TI Designs
Bluetooth® Low Energy (BLE) Beacons Reference Design

Description

This TI Design contains a description of *Bluetooth*® low energy beacons and implementations of three different beacon standards. These projects demonstrate how both connectable and non-connectable beacons can be used for various applications, such as asset tracking and location services. The transfer of data can be accomplished with very little power consumption by using these beacon implementations.

Resources

TIDC-Bluetooth-Low-Energy-Beacon	Design Folder
CC2640	Product Folder
CC2650	Product Folder
BLE-Stack	Tools Folder

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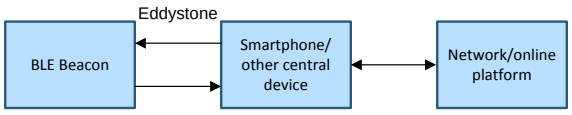
Features

- Runs on SimpleLink™ Technology *Bluetooth* low energy CC2640 Wireless Microcontroller (MCU)
- Uses TI Royalty-Free BLE-Stack™ Software Development Kit (SDK)
- Easily Runs on CC2650 LaunchPad™
- Offers Generic Projects That can be Modified to Fit Various Applications
- Very Long Battery Life and Excellent Radio Frequency (RF) Range

Applications

- Micro-Location Services
- Asset Tracking and Identification
- Broadcasting Ambient or Sensor Data



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1 System Overview

1.1 System Description

This TI Design includes links to application notes that describe what beacons are, what they can be used for, and how they can be implemented using the Texas Instruments' *Bluetooth* low energy software stack (BLE-Stack) version 2.2. There are also descriptions of beacon implementations that adhere to three different beacon protocols as well as sample projects demonstrating these protocols. These projects are designed to work on the CC2650 *Bluetooth* low energy LaunchPad Development Kit (LAUNCHXL-CC2650) and can easily be ported to work with any CC2640 wireless MCU-based design. Considerations for battery life, detectable range, and size are also discussed in detail.

The *Bluetooth* low energy application report (SWRA475) describes beacons and Apple's iBeacon technology as well as proprietary *Bluetooth* low energy implementation. Implementing a beacon using TI's *Bluetooth* low energy stack is described in detail with explanations of the relevant sections of the protocol stack and what features are specific to beacons. Explanations of the iBeacon and proprietary beacon implementations are provided, and the design and testing processes are discussed.

The Eddystone™ *Bluetooth* smart beacons application report (SWRA491) provides a detailed explanation of the Eddystone beacon protocol and accompanying *Bluetooth* low energy implementation. The Eddystone specifications are discussed, and one potential implementation is provided and described. Ways to test and validate the device are also provided.

1.2 Key System Specifications

Bluetooth low energy beacons can run on any of the CC2640, CC2650, and CC1350 wireless MCU platforms supported by the BLE-Stack. The projects in this TI Design are built on the CC2650 LaunchPad though they could be run on other supported reference designs as well, such as, the CC2650 Microtag. The Microtag is a very compact reference design with on-board sensors, which makes it ideal for compact *Bluetooth* low energy devices including beacons. A Microtag used to implement a beacon will have a much shorter battery life than the LaunchPad because it runs on a coin cell battery and the frequent broadcasting required of beacons will run the battery down. A LaunchPad running on two AA batteries can have a battery life up to almost two years, which makes it an ideal long-term solution to *Bluetooth* low energy beacons.

1.3 Block Diagram

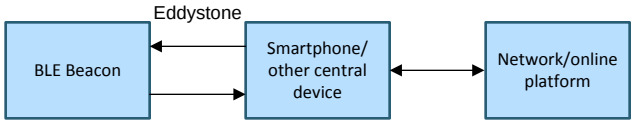

Figure 1. Block Diagram Showing How Beacons Interact With Central Devices

The beacon device sends information to the central or scanning device (commonly a smartphone), and this data can then be sent to and used by other devices and platforms. In the case of non-connectable beacons, such as those implementing iBeacon technology, the central device cannot initiate connections with the beacon and can therefore never send information or data to it. Eddystone beacons, like the one provided here, can enter into a mode in which they are sending connectable advertisements. This mode allows a central device to initiate a connection with the beacon to update it before it goes back to continuing to broadcast information.

2 Getting Started Hardware and Software

2.1 Required Hardware and Software

- CC2650 LaunchPad
- TI BLE Stack V2.2
- Beacon sample project files from the ble_examples Git repository
- Additional requirements, such as integrated development environments (IDEs), are covered in the applicable application notes (SWRA475, SWRA491)

2.2 Installing the Projects

1. Copy the following folders into the appropriate directories in the SDK, depending on which project you want to run.

   Eddystone Beacon:
   ble_examples/examples/cc2650lp/simple_eddystone
   ble_examples/src/examples/simple_eddystone/cc26xx
   ble_examples/src/profiles/EddystoneURLCfg

   iBeacon:
   ble_examples/examples/cc2650lp/simple_beacon
   ble_examples/src/examples/simple_beacon/cc26xx

   Proprietary Beacon:
   ble_examples/examples/cc2650lp/ simple_proprietary_beacon
   ble_examples/src/examples/ simple_proprietary_beacon/cc26xx
2. Use either IAR Embedded Workbench or Code Composer Studio™ (CCS) to build and download the projects to the CC2560 LaunchPad. See the application note for the applicable project and the Software Developer's Guide (SWRU393) for more details.
3. When programmed with the sample application, the device should immediately begin advertising with the specified beacon format. For the Eddystone Beacon project, the buttons can be used to toggle between broadcasting modes, as described in the Eddystone Beacon application note (SWRA491).

3 Testing and Results

All three beacon formats can be tested by using the Texas Instruments' Packet Sniffer to view the data in the advertising packets. These results can be checked against Figure 2, Figure 3, and Figure 4.

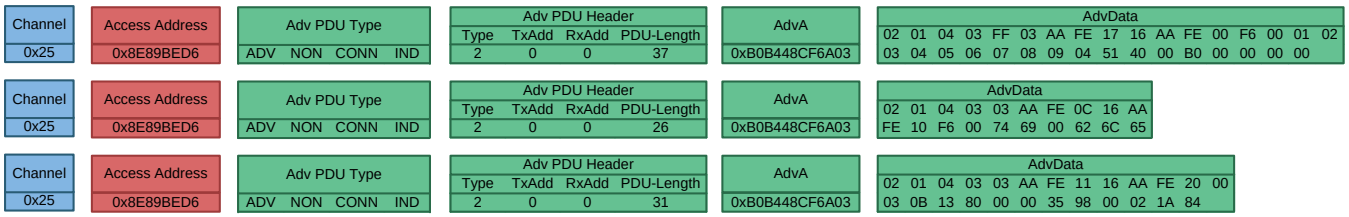

Figure 2. Eddystone UID, URL, and TLM Packets, Respectively

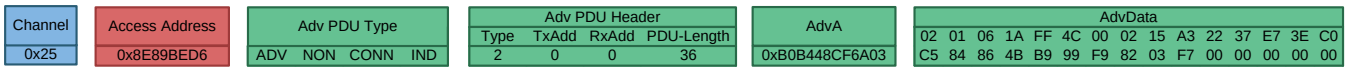

Figure 3. iBeacon Broadcasting Packets

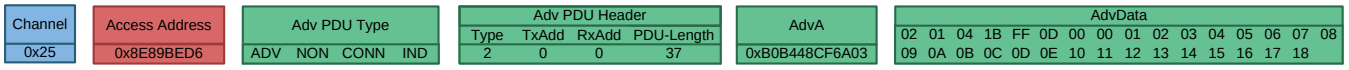

Figure 4. Proprietary Broadcasting Packets

The following steps can be taken to test the data using the packet sniffer:

- Obtain one CC2540 Bluetooth low energy USB dongle.
- Install the SmartRF Flash Programmer and use it to flash the dongle with the image for the packet sniffer.
- Once the desired beacon project has been downloaded onto the LaunchPad, the device should immediately start broadcasting. For the Eddystone beacon project, the buttons can be used to toggle between different broadcasting modes as described in the application note.
- Use the packet sniffer to confirm that the advertised data, broadcasting period, and other factors adhere to the applicable beacon protocol.
- Refer to the TI Packet Sniffer Guide on the TI BLE Wiki for more details.

In addition to using the packet sniffer, there are additional validation tools that can be used to verify all of the features and functions of the Eddystone beacon project. The Eddystone Validator and Eddystone-URL Config Validator can be used to verify the UID, URL, and TLM frames and URL configuration. Figure 5 shows the screenshots of Eddystone Validator and Eddystone-URL Config Validator that have been used to verify SimpleEddystoneBeacon sample application.

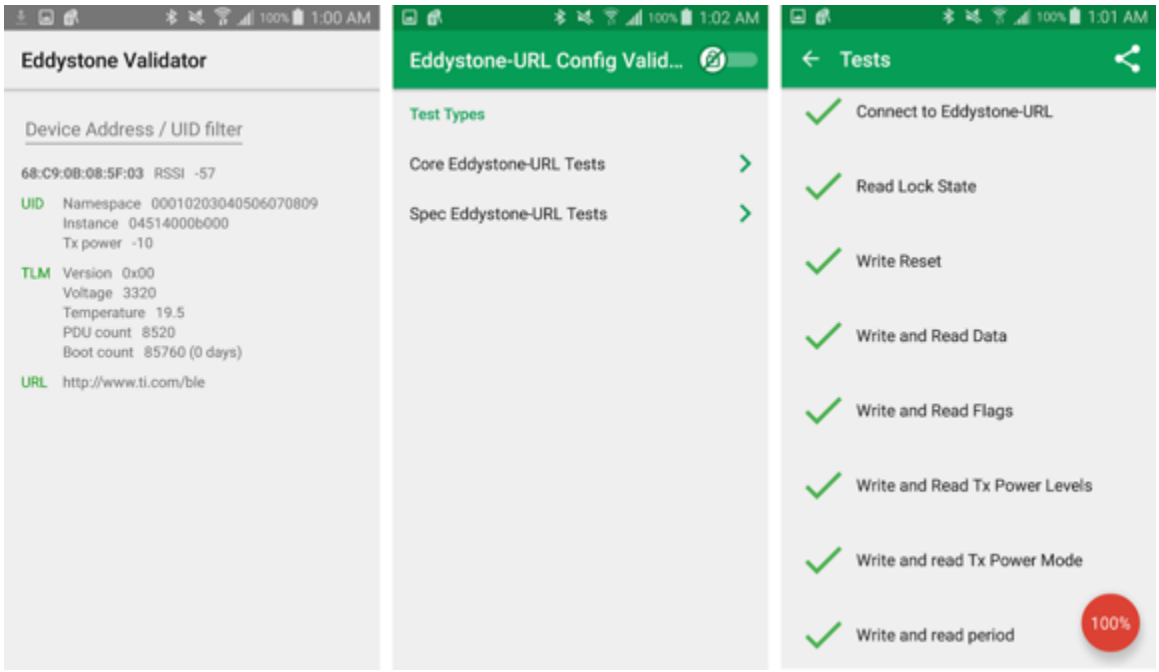

Figure 5. Eddystone Validator and Eddystone-URL Config Validator

Additionally, there are several Android and iOS applications that can be used to test regular advertising mode functionalities of Eddystone-compatible beacons. For example, the Estimote Android App can be used to see how Eddystone-compatible advertising packets are parsed and used by the application as shown in Figure 6. These smartphone applications are not developed or supported by Texas Instruments.

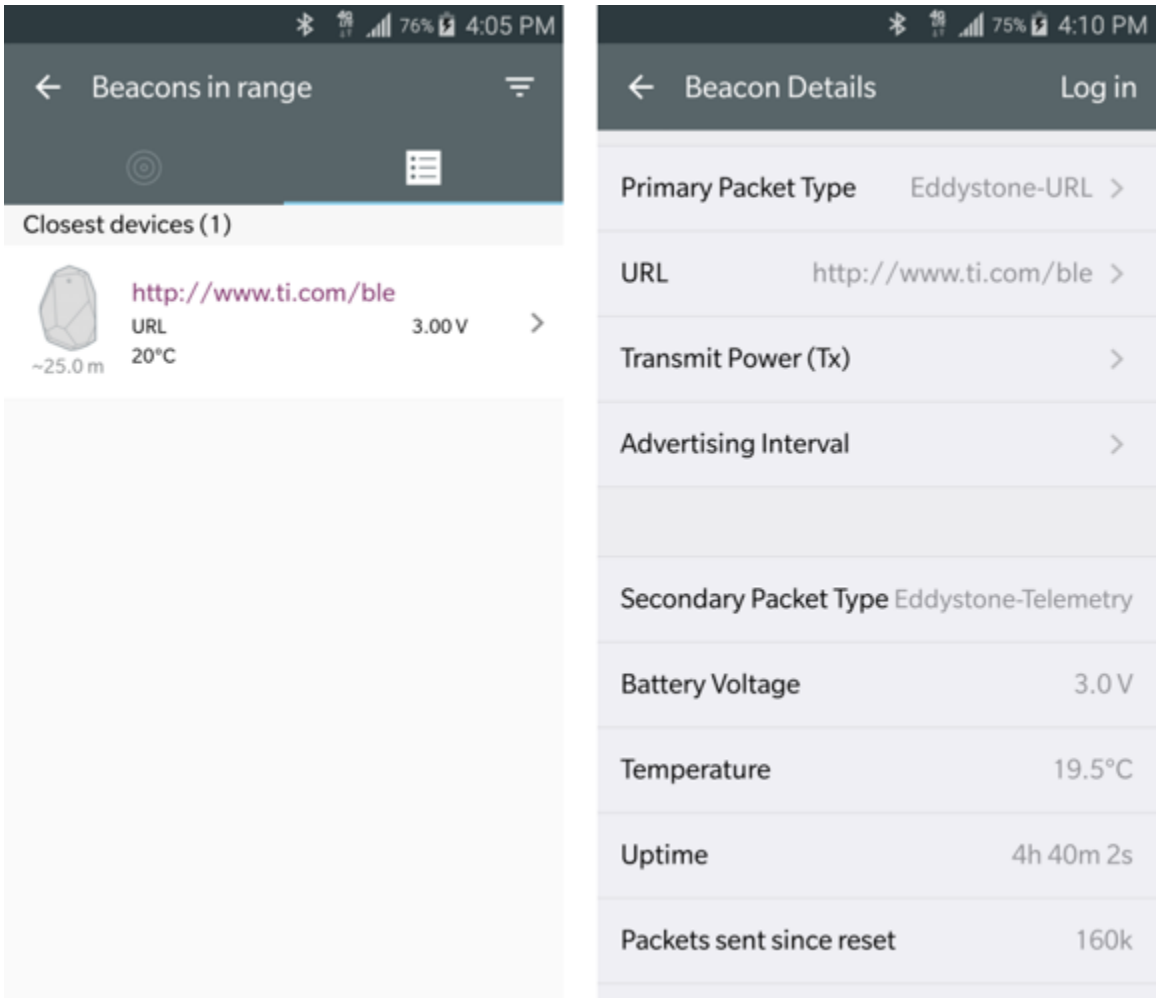

Figure 6. Estimote Android App

4 References

1. Texas Instruments, *BLE Stack V2.2*, Tools Folder (BLE-STACK)
2. Texas Instruments, *CC2650 LaunchPad MCU*, Tools Folder (LAUNCHXL-CC2650)
3. Texas Instruments, *Bluetooth® Low Energy Beacons*, Application Report (SWRA475)
4. Texas Instruments, *Implementing Eddystone™ Bluetooth® Smart Beacons Using the TI BLE-Stack™ Beacons*, Application Report (SWRA491)
5. Texas Instruments, *CC2650 Microtag*, Tools Folder (TIDC-CC2650-UTAG)
6. GitHub, ble_examples GitHub repository (http://www.github.com/ti-simplelink/ble_examples)
7. Texas Instruments, *SimpleLink Bluetooth low energy CC2640 wireless MCU Software Developer's Guide* (SWRU393)
8. Texas Instruments, *SmartRF Protocol Packet Sniffer*, Tools Folder (PACKET-SNIFFER)

5 About the Author

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