# nRF51822 *Bluetooth*® Smart Beacon Kit

nRF51822-BEACON

## User Guide v1.1

## Revision history

| Date | Version | Description |
|---|---|---|
| September 2014 | 1.1 | **Updated:**<br>*Table 4 "P2 interface connector"* on page 25.<br>*Figure 24 "PCA20006 schematic"* on page 22 |
| April 2014 | 1.0 | First release. |

# 1    Introduction

The nRF51822 *Bluetooth*® Smart Beacon Kit is a reference design that lets you explore the full range of development possibilities for beacons using *Bluetooth* Smart technology. It consists of a complete hardware and software solution that when used with our nRF Beacon App (available for both iOS and Android) gives you everything required for designing a comprehensive beacon system.

The kit can be used for developing beacons that follow Apple's iBeacon specification and also for developing other proprietary beacons. The kit has two buttons which can be programmed to enable easy switching between modes and/or functionality, as well as a 3-color LED which can be configured for different indication behavior patterns. Ten GPIOs are available for expansion and the kit can be connected to an external programmer/debugger during development work. The nRF51822 *Bluetooth* Smart Beacon Kit also supports complete Over-The-Air (OTA) Device Firmware Upgrade (DFU) of the application on the nRF51822 chip.

## 1.1    Minimum requirements

A mobile phone with *Bluetooth* 4.0 support is needed as well as the nRF Beacon app.

- For Android devices, Android version 4.3 or later.
- For iOS devices, iPhone 4S or later with iOS version 7.0 or later.

## 1.2    Resources

The nRF51822 *Bluetooth* Smart Beacon Kit includes documentation, hardware schematics, layout files, and source code. To access these files, log in to your My Page account and enter the nRF51822 *Bluetooth* Smart Beacon Kit product key (found on the nRF51822 *Bluetooth* Smart Beacon Kit package) to download the files.

Below is a list of the additional files available with the Beacon Kit.

| Resource | Description |
|---|---|
| nRF51822 *Bluetooth* Smart Beacon Kit Hardware Files | The Beacon Kit includes hardware schematics and layout files. Included are the following files:<br>• Altium Designer files<br>• Schematics<br>• PCB layout files<br>• Production files<br>    • Assembly drawings<br>    • Drill files<br>    • Gerber files<br>    • Pick and Place files<br>    • Bill of Materials |
| nRF51822 *Bluetooth* Smart Beacon Firmware | The firmware documentation is available in a folder on your computer after you run the installer file. Here you can find information regarding hardware and SoftDevice version compatibility. The following files are included:<br>• Firmware documentation<br>• Firmware for nRF51822 Bluetooth Smart Beacon module<br>• Precompiled HEX files<br>• Source code<br>• Keil ARM® project files |
| Source code | The nRFBeacon source code is available for both the Android and iOS app. |

## 2 Kit content

In addition to hardware, the Beacon Reference Design consists of firmware, source code, hardware schematics, and layout files which are available from www.nordicsemi.com. See cross ref



***Figure 1*** *nRF51822 Bluetooth Smart Beacon Kit contents*

# 3 Getting started

This section shows you how to set up the nRF51822 *Bluetooth* Smart Beacon Kit and run the mobile app example.

## 3.1 Download and install the mobile app

**Android**

Go to Google Play and download the nRF Beacon app.

**iOS**

The app is not currently available on iTunes. To use the app, download and compile the source code provided.

1. Download and unzip **nRFBeacons_iOS.zip**.
2. Open **nRFBeacons.xcodeproj** in XCode IDE.
3. Compile and upload the app to your iOS device.

## 3.2 Prepare the hardware

1. Unpack your nRF51822 *Bluetooth* Smart Beacon Kit.
2. Insert the CR1632 battery. The LED should now be lit purple, indicating that it is in beacon mode.
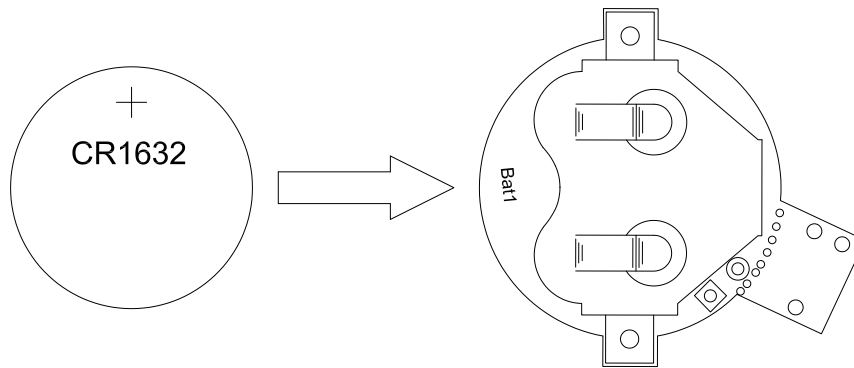


**Figure 2**  *Insert battery*

3. Open the app and begin adding a new beacon. For more detailed information regarding the Android app, please see *Chapter 4.2 "nRF Beacon app for Android"* on page 7. For information on the iOS app, please see *Chapter 4.3 "nRF Beacon app for iOS"* on page 15.
4. Set your device in close proximity to the beacon. After a few seconds, the device should detect the new beacon.

# 4      System overview

This chapter describes the functionality of the nRF51822 *Bluetooth* Smart Beacon Kit. The default behavior of the beacon is simple in that it is a non-connectable device that only sends out advertising packets. Because the amount of data in an advertising packet is limited, the information provided by a beacon is only an ID with the information of interest coming from elsewhere. The beacon sends data which is received by a dedicated mobile app. The app interprets the beacon ID and fetches the correct information from a database which is displayed to the user.
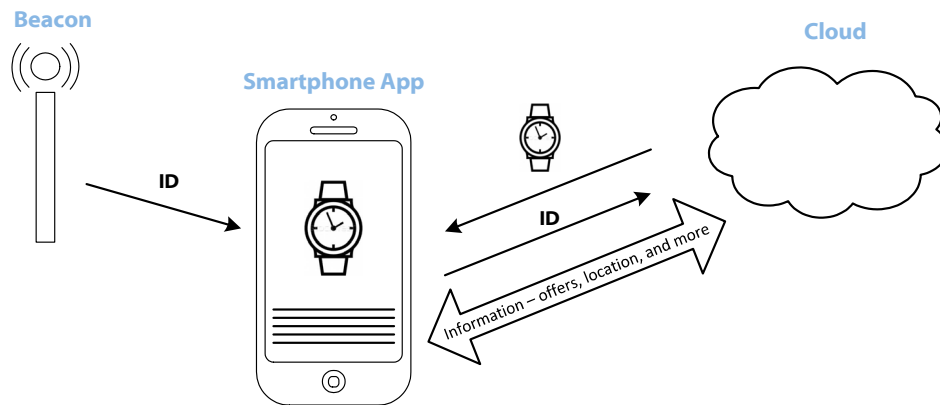


***Figure 3***  *Bluetooth Smart Beacon system overview*

## 4.1      Standard operation

By default, the firmware is in beacon mode where the beacon advertises in a certain interval. To indicate that the beacon is in standard operation mode, the LED on the beacon will blink purple. Please see the firmware documentation for more information.

### 4.1.1         Beacon advertising packet

The beacon advertising packet consists of the following seven data fields:

- Vendor ID
- Service
- Data payload size in bytes
- UUID – manufacturer specific data
- Major value
- Minor value
- Output power

## 4.2 nRF Beacon app for Android

The nRF Beacon application is available for download in the Google Play store online. The app provides functionality for scanning, ranging, and configuring beacons. While the app works with beacons from any manufacturer, the Configuration Mode is available only on the Nordic Beacon provided in this kit because it's preloaded with firmware from Nordic Semiconductor. The app has two main features: Beacons and Update.

### 4.2.1 BEACONS tab

The Beacons feature is found under the **BEACONS** tab. Here you can scan for beacons and see a list of the active beacons within range. Initially the list of beacons is empty. You must tap **+** to add a new beacon.
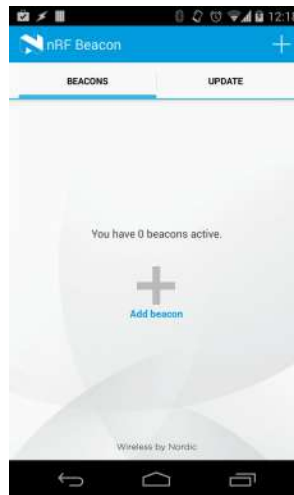


***Figure 4*** *Beacons tab*

After tapping **+**, a window will pop up showing that the application is scanning for beacons in the immediate (close) area. To add a beacon, place the phone close to the beacon for two to three seconds until it is added in the app. The scanning mode can be used to add more beacons or to edit the configuration of previously added beacons.
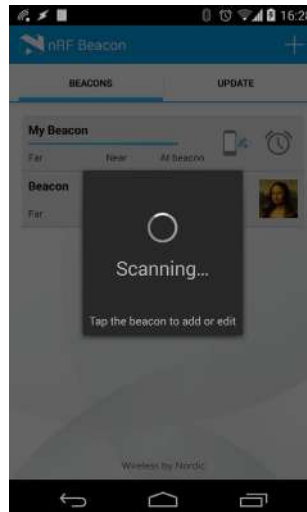


***Figure 5*** *Scanning for Beacons*

When the scanner detects a beacon in the immediate area, you will be taken to the customization screen where you can set a name, assign an action, and select the event that is triggered when the beacon is in range.

At the top of the screen the application shows the parameters of the beacons: service UUID, major, and minor numbers. These values are obtained from the beacon and may not be altered. You can modify the name, event, action, or the action parameter (if appropriate) by tapping on it. The default name given to a new beacon is "nRF Beacon".



**Figure 6**  *Beacon customization screen*

You can choose from the following four events:

- **Out of range** – the action is triggered when the phone leaves the area defined by the beacon for more than approximately 20 seconds.
- **In range** – the action is triggered when the phone detects a beacon in the defined area. The action will not be triggered if the device was already in the area when scanning began. You must enter the region after scanning for at least 4 seconds with no beacon signal received.
- **Near** – the action is triggered when the phone is approximately one to two meters from the beacon and moving in the direction of the beacon.
- **At beacon** – the action is triggered when the phone gets very close to the beacon. The real distance depends on the device that is being used, the beacon, and the phone's orientation.

When using **In range** and **Out of range** events, do not navigate to other views. Switching to the UPDATE tab or editing the beacon configuration will stop the ranging and when started again, the action will not be triggered.
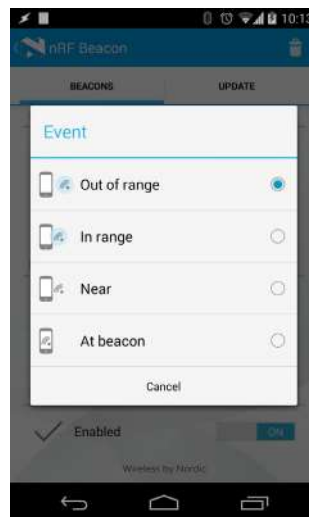


**Figure 7**  *Events*

There are five actions to choose from, all of which are configurable.

- **Show Mona Lisa** – this action opens a short description about the Mona Lisa painting. It can be used to demonstrate the most common use case for beacons – to show information or a personalized offer about the product a user is close to.
- **Open website** – opens a URL in your browser. The URL may be configured after selecting this action.
- **Open application** – any application installed on your phone can be opened. You can select which application after selecting this action.
- **Play alarm** – the alarm is played. Check the alarm volume settings to make sure it's loud enough.
- **Silence phone** – this action mutes the ringer and notification volume on the phone. This is useful for meeting rooms, libraries, museums, cinemas, and so on where people are asked to disable sound on their phone.

Tapping the back icon or the arrow at the left-top corner of the screen saves the settings and navigates to the main screen where the application monitors for saved regions.
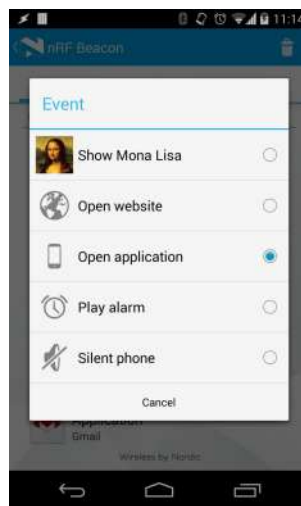


***Figure 8*** *Action configuration*
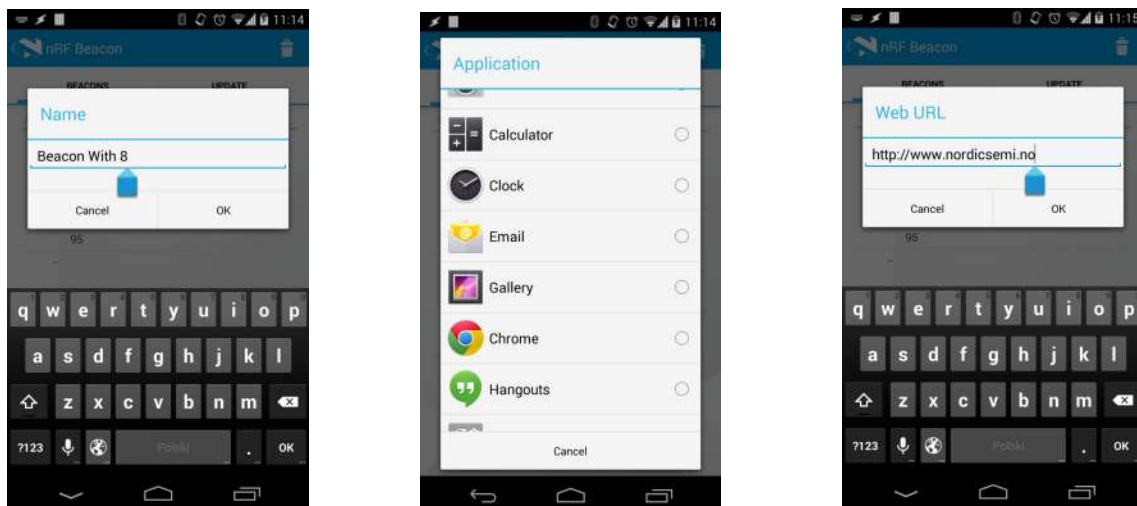


***Figure 9*** *Action configuration*

The blue bar indicates the relative distance to the beacon. The bar is hidden if no packets are received from the beacon in the last three seconds or if the beacon signal is very weak.



**Figure 10**  *Beacon monitoring*

Scanning for beacons consumes a lot of battery. The app only scans for beacons when you are on the BEACONS monitoring screen, as seen in **Figure 10**. The device will stop scanning and events will not be triggered when you go to a beacon configuration screen or are in UPDATE. The device's notification bar shows when the app is scanning.
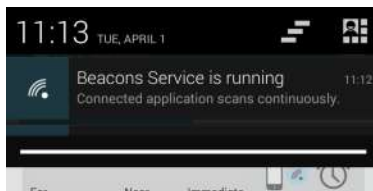


**Figure 11**  *Notification bar*

## 4.2.2    UPDATE tab

The Nordic beacon firmware provides two ways to configure the beacons: Config Mode and DFU. Config Mode allows you to modify the beacon's service UUID, major number, minor number, or the calibrated RSSI at one meter distance from the beacon. DFU mode is used to send updates to the beacon device that may contain more sophisticated changes like different advertising intervals, LED schemes, and so on.

The UPDATE tab allows you to communicate with a beacon in the Config Mode. The nRF51822 *Bluetooth* Smart Beacon module can be set in a configuration mode where it is possible to connect to the device and update some of the parameters in the advertising packet.

To enter configuration mode, press the SW2 button on the beacon module. The beacon module will now start to advertise and be connectable. The module will indicate configuration mode with a blinking yellow color on the LED.

Connect to the device and do service discovery. Now the following parameters can be updated:

| Parameter | Action |
|---|---|
| Major and minor values | Write 4 bytes to characteristic with UUID 0x1526. First two bytes are the major and last two bytes are the minor. |
| RSSI at 1 m | Write 1 byte to characteristic with UUID 0x1525. |
| Beacon UUID | Write 16 bytes to characteristic with UUID 0x1524. (default: 01-12-23-34-45-56-67-78-89-9A-AB-BC-CD-DE-EF-F0) |

*Table 1* Config Mode parameters

When you are in UPDATE, the screen will look like **Figure 12**. Tapping the Info icon displays information on how to enter the Config Mode on the beacon in order to connect with it.
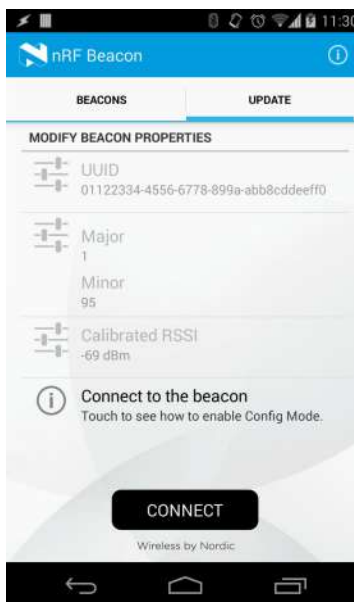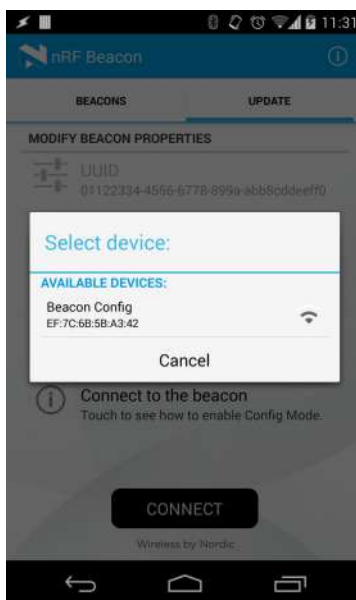


**Figure 12**  Configure mode

**Figure 13**  *Information*

Tapping CONNECT starts a search for beacons advertising with the 128-bit UUID:

- 955A1523-0FE2-F5AA-0A094-84B8D4F3E8AD

Detected beacons in the Config Mode will be shown in the scanner window. Selecting a row will establish a connection.



**Figure 14**  *Search for advertising beacons*

The current UUID, major number, minor number, and calibrated RSSI will be shown on the screen. Here you can change the value for each parameter by tapping on it. You can also modify the calibrated RSSI value.

Before transmitting to the beacon, all values will be verified by the application to match required range and pattern.
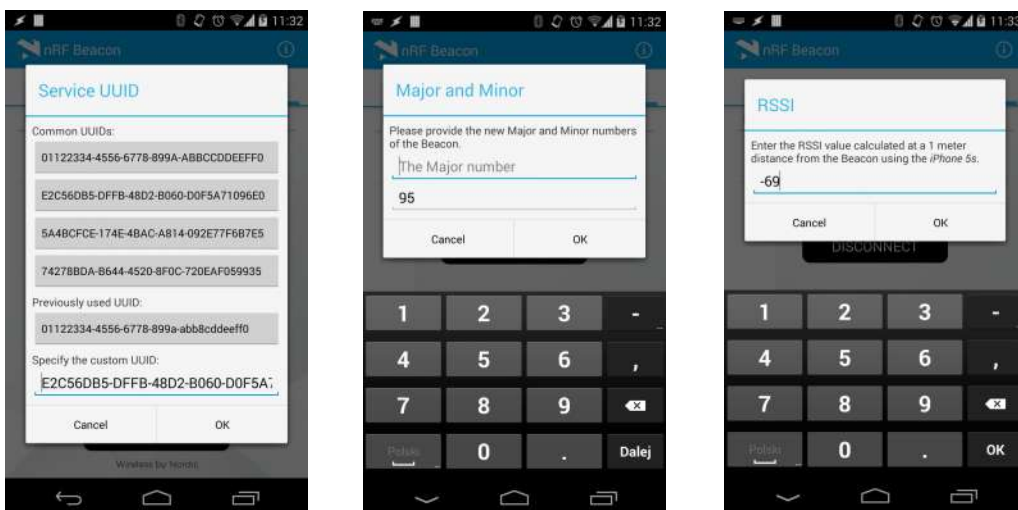


**Figure 15**  *Modify Beacon properties*



**Figure 16**  *Beacon properties*

The DFU mode is not supported by the application in the current version. The functionality, however, is available through other Nordic apps including nRF Toolbox or nRF Master Control Panel on Android, all available for free in Google Play.

To put the device in DFU mode, press the **SW1** button on the beacon module. The beacon module will now start to advertise and be connectable. The module indicates it's in DFU mode when the LED is green. When in DFU mode the firmware in the application space of the device can updated.

## 4.3      nRF Beacon app for iOS

The nRF Beacon application is available for download from the Apple iTunes store online. The app provides functionality for scanning, ranging, and configuring beacons. The nRF Beacon app for iOS has two main features: Beacon and Update. You can toggle between these functions by using the icons at the bottom of the app screen.
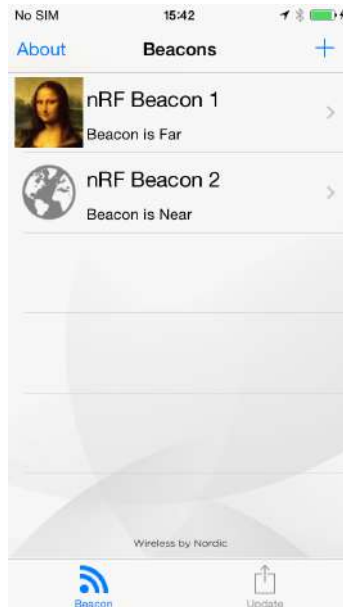


**Figure 17**  *Beacon monitoring*

### 4.3.1       Beacon tab

The Beacons feature is found under the **Beacons** tab. Here you can scan for beacons and see a list of the active beacons within range. Initially the list of beacons is empty. You must tap **+** in the top right of the app screen to add a new beacon.

After tapping **+**, a window will pop up showing that the application is scanning for beacons in the immediate (close) area. To add a beacon, place the phone close to the beacon for two to three seconds until it is added in the app. The scanning mode can be used to add more beacons or to edit the configuration of previously added beacons.

Once a beacon has been added, it is assigned one of four available UUIDs and given a name. You can change the Beacon's default configuration. However, it is important that the UUID, Major, and Minor values for a newly added Beacon are correct. For Beacons from Nordic Semiconductor you can get the UUID, Major and Minor values by using the **Update** tab.

The app can apply the following features to the nRF Beacons:

- **Name:** By default newly added Beacons are given the name "nRF Beacon" but this can be changed in **Configuration**.
- **UUIDs:** There are four available UUIDs that can be assigned to beacons. This means the app can monitor up to four beacons, as long as they all are given a UUID.
- **Major and minor values:** You can add major and minor values to your beacons to help micro-locate them. You can add a value between 0 - 65535 for both major and minor values.
- **Events:** There are four events on the app that can be used. They cannot be used concurrently. To define the specific range of an event requires the RSSI value on the beacon to be properly calibrated. You can choose from the following four events:
  - **Out of range** – the action is triggered when the phone leaves the area defined by the beacon (max range is between 10 to 15 meters) for more than approximately 20 seconds.
  - **In range** – the action is triggered when the phone detects a beacon entering the defined area (max range is between 10 to 15 meters). The action will not be triggered if the device was already in the area when scanning began. You must enter the region after scanning for at least 4 seconds with no beacon signal received.
  - **Near** – the action is triggered when the phone is less than one meter to a few centimeters from the beacon and moving in the direction of the beacon.
  - **At beacon** – the action is triggered when the phone gets within a few centimeters to the beacon. The real distance depends on the device that is being used, the beacon, and the phone's orientation.

There are three actions to choose from, all of which are configurable.

- **Show Mona Lisa** – this action opens a short description about the Mona Lisa painting. It can be used to demonstrate the most common use case for beacons – to show information or a personalized offer about the product a user is close to.
- **Open website** – opens a URL in your browser. The URL may be configured after selecting this action.
- **Play alarm** – the alarm is played. Check the alarm volume settings to make sure it's loud enough.

It is also possible to stop scanning for beacons by turning off the Enable switch in the Configuration view. It is also possible to delete any existing beacons on your app by tapping the trash icon at the top of the Configuration view.
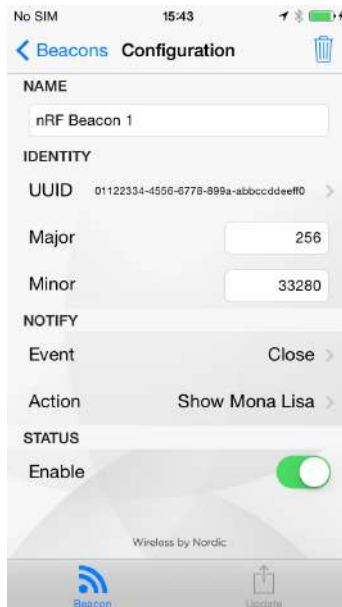


**Figure 18** *Configuration*

### 4.3.2 Update tab

The Nordic beacon firmware provides two ways to configure the beacons: Config Mode and DFU. Config Mode allows you to modify the beacon's service UUID, major number, minor number, or the calibrated RSSI at one meter distance from the beacon. DFU mode is used to send updates to the beacon device that may contain more sophisticated changes like different advertising intervals, LED schemes, and so on.

The Update tab allows you to communicate with a beacon in the Config Mode. The nRF51822 *Bluetooth* Smart Beacon module can be set in a configuration mode where it is possible to connect to the device and update some of the parameters in the advertising packet. To enter configuration mode, press the SW2 button on the beacon module. The beacon module will now start to advertise and be connectable. The module will indicate configuration mode with a blinking yellow color on the LED.

Connect to the device and do service discovery. Now the following parameters can be updated:

| Parameter | Action |
|---|---|
| Major and minor values | Write 4 bytes to characteristic with UUID 0x1526. First two bytes are the major and last two bytes are the minor. |
| RSSI at 1 m | Write 1 byte to characteristic with UUID 0x1525. |
| Beacon UUID | Write 16 bytes to characteristic with UUID 0x1524. (default: 01-12-23-34-45-56-67-78-89-9A-AB-BC-CD-DE-EF-F0) |

**Table 2** *Config Mode parameters*

After the parameters have been updated, disconnect from the beacon module, and it will enter normal beacon mode.

To start updating firmware on your Nordic Beacon device you must first switch the beacon to Beacon Configuration mode. After the app connects to the beacon the beacon's UUID, Major, Minor, and Calibrated RSSI values are shown in the Update tab.
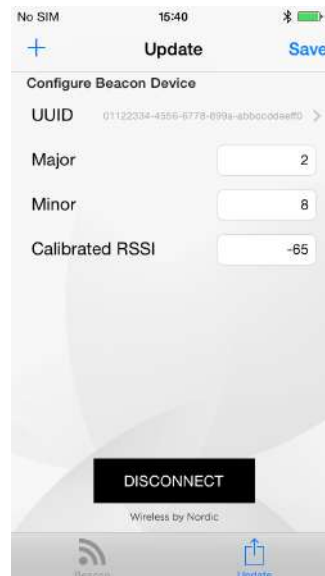


**Figure 19** *Update*

You can change these values and save updated values by tapping **Save** on top right of the app. You can also add the beacon to the app by tapping **+** on the top left of the app. After you have made your changes you can tap **DISCONNECT** and go to the **Beacon** tab. In the **Beacon** tab, you will see the newly added/updated beacon with its UUID, Major, and Minor values.

The nRF Beacons app assigns default configuration values for newly added beacons. However, if new beacons are added from the **Update** tab, then the UUID, Major, and Minor values will be taken from there instead.

The default values assigned to a beacon are:

- **Name:** nRF Beacon
- **UUID:** 01122334-4556-6778-899A-ABBCCDDEEFF0
- **Major:** 0
- **Minor:** 0
- **Event:** Close
- **Action:** Show Mona Lisa
- **Enable:** YES
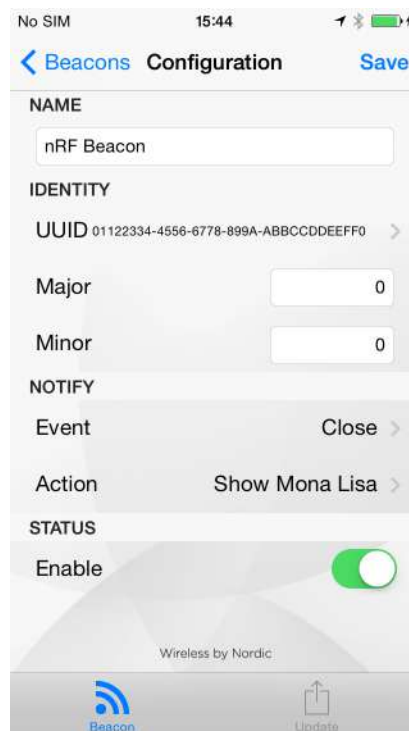


**Figure 20** *Default configuration values*

The DFU mode is not supported by the application in the current version. The functionality, however, is available through the nRF Toolbox app, available for free from the iTunes store.

To put the device in DFU mode, press the **SW1** button on the beacon module. The beacon module will now start to advertise and be connectable. The module indicates it's in DFU mode when the LED is green. When in DFU mode the firmware in the application space of the device can updated.

# 5 Hardware description

The nRF51822 *Bluetooth*® Smart Beacon module (PCA20006) is a compact battery powered design the size of a coin cell battery. The module is *Bluetooth* low energy (BLE) enabled with an nRF51822 chip and includes two buttons, an RGB LED, and a programming interface for firmware updates.
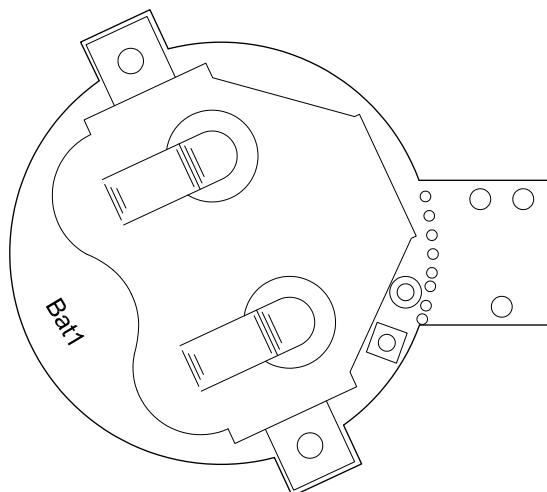
## 5.1 Key features

The Beacon module has the following key features:

- nRF51822 System on Chip (SoC)
  - *Bluetooth* low energy compatible
  - 2.4 GHz compatible with nRF24L devices
- Two buttons and a RGB LED for user interaction
- SWD programming and debugging interface
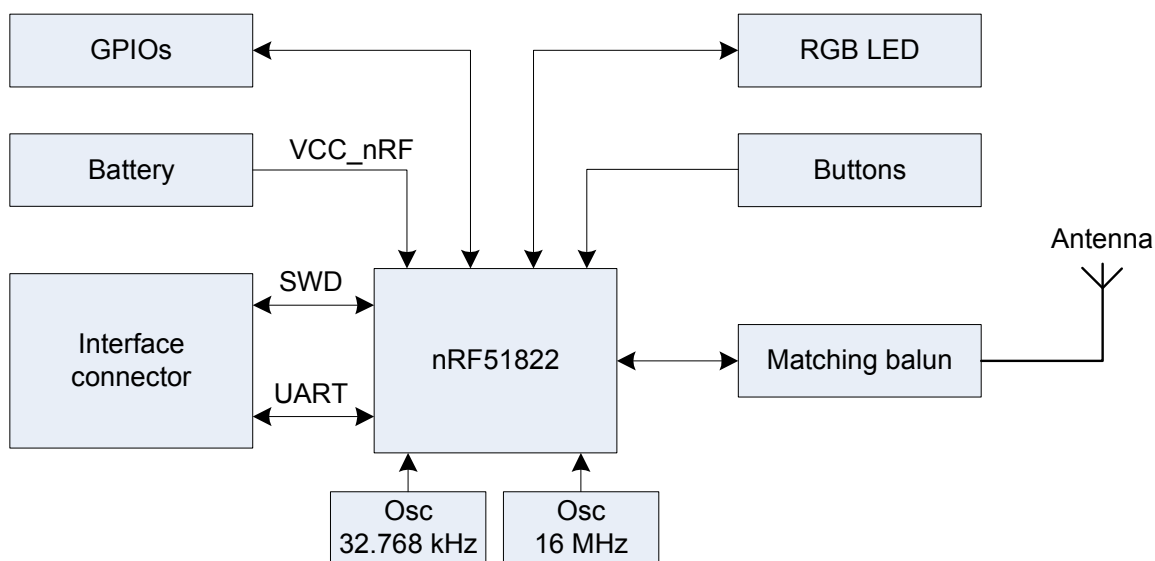- Ten GPIOs available on pads for connecting custom hardware

## 5.2 Hardware figures
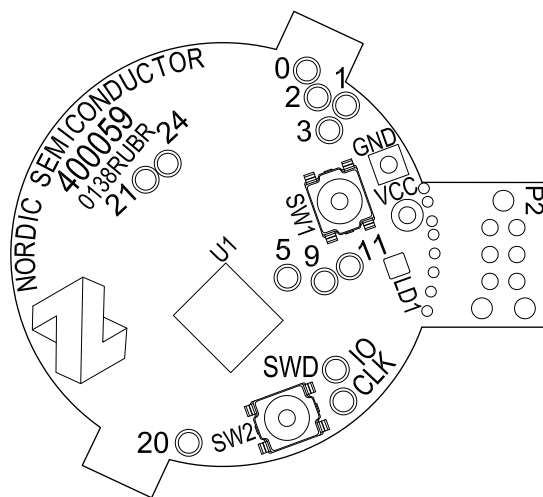


***Figure 21*** *PCA20006 top view*

*Figure 22* PCA20006 bottom view

## 5.3 Block diagram



*Figure 23* PCA20006 block diagram
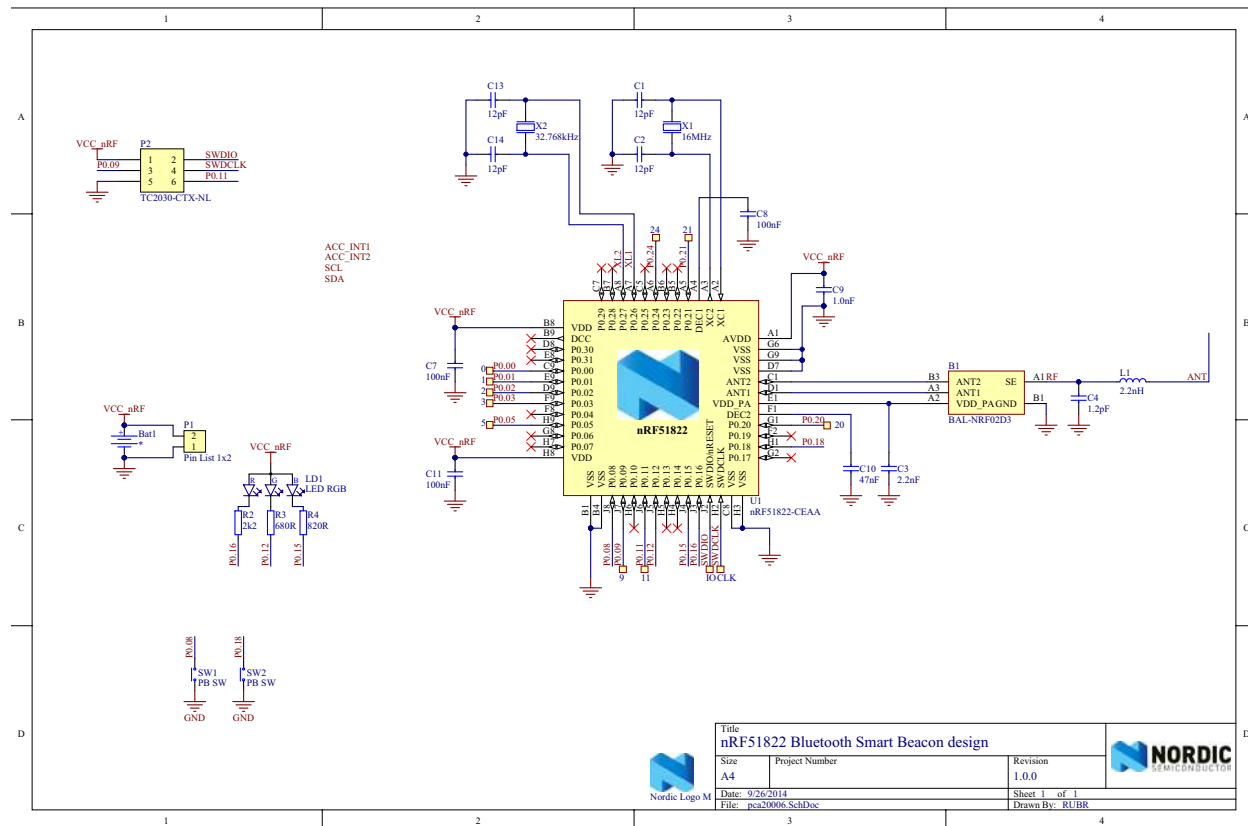
## 5.4    Schematic



**Figure 24**  *PCA20006 schematic*

## 5.5 Design description

### 5.5.1 Buttons and LED

The Beacon module features two tactile buttons with active low functionality and an RGB LED. Each color of the LED is sinked through a current limiting resistor. See **Table 3** for GPIO connection and **Figure 25** for the circuit diagram.

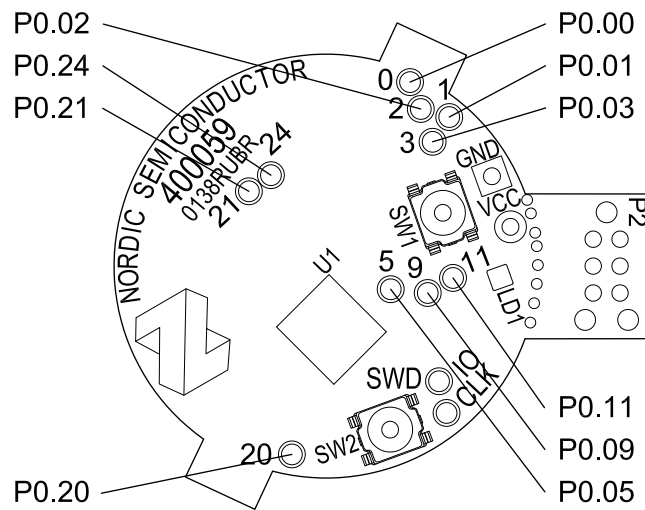| Component | nRF51822 pin number |
|---|---|
| LD1 (Red) | P0.16 |
| LD1 (Green) | P0.12 |
| LD1 (Blue) | P0.15 |
| SW1 | P0.08 |
| SW2 | P0.18 |

**Table 3** *LED and button GPIO connection*
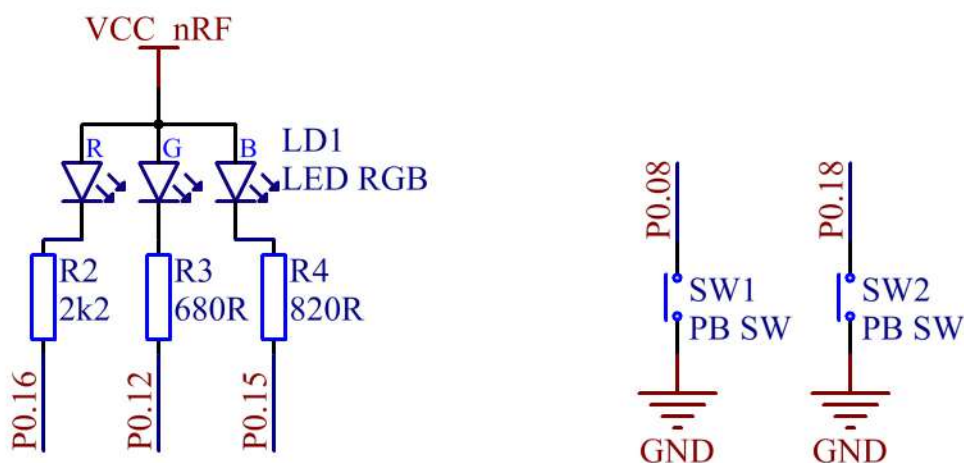


**Figure 25**  *Circuit diagram*

### 5.5.2 GPIO accessibility

The Beacon module has ten available GPIOs for interfacing with custom hardware. The GPIOs are located on test pads as shown in **Figure 26**.



**Figure 26** *GPIO accessibility*

### 5.5.3 Power supply

The Beacon module holds a CR1632 cell battery that mounts on the bottom layer of the module. The connection points VCC and GND are available for utilizing an external power source, see **Figure 27**. They can be used instead of a battery to power external components from the CR1632 cell on the module or supply the board from an external power source.

> **Note:** Do not connect an external source when using a battery.
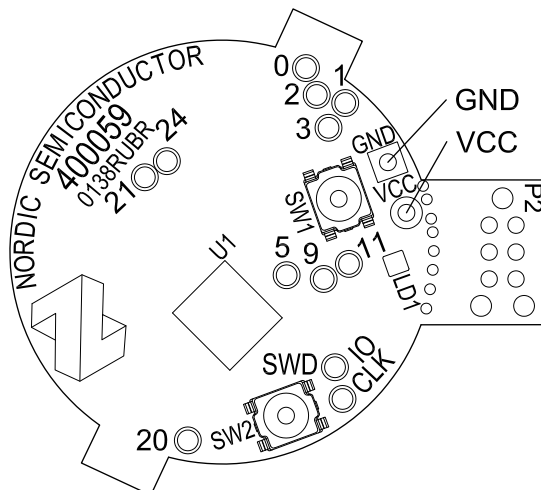


**Figure 27** *External power supply*

### 5.5.4        Programming interface

The Beacon module has a break-off tab with a TC2030 connector footprint from Tag Connect. TC2030 has connectors for the SWD programming interface and two GPIOs available for UART during debugging. *Table 4* shows the pinout of the connector.

| Pin number | Function |
|:---:|:---:|
| 1 | VCC |
| 2 | SWDIO |
| 3 | P0.09 |
| 4 | SWDCLK |
| 5 | GND |
| 6 | P0.11 |

***Table 4*** *P2 interface connector*



***Figure 28***  *TC2030 connector*

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