Introduction

The BLE-Sub1 GHz development kit uses the BlueNRG-1/2 system-on-chip for Bluetooth® low energy (BLE) functionality and the S2-LP transceiver for sub-1 GHz functionality.

This package is for applications aiming to implement the BLE and sub-1 Ghz protocols with the corresponding BlueNRG-1/2 and S2-LP devices. It includes use examples and recommendations on the simultaneous use of the two protocols.

This package is based on specific BlueNRG-1/2 and S2-LP SDK software component versions available at the time of release. Check release notes to find the version number associated with each SDK.

For further information, refer to STSW-BLUNRG1-DK literature for the BlueNRG-1/2 hardware and software development kit, and STSW-S2LP-DK and STSW-S2LP-SFX-DK literature regarding S2-LP hardware and software development kit.
1  Getting started

This section describes the software and hardware components of the kits.

1.1  Software

Download the BLE-Sub1 GHz software package (STSW-BNRG-S2LP-DK) from www.st.com and extract BLE-Sub1 GHz DK-Setup-x.x.x.zip contents to a temporary directory.

Launch BLE-Sub1 GHz DK-Setup-x.x.x.exe and follow the on-screen instructions.

1.2  Hardware

To run the demo of this package, one of the following is necessary:

- a BlueNRG-1 STEVAL-IDB007V2 kit (refer to UM2071 on www.st.com for details).

![Figure 1. STEVAL-IDB007V2 board](image)

Figure 2. STEVAL-IDB008V2 board

- a BlueNRG-1 STEVAL-FKI001V1 kit (refer to DB3740 on www.st.com for details).

Figure 3. STEVAL-FKI001V1

- The BlueNRG-2 ST Monarch reference design see Section 1.2.3 ST Sigfox Monarch reference design
Together with the STEVAL-IDB007V2 or the STEVAL-IDB008V2, you also needs:
- an S2-LP STEVAL-FKI888V2 or STEVAL-FKI915V1 kit, depending on the operating band (see UM2149 on www.st.com for details).
For users interested in the Sigfox protocol, the table below shows which boards cover which radio configuration zone (RCZ) or zones. See UM2169 on www.st.com for more details.

Table 1. S2-LP boards for Sigfox radio configuration zones

<table>
<thead>
<tr>
<th>S2-LP board</th>
<th>Radio configuration zone</th>
</tr>
</thead>
<tbody>
<tr>
<td>STEVAL-FKI868V2</td>
<td>RCZ1, RCZ3, RCZ5, RCZ6</td>
</tr>
<tr>
<td>STEVAL-FKI915V1</td>
<td>RCZ2</td>
</tr>
<tr>
<td>STEVAL-FKI915V1</td>
<td>RCZ4</td>
</tr>
</tbody>
</table>

1.2.1 Modifying the STEVAL-IDB007V2 or STEVAL-IDB008V2 kit

To render the STEVAL-IDB007V2 or the STEVAL-IDB008V2 compatible with the STEVAL-FKI868V2 and STEVAL-FKI915V1 boards, perform these modifications on the rear side of the board.

Step 1. Remove R12
Step 2. Create a short-circuit between pin 8 and pin 7 on the CN3 connector

Figure 5. CN3 alterations

Step 3. Remove R25, R21, R19 and R16
Step 4. Set a short between the internal pad of R21 and R17
Step 5. Set a short between the pin 6 of the CN4 connector and the internal pad of R19
Figure 6. CN4 alterations

Before:

<table>
<thead>
<tr>
<th>R25</th>
<th>R23</th>
<th>R21</th>
<th>R19</th>
<th>R17</th>
<th>R16</th>
</tr>
</thead>
<tbody>
<tr>
<td>CN4-pin6</td>
<td>CN4-pin5</td>
<td>CN4-pin4</td>
<td>CN4-pin3</td>
<td>CN4-pin2</td>
<td>CN4-pin1</td>
</tr>
</tbody>
</table>

After:

<table>
<thead>
<tr>
<th>R25</th>
<th>R23</th>
<th>R21</th>
<th>R19</th>
<th>R17</th>
<th>R16</th>
</tr>
</thead>
<tbody>
<tr>
<td>CN4-pin6</td>
<td>CN4-pin5</td>
<td>CN4-pin4</td>
<td>CN4-pin3</td>
<td>CN4-pin2</td>
<td>CN4-pin1</td>
</tr>
</tbody>
</table>
### 1.2.2 BlueNRG-1/2 SoC connections

The platform pin connection of the STEVAL-IDB007V2 or the STEVAL-IDB008V2 is given in the following table.

**Note:** The information refers to a STEVAL-IDB007V2 or the STEVAL-IDB008V2 board that has been modified for compatibility with the STEVAL-FKI868V2 and STEVAL-FKI915V1 boards.

Table 2. Platform pin description with board function

<table>
<thead>
<tr>
<th>Pin name</th>
<th>Pin n</th>
<th>LEDs</th>
<th>S2-LP</th>
<th>Buttons</th>
<th>FKI_E2PROM</th>
<th>Pressure sensor</th>
<th>3D accelerometer and gyroscope</th>
<th>JTAG</th>
<th>Arduino connectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIO10</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CN1</td>
</tr>
<tr>
<td>DIO9</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CN2</td>
</tr>
<tr>
<td>DIO8</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td>SPI_CS</td>
<td></td>
<td></td>
<td></td>
<td>CN3</td>
</tr>
<tr>
<td>DIO7</td>
<td>4</td>
<td>DL2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CN4</td>
</tr>
<tr>
<td>DIO6</td>
<td>5</td>
<td>DL1</td>
<td></td>
<td></td>
<td>SDN</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DIO5</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td>PUSH2</td>
<td>SDA (PUSH2 button)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DIO4</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SCL</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DIO3</td>
<td>9</td>
<td></td>
<td>SPI_SDO</td>
<td></td>
<td>SPI_SDO</td>
<td>SPI_SDO</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DIO2</td>
<td>10</td>
<td></td>
<td>SPI_SDA</td>
<td></td>
<td>SPI_SDA</td>
<td>SPI_SDA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DIO1</td>
<td>11</td>
<td></td>
<td></td>
<td></td>
<td>SPI_CS</td>
<td>JTAG-TDO</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DIO0</td>
<td>12</td>
<td></td>
<td>SPI_SCL</td>
<td></td>
<td>SPI_SCL</td>
<td>JTAG-TDI</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DIO14</td>
<td>13</td>
<td>DL3</td>
<td>SPI_CS</td>
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<tr>
<td>RESET</td>
<td>25</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>RESET</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DIO13</td>
<td>29</td>
<td></td>
<td>GPIO3</td>
<td></td>
<td>PUSH1</td>
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<tr>
<td>DIO12</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>INT1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DIO11</td>
<td>32</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

### 1.2.3 ST Sigfox Monarch reference design

The reference hardware for Monarch uses the BlueNRG-2 for the Bluetooth® low energy (BLE) part and the S2-LP for the Sub-GHz. The aim of this module is to provide the compatibility of Sigfox communication for every RC zone supported from Sigfox. To satisfy this requirement the design mounts a front-end module (FEM) which
integrates a power amplifier and a low noise amplifier (LNA). In particular, the power amplifier (PA) can be selectively turned on or off depending on the RC configuration.

**Figure 7. Steval-Monarch reference design**

The device shown above should be mounted into a motherboard, which must provide the power supply and two antenna/RF connectors for both BLE and the Sub-GHz part.

The Monarch reference design is fully certified for Monarch operation for all the zones currently supported by Sigfox (RC1 to RC6). Based on Sigfox verified program, a module maker can freely cut and paste the reference design (schematic, BOM and board manufacturing specifications) in order to maintain the certification status.

The reference documents for such design are available in to ST website at the following address: https://www.st.com/en/wireless-connectivity/s2-lp.html

The BLE-Sub1 GHz development kit includes also the software API to enable the Monarch features. The latter is demonstrated by the demo BLE-Sigfox Monarch scan sensor demo described into Section 1.2.4 S2-LP.

### 1.2.4 S2-LP

The S2-LP embedded on the STEVAL-FKI868V2 or STEVAL-FKI915V1 board connected to the STEVAL-IDB007V2 or the STAVAL-IDB008V2 can be driven by the BlueNRG-1/2 via SPI.

GPIO3 is connected to a BlueNRG-1/2 wake-up pin to signal certain events to the BlueNRG-1/2.

The BlueNRG-1/2 SoC acts as an SPI master and can configure the device through registers as well as send and receive data to and from the sub-1 GHz channels.

### 1.2.5 E2PROM

The E2PROM containing the manufacturing data of the S2-LP board can be accessed by the BlueNRG-1/2 using the SPI bus.

### 1.2.6 Hardware setup

1. Connect a 2.4 GHz antenna to the STEVAL-IDB007V2 or the STEVAL-IDB008V2 SMA connector
2. Connect an 868 or 915 MHz antenna to the STEVAL-FKI868V2 or STEVAL-FKI915V1, respectively
3. Ensure the jumper configuration on the board is as in s 0
4. Connect the motherboard to the PC with a USB cable
5. Verify that PWR LED DL4 is on
The BLE-sub1 GHz navigator application in the software package is an interactive, simple and user friendly graphical user interface for browsing the following BLE-Sub1 GHz DK SW package resources:

- BLE-Sub1 GHz examples
- Board description and related changes
- BLE-Sub1 GHz development kits
- Release notes
- License files

This GUI lets you directly download and run the selected prebuilt application binary image on the BlueNRG-1/2 platform without a JTAG interface. The user has access to the demo description, board configuration and the source code.

**Run the utility** by double-clicking the BLE-Sub1 GHz navigator icon in

- Start → STMicroelectronics → BLE-Sub1 GHz DK X.X.X → BLE-Sub1 GHz navigator

![Figure 8. BLE-Sub1 GHz navigator](image.png)

The BLE-Sub1 GHz DK SW package release notes and license file can be accessed from the menu.

### 2.1 Demonstration applications

Navigate the menus to find the reference/demo application you wish to run. The following information is provided for each application:

- Application settings (if applicable)
- Application description
• Hardware-related information (LED signals, jumper settings etc.)

Figure 9. BLE-Sigfox sensor demo application window

The following functions are available for each application:
• **Flash & Run**: to automatically download and run the available prebuilt binary file on a BlueNRG-1/2 platform connected to a PC USB port.

Figure 10. BLE-Sigfox sensor demo application flashing

• **Doc**: to access the application documentation
2.2 Development kits

This window displays the available BLE-Sub1 GHz DK kit platforms and resources.

**Figure 12. STEVAL-IDB007V2/DB008V2 plus FKI868V1 kit components**

Hovering the mouse pointer over a specific item highlights the component on the board image.

- **Project**: to open the project folder containing the application headers, code and IAR files.
3 Programming with BlueNRG-1/2 system-on-chip

The BlueNRG-1/2 Bluetooth low energy (BLE) stack is provided as a binary library of APIs to control its BLE functions. Some callbacks are included for user applications to handle BLE stack events. The user must link this binary library to the application and use the relevant APIs for BLE functionality and complete the related stack event callbacks to handle stack events in the desired manner. A set of software driver APIs is also available to access the BlueNRG-1/2 SoC peripherals and resources (ADC, GPIO, I²C, MFTX, Micro, RTC, SPI, SysTick, UART and WDG).

3.1 Software directory structure

The BLE-Sub1GHz DK SW package files are organized as follows:

- **Application**: contains BLE-Sub1 GHz navigator PC application.
- **Doc**: contains the BLE-Sub1 GHz demo applications doxygen documentation DK release notes and license file.
- **Firmware**: contains prebuilt binary applications.
- **Library**
  - **Bluetooth LE**: Bluetooth low energy stack binary library and all the definitions of stack APIs, stack event callbacks and constants. OTA firmware upgrade source and header file.
  - **BlueNRG1_Periph_Driver**: BlueNRG-1/2 drivers for device peripherals (adc, clock, dma, flash, gpio, i2c, timers, rtc, spi, uart and watchdog).
  - **CMSIS**: BlueNRG-1/2 CMSIS files.
  - **SDK_Eval_BlueNRG1**: SDK drivers providing an API interface to the BlueNRG-1/2 platform hardware resources (LEDs, buttons, sensors, I/O channel).
  - **hal**: Hardware abstraction level APIs for abstracting some BlueNRG-1/2 hardware features (sleep modes, clock based on SysTick, etc.).
  - **SDK_Eval_S2LP**: SDK drivers providing an API interface to the S2-LP platform hardware resources (S2-LP SPI and GPIOs, E2PROM).
  - **Sigfox**: contains the library for the sigfox protocol on the BlueNRG-1/2 (ARM® Cortex®-M0 core).
  - **S2LP_Library**: contains the generic library for the S2-LP.
- **Projects**
  - **SigFox_Applications**: contains demonstration applications using the BLE and Sigfox protocols. Headers, source files and Keil and IAR project files are available. These applications link the Sigfox library contained in the Library/Sigfox folder (not the S2-LP library).
  - **common/st_lowlevel**: contains the implementation of the ST LowLevel API to run the library on the BlueNRG-1/2.
  - **common/id_key_retriever**: is used to retrieve the Sigfox data as ID and PAC from the board.
  - **BLE_SigFox_SensorDemo**: sources and projects files of the BLE_Sigfox_SensorDemo.
  - **BLE_Sigfox_MonarchScanSensorDemo**: sources and project files of the BLE_Sigfox_MonarchScanSensorDemo.
  - **Dual_Radio_Chat**: an application for communication between a mobile device and an S2-LP using BLE-Sub1 GHz functionality.
  - **S2LP_Communication**: a simple application that uses the S2-LP to exchange packets with another node; it uses the S2LP library to configure the S2-LP.

3.2 Before using the kit

You should register your STEVAL-FKI868V2 or STEVAL-FKI915V1 board with a Sigfox ID/PAC/KEY before using it with the STEVAL-IDB007V2 or the STEVAL-IDB008V2 (see user manual UM2169 on www.st.com).

3.3 Initialization sequence

This procedure lets you develop an application for Sigfox on the STEVAL-FKI868V2 or STEVAL-FKI915V1 platforms.
Step 1. Remap your hardware configuration modifying one of the `Platform_Configuration_x.h` files according to your needs and rename it `USER_Platform_Configuration.h`.

Step 2. Set the preprocessor define `USER_DEFINED_PLATFORM=USER_EVAL_PLATFORM`.

Step 3. Call the `ST_Init()` function.

Step 4. Call `aci_hal_write_config_data()` API to configure BlueNRG-1/2 public address (if public address is used).

Step 5. Call `aci_gatt_init()` API to initialize the BLE GATT layer.

Step 6. Call `aci_gap_init("role")` API to initialize the BLE GAP layer depending on the selected device role.

Step 7. Call `aci_gap_set_io_capability()` and `aci_gap_set_authentication_requirement()` APIs to set the proper security I/O capability and authentication requirement (if BLE security is used).

Step 8. Call `aci_gatt_add_service()`, `aci_gatt_add_char()` and `aci_gatt_add_char_desc()` APIs to define the required Services & Characteristics & Characteristics Descriptors if the device is a GATT server.

Step 9. Call `BlueNRG_Stack_Initialization(&BlueNRG_Stack_Init_params)` to initialize the BLE stack.

Step 10. Initialize the S2-LP SPI and S2-LP SDN pin setting it high.

Step 11. Call the `ST_Sigfox_Init()` function.

Step 12. Add the following `while(1)` loop:

```
while (1) {
    BTLE_StackTick(); - the BLE stack tick
    APP_Tick(); - a user tick handler where user actions/events are processed
    YourCustomRoutine();
    BlueNRG_Sleep(...); - enables BlueNRG-1/2 sleep mode and preserves the BLE radio operating modes
}
```

Step 13. Transmit a Sigfox frame with the 4-byte `customer_data` buffer to send:

- without downlink request:
  ```
  ST_SIGFOX_API_send_frame(customer_data,4,customer_resp,2,0);
  ```
- with downlink request:
  ```
  ST_SIGFOX_API_send_frame(customer_data,4,customer_resp,2,1);
  ```

The function returns after approximately 50 s and, if the error code is 0 (ok), the `customer_resp` will contain an 8-byte response.

3.4 ST LowLevel implementation

The `mcu_api_bluenrg.c` module in Projects/SigFox_Applications/common/st_lowlevel interfaces the ST Sigfox library with the hardware platform using:

- S2LP_CORE_SPI, S2LP_CORE_GPIO and E2PROM modules
- BlueNRG1_Periph_Driver

To avoid losing the BLE connection while the Sigfox frame is being transmitted, it is necessary to tick the BLE stack while the CPU is not performing operations related to the S2-LP.

The ST-Sigfox library continuously calls the `ST_MCU_API_WaitForInterrupt()` function whenever it is locked in a wait (for an event) state. Thus this function can be exploited to tick the BLE stack and the application in order to prevent disconnection of the paired BLE devices.

The following function is continuously called at two points of the application:

```c
void BLE_Activity(void)
{
    /* BLE Stack Tick */
    BTLE_StackTick();

    /* Application Tick */
```
One point is the `while(1)` main loop and the second is the following wait for interrupt function:

```c
void ST_MCU_API_WaitForInterrupt(void){
    /* if the MCU is stuck waiting for some IRQ, keep on the BLE activity */
    BLE_Activity();
}
```

The library needs to be informed when the S2LP IRQ is raised. In this case, `ST_RF_API_S2LP_IRQ_CB` must be called by the GPIO ISR. This function is implemented by the ST-Sigfox library.

A possible implementation of the GPIO ISR could be:

```c
void GPIO_Handler(void){
    /* assert that the interrupt comes from the S2-LP pin */
    if(GPIO_GetITPendingBit(M2S_GPIO_IRQ_PIN)){
        /* inform the library that the interrupt has been raised by the S2-LP */
        ST_RF_API_S2LP_IRQ_CB();

        /* clear the pending bit of the IRQ */
        GPIO_ClearITPendingBit(M2S_GPIO_IRQ_PIN);
    }
}
```

Different actions may be performed when `ST_RF_API_S2LP_IRQ_CB()` is called, according to the status of the library:

- **Transmission (uplink):** FIFO SPI transactions are performed by `ST_RF_API_S2LP_IRQ_CB()` to refill the TX FIFO. It is important to ensure that the SPI access is exclusive and that any SPI transactions performed by the main thread or by lower priority interrupts are not interrupted by this ISR. In this case, the ISR should be processed within 1 ms for RCZ2 and RCZ4 and 6 ms for RCZ1,3,5,6.

- **Reception (downlink):** Register and FIFO readings are not time critical and are not directly performed by `ST_RF_API_S2LP_IRQ_CB()`. The callback just sets a flag to signal the running routines in the library that the interrupt has been raised and to perform the appropriate actions.

With this implementation, it is possible to ensure that required timings are satisfied and the modulation is correctly performed.

### 3.5 Sample applications

#### 3.5.1 BLE-Sigfox sensor demo

The project demonstrates how BLE (see user manual UM2071 on www.st.com) connectivity and Sigfox transactions can coexist.

**Note:** You must first set up the S2-LP FKI board with a sigfox ID, PAC and KEY and register it on the Sigfox backend (see user manual UM2169 on www.st.com). If the board is not registered, the ID check routine fails and LED DL2 blinks indefinitely.

This demo merges:

- the BLE sensor demo in the STSW-BLUNRG1-DK
- the push button project in the STSW-S2LP-SFX-DK.

This application provides the same BLE services as the BLE sensor demo, including the free fall characteristic. In addition to sending the BLE notification to the master, the application sends a “free fall” message to the Sigfox network.

When you press PUSH BUTTON 2 (SW1 for FKI001V1), the application transmits a Sigfox frame over a certain duration (up to a few seconds, depending on the RCZ) while still maintaining the BLE connection.

A BlueNRG application for iOS™ and Android™ is available, that also interacts with the BlueNRG-1/2 BLE sensor profile demo.
This app enables notification of the acceleration characteristic and displays the value on screen. A free fall event causes the app to show a yellow triangle on your mobile device, while the Sigfox backend terminal shows a message with the hexadecimal representation of the “free fall” message.

**Figure 13. Free fall notification on BlueNRG app**

![Free fall notification on BlueNRG app](image)

![Free fall notification on Sigfox backend](image)

The `sensor.c` file contains the sensor management (initialization, reading and free fall detection) logic. It is very similar to `BLE_SensorDemo` in the BlueNRG-1 DK, except that the SPI acceleration reading (sensor LSM6DS3) is performed in a critical section to avoid competition on the SPI bus between the S2-LP management (performed in the GPIO ISR) and the sensor itself.

The `s2lp_irq` function is shown below:

```c
void s2lp_irq(FunctionalState en)
{
    NVIC_InitType NVIC_InitStructure;

    /* Set the GPIO interrupt priority and enable/disable it */
    NVIC_InitStructure.NVIC_IRQChannel = GPIO_IRQn;
    NVIC_InitStructure.NVIC_IRQChannelPreemptionPriority = LOW_PRIORITY;
    NVIC_InitStructure.NVIC_IRQChannelCmd = en;
    NVIC_Init(&NVIC_InitStructure);
}
```

This function is used to disable or enable the GPIO interrupt on the core immediately before or after the accelerometer read:
/* Disable the IRQ from S2-LP */
s2lp_irq(DISABLE);
/* Get Acceleration data */
if(GetAccAxesRaw(\&acc_data) == IMU_6AXES_OK) {
    Acc_Update(\&acc_data);
}
/* Get free fall status */
GetFreeFallStatus();
/* Enable the IRQ from S2-LP */
s2lp_irq(ENABLE);

This ensures that the ST_RF_API_S2LP_IRQ_CB() callback is called while the SPI bus is free, without disrupting sensor reading and avoiding competition on the SPI bus.

Temperature and pressure sensor data are emulated because PUSH BUTTON 2 shares the I²C data line and asynchronous activation of this button may interfere with real LPS25HB sensor data reading.

You can enable real sensor data reading (gatt_db.c file) if you do not plan to use PUSH BUTTON 2.

You can force the application to use the Sigfox public key (for testing purposes or usage with the Sigfox network emulator - SNE tool) by:
1. pressing and holding PUSH BUTTON 2
2. pressing the board RESET button
3. releasing PUSH BUTTON 2

3.5.2 BLE-Sigfox Monarch scan sensor demo

The project increases the BLE-Sigfox sensor demo with the Sigfox Monarch feature to be used in conjunction with the reference design described in Section 1.2.3 ST Sigfox Monarch reference design. The aim of the Monarch feature is to provide a way for Sigfox devices to know what kind of Sigfox radio configuration (RC) to apply wherever they are in the world. These features are enabled by means of specific beacons that base station sends periodically (5 min) with a duration of 400 ms to Sigfox devices. Such beacons are demodulated by the S2-LP and then processed by the BlueNRG-2 to establish the correct RCZ, see figure below.

![Figure 15. Beacon demodulation](image)

**Sigfox Monarch scan demo main flow**

If a Sigfox node is moving through the world, it cannot transmit any information while it is not aware about the current zone. For this reason, in this demo there is a start-up phase in which the node starts to scan for Monarch beacons. During this time the board cannot send any information to Sigfox base stations while BLE capability are instead available. The monarch scan session is triggered by means of the following API function.

```c
sfx_error_t SIGFOX_MONARCH_API_execute_rc_scan (sfx_u8 rc_capabilities_bit_mask, sfx_u16 timer, sfx_timer_unit_enum_t unit, sfx_u8 (*app_callback_handler) (sfx_u8 rc_bit_mask, sfx_s16 rssi) ).
```

where `timer` and `unit` specify a time unit in terms of millisecond, seconds, minutes or hours. The function returns the `rc_bit_mask` value corresponding to the beacon found and its rssi level by means of the callback `app_callback_handler` passed as parameter. To inform the Sigfox library about the device supported RC zones a bitmask is passed through the 8-bit parameter named `rc_capabilities_bit_mask`.

In the demo the function explained above is called into the main function as follows:
In the latter the monarch scan has been set for about 5 minutes, considering the periodicity of Monarch beacons. The `rc_capabilities_bit_mask` is set to 63 (111111) in order to inform the library that the board can manage all RCs (from 1 to 6). Once the 5 minute timeout expiration, or after that the board recognizes the RCZ, the following callback is called.

```c
sfx_u8 monarch_callback_for_found(sfx_u8 rc_bit_mask, sfx_s16 rssi)
{
    printf("return rc_bit_mask %d\n", rc_bit_mask);
    printf("return rssi %d\n", rssi);
    switch (rc_bit_mask)
    {
        case 0x00: // RC0
        {
            printf("Detected RC0!!!:\n\n");
            /* Turn Power Amplifier Off - 14 dBm out */
            ST_RF_API_set_pa(0);
            detected_zone=0;
        }
        break;
        case 0x01: // RC1
        {
            printf("Detected RC1!!!:\n\n");
            /* Turn Power Amplifier Off - 14 dBm out */
            ST_RF_API_set_pa(0);
            detected_zone=1;
        }
        break;
        case 0x02: // RC2
        {
            printf("Detected RC2!!!:\n\n");
            /* Turn Power Amplifier On - 24 dBm out */
            ST_RF_API_set_pa(1);
            detected_zone=2;
        }
        break;
        case 0x04: // RC3a
        {
            printf("Detected RC3!!!:\n\n");
            /* Turn Power Amplifier Off - 14 dBm out */
            ST_RF_API_set_pa(0);
            detected_zone=3;
        }
        break;
        case 0x08: // RC4
        {
            printf("Detected RC4!!!:\n\n");
            /* Turn Power Amplifier On - 24 dBm out */
            ST_RF_API_set_pa(1);
            detected_zone=4;
        }
        break;
        case 0x10: // RC5
        {
            printf("Detected RC5!!!:\n\n");
            /* IN RC5 maximum output power is 12 dBm */
            /* ST_RF_API_reduce_output_power(2); */
            /* Turn Power Amplifier Off - 14 dBm out */
            ST_RF_API_set_pa(0);
            detected_zone=5;
        }
        break;
        case 0x20: // RC6
        {
            printf("Detected RC6!!!:\n\n");
            /* Turn Power Amplifier Off - 14 dBm out */
            ST_RF_API_set_pa(0);
            detected_zone=6;
        }
    }
}
```
As it should be pointed out, depending on the found configuration, the callback passes the proper value to the `ST_RF_API_set_pa` in order to activate or not the power amplifier. This decision is based on the local laws in terms of admissible output power. Further, a message will appear in the UART terminal and the devices will send a frame in the proper RCZ.

It should be pointed out that, during a Monarch scan it is not possible to send any message into the Sigfox cloud, in fact, when a Monarch session is ongoing, the device will be in the MONARCH SCAN state (see figure below) and it cannot reach the READY state (the state for transmitting any Sigfox message).

Figure 16. Sigfox state machine (partial)

To summarize, for running the BLE-SigFox Monarch scan sensor demo we assume that the monarch signal is present. After the board reset the following procedure is executed by the firmware:

1. The Monarch scan session starts for a period of 5 minutes. During this time is not possible to send Sigfox messages but BLE connectivity still working as well as for the BLE-Sigfox sensor demo
2. After a beacon detection the proper RCZ is configured (e.g. RC1)
3. The device sends a frame to a base station which reports the detected zone
4. Starting from here is possible to send message by means of button or the free fall event

Expected results
If the device is in the zone 1, for example, when a Monarch beacon has been received and the boards is connected to a UART terminal (via an USB to serial adapter) the 01 message (RC1) is shown in the Sigfox backend while Detected RC1! message appears into the UART terminal.

Figure 17. Message in the back-end indicating a beacon in RC1

If, instead, the device is in the zone 2, in the UART terminal reports the message Detected RC2! At the same time into the backend the following appears (02 for RC2)-
If during the Monarch session no beacons have been found, the following message appears in to the terminal: **Monarch Scan Timeout**. In this case, the user should reset the board to start a new scan.

### 3.5.3 Dual radio chat

This application allows message exchange between mobile devices and an S2-LP node via the BLE-Sub1 GHz bridge.

The Bluetooth part exposes a single chat service with the following (20-byte max.) characteristics:

- **TX characteristic** through which the client can enable notifications; when the server has data to be sent, it sends notifications with the value of the TX characteristic. The data coming from the S2-LP is received in a continuous stream.
- **RX characteristic** (writable); when the client (mobile device) has data to be sent to the server, it writes a value in this characteristic, which forwards it on to the S2-LP.

#### Table 3. S2-LP radio configuration

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>868 MHz</td>
</tr>
<tr>
<td>Modulation</td>
<td>2-FSK</td>
</tr>
<tr>
<td>Datarate</td>
<td>38.4 kbps</td>
</tr>
<tr>
<td>F. Dev.</td>
<td>20 kHz</td>
</tr>
<tr>
<td>Ch. Filter</td>
<td>100 kHz</td>
</tr>
</tbody>
</table>

#### Table 4. S2-LP packet configuration

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Packet type</td>
<td>BASIC</td>
</tr>
</tbody>
</table>
### Parameter Configuration

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preamble length</td>
<td>4 bytes</td>
</tr>
<tr>
<td>SYNC</td>
<td>0x88888888</td>
</tr>
<tr>
<td>Whitening</td>
<td>Enabled</td>
</tr>
<tr>
<td>FEC</td>
<td>Disabled</td>
</tr>
<tr>
<td>CRC</td>
<td>0x07 (1 byte)</td>
</tr>
<tr>
<td>Length mode</td>
<td>Variable (2 bytes)</td>
</tr>
</tbody>
</table>

This is the same default configuration used by the S2-LP DK GUI, so it is possible to transmit packets through the GUI and receive them with this application.

The B-BLE application can run on your mobile client device to send and receive messages; you can use any similar generic app able to discover the characteristic and enable notification writing and reception.

#### 3.5.3.1 Communicating between the BLE-Sub1 GHz node and a mobile device

This procedure connects your mobile to the BLE-Sub1GHz node.

**Step 1.** Run the B-BLE app  
**Step 2.** Select the BlueNRG1_DualRadio device  
**Step 3.** Scroll down to explore the service (0x87E0D280) and the TX (0x87E0D281) and RX (0x87E0D282) characteristics.

![Figure 20. BlueNRG1_DualRadio service and characteristics](image)

**Step 4.** Select the 0x87E0D281 characteristic  
Select this characteristic to transmit a message from the S2-LP to the mobile device  
A new page for the characteristic opens

**Step 5.** Click NOTIFY on the new page  
**Step 6.** Run the S2-LP GUI and connect to a STEVAL-FKI868V2 or STEVAL-FKI915V1 kit  
**Step 7.** Go to the TX tab, write a message and click on the START button  
The app displays the message on your phone.
Step 8. Return to the B-BLE app page listing the BlueNRG1_DualRadio service and characteristics
Step 9. Select the 0x87E0D282 characteristic
Select this characteristic to transmit a message from your mobile device to the S2-LP.
Step 10. click WRITE on the new page
Step 11. Open the S2-LP GUI and go to the RX TAB
Step 12. Zero out the RX timeout and press the START button
Step 13. Select the Text Format, type a message in the Write Data field and click on the SEND button
The message is visible on the S2-LP GUI.

3.5.4 S2-LP communication
This simple application shows how to perform transmission and reception by driving the S2-LP with the BlueNRG-1/2 as a core.
It does not use the BLE stack as its only purpose is to demonstrate simple S2-LP management to exchange packets. The S2-LP library is used to configure and to manage the S2-LP.

**Table 5. S2-LP radio configuration**

<table>
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<tr>
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</thead>
<tbody>
<tr>
<td>Frequency</td>
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</tr>
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</table>

**Table 6. S2-LP packet configuration**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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</thead>
<tbody>
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<td>Packet type</td>
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<td>CRC</td>
<td>0x07 (1 byte)</td>
</tr>
<tr>
<td>Length mode</td>
<td>Variable (2 bytes)</td>
</tr>
</tbody>
</table>

The node is set to continuous RX, with each received packet payload printed directly to the serial terminal. When the PUSH BUTTON 2 (SW1 for the FKI001V1) is pressed, a packet is transmitted by the device and the RX state is recovered to prepare for the next reception.

The configuration is the same as the default S2-LP DK GUI configuration, so you can transmit packets via the GUI and receive them in this application.

**Figure 23. Receive at the node**

Similarly, you can transmit packets from the application and receive them via the GUI.
Figure 24. Transmit to the node
All of the listed resources are available on www.st.com

2. User Manual UM2149 - Getting started with the S2-LP Kit
3. User Manual UM2169 - Getting started with the S2-LP SigFox Kit
4. User Manual UM2173 - Getting started with the S2-LP SigFox firmware
## Revision history

<table>
<thead>
<tr>
<th>Date</th>
<th>Version</th>
<th>Changes</th>
</tr>
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<tr>
<td>02-May-2017</td>
<td>1</td>
<td>Initial release.</td>
</tr>
<tr>
<td>12-Nov-2018</td>
<td>2</td>
<td>Updated references to BlueNRG-1/2 throughout the document.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Added Figure 2. STEVAL-IDB008V2 board.</td>
</tr>
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<td></td>
<td></td>
<td>Added Section 1.2.3 ST Sigfox Monarch reference design.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Updated Figure 8. BLE-Sub1 GHz navigator, Figure 9. BLE-Sigfox sensor demo application window, Figure 10. BLE-Sigfox sensor demo application flashing, Figure 12. STEVAL-IDB007V2/DB008V2 plus KI868V1 kit components, Figure 19. Dual radio chat block diagram.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Minor text changes.</td>
</tr>
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