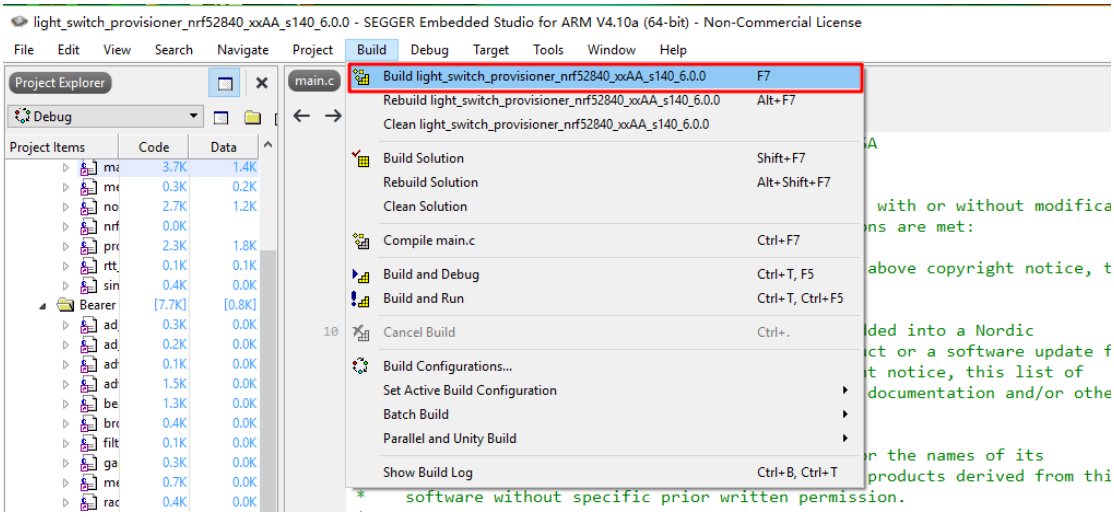
- Connect NRF52840 Eval Kit board to PC. Decide which board you want to use as client and which one as provisioner
- Open projects with SEGGER Embedded Studio for ARM 4.10a
  - Provisioner:

    MESH\nrf5_SDK_for_Mesh_v2.2.0_src\examples\light_switch\provisioner\light_switch_provisioner_nrf52840_xxAA_s140_6_0_0.emProject
  - Server:

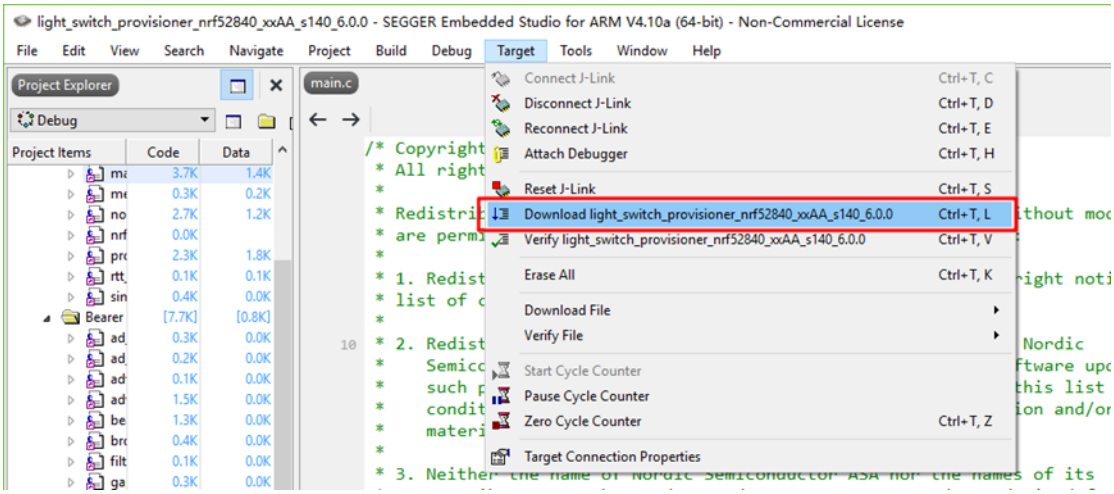
    MESH\nrf5_SDK_for_Mesh_v2.2.0_src\examples\light_switch\proxy_server\light_switch_proxy_server_nrf52840_xxAA_s140_6_0_0.emProject
  - Client:

    MESH\nrf5_SDK_for_Mesh_v2.2.0_src\examples\light_switch\proxy_client\light_switch_proxy_client_nrf52840_xxAA_s140_6_0_0.emProject

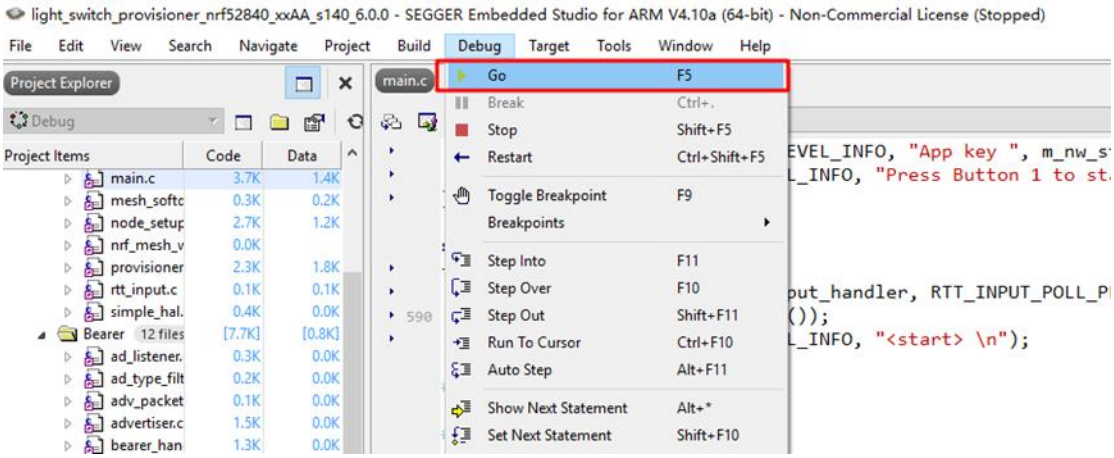
- Compile projects



- Download projects



- You can also try to debug



Running example:

When the flashing is complete, the script executes a reset operation to start the example applications.

After the reset, the provisioner waits for user input. Follow these steps to see the mesh network in actions:

1. Press Button1 on the provisioner board to start the provisioning process
    a) The provisioner first provisions and configures the client and assigns the address 0x100 to the client node
    b) The two instances of the OnOff client models are instantiated on separate secondary elements. For this reason, they get consecutive addresses starting with 0x101
    c) Finally, the provisioner picks up the available devices at random, assigns them consecutive addresses, and adds them to odd and even groups
    d) Observe the LED status on the provisioner, client and server boards.
    e) Wait until LED1 on the provisioner board remains ON steadily for a few seconds, which indicates that all available boards have been provisioned and configured
    f) Press buttons on the client board to change the state of LED1 on the server boards:
        i. Press Button1 on the client board to turn ON LED1 on all servers with ODD address

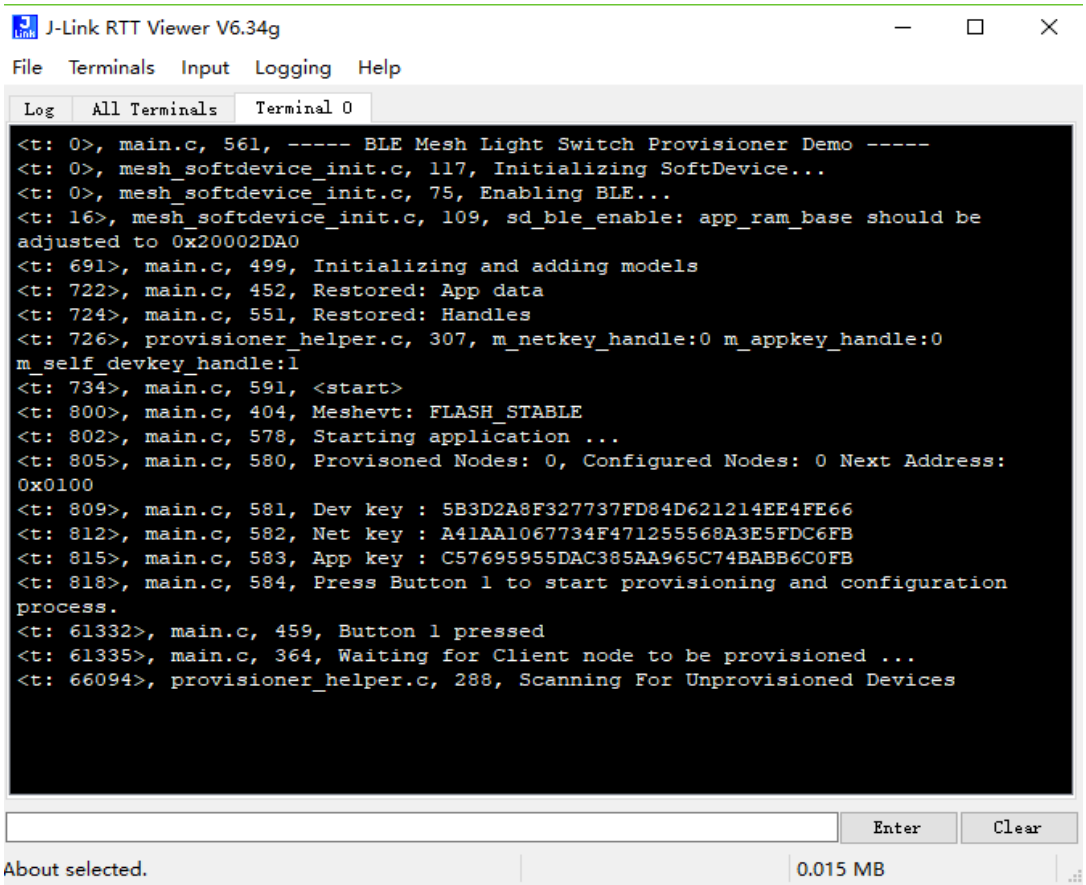
ii. Press Button2 on the client board to turn OFF LED1 on all servers with ODD addresses

iii. Press Button3 on the client board to turn ON LED1 on all servers with EVEN address

iv. Press Button4 on the client board to turn OFF LED1 on all servers with EVEN address

g) Press Button1 on the servers to locally change the state of LED1 and observe that the client receivers the status message from the corresponding server containing the new state value.

h) You can monitor the RTT logs with J-Link RTT viewer by connecting provisioner and client.



User Phone as provisioner

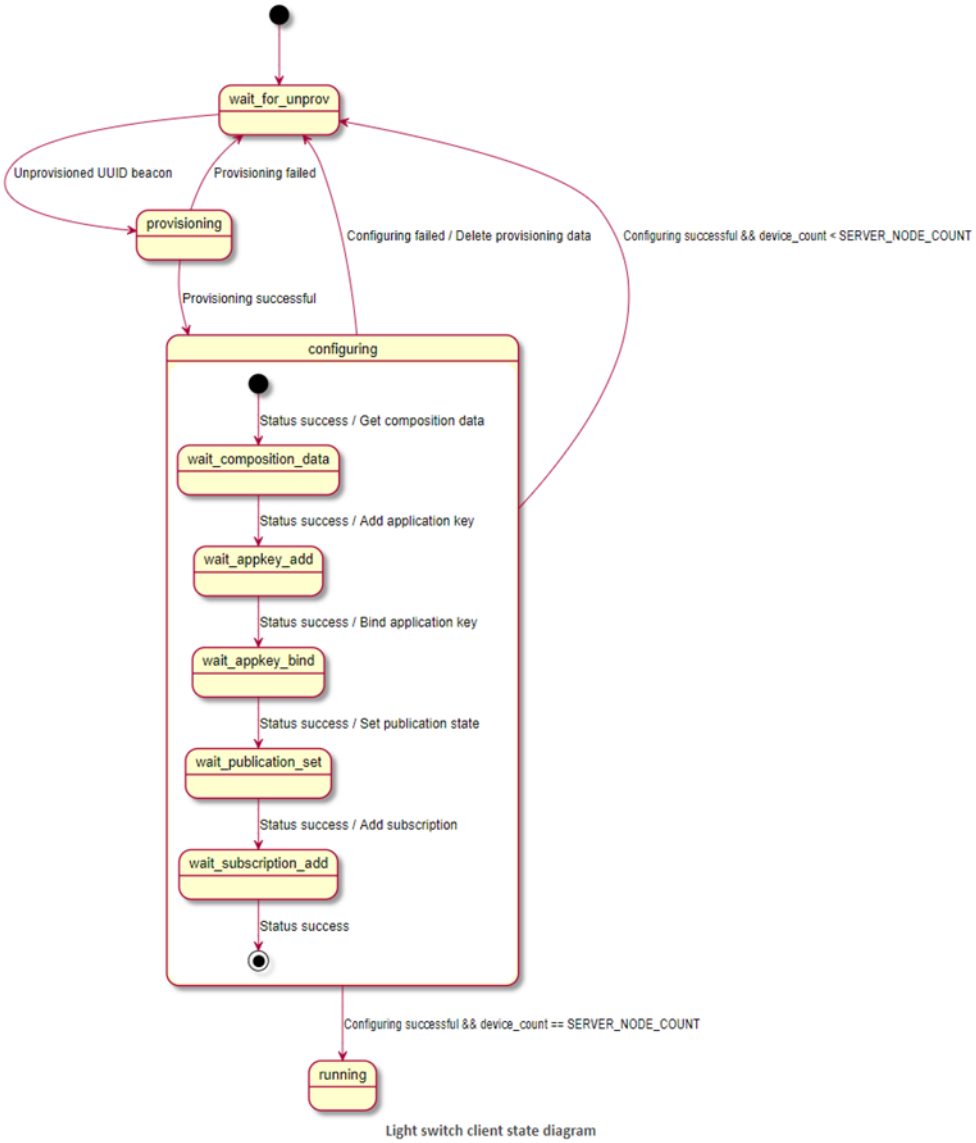
Besides the NRF52840 board, you can also use your phone as provisioner.

1. Download client and server project to Eval Kit board respectively.
2. Install nRF Mesh APP to your phone to work as a provisioner.
3. Connect to client and server
4. Configure client and server
5. Press Button1 on client board turns ON LED1 of server
6. Press Button2 on client board turns OFF LED1 of server

Provisioner:

The provisioner configures a network in a fixed, predefined way. it is implemented as a multi-layered state machine due to the asynchronous nature of the provisioning and configuration process.

The provisioner first provisions and configures a client device with a known URI hash. Then configures the servers and networking.



Light switch client state diagram

Client:

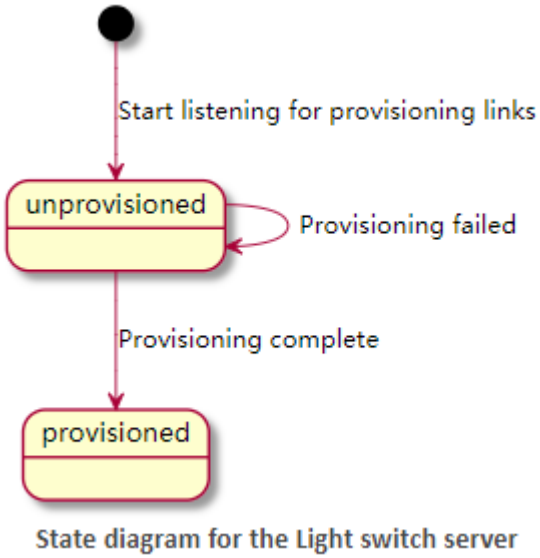
The light switch client implements a Generic OnOff client. Together with light switch server and mesh provisioner, it is part of the light switch example network demonstration, in which it has a provisioner role.

Server:

The light switch server is a Generic OnOff server that has a provisionee role in the light switch example network demonstration, which is also composed of light switch

client and mesh provisioner. There can be one or more servers in this network, for example light bulbs.

The provisioner configures this server model instance to communicate with the client model.



State diagram for the Light switch server