Energy Harvesting Bluetooth® Low Energy Switch User Guide

ON Semiconductor®

EVAL BOARD USER'S MANUAL

Overview

The Energy Harvesting Bluetooth Low Energy Switch reference design is battery-free Bluetooth switch based on the RSL10 SIP, the the industry's lowest power Bluetooth 5 radio integrated into a complete System-in-Package (SiP) solution.

The energy harvested from the actuation of the switch using the ZF™ AFIG−0007 generator is sufficient to communicate the switch actuation via Bluetooth Low Energy reliably without the need for any additional battery. With the wide input voltage range of the RSL10 (1.1−3.3 V) no external DC/DC converters are required on the board.

The Bluetooth Low Energy switch is preloaded with energy harvesting sample code that can be demonstrated using standard Beacon mobile applications. This code can be easily customized using the RSL10 Software Development Kit (SDK), including the ability to add or remove functionalities, modify beacon sample code, and more. The Switch is also compatible with the Bluetooth IoT Development Kit (B−IDK) and IoT Development Kits. In that case, the Bluetooth baseboard/shield acts as a receiver of beacon messages from the switch. Designers can use the B−IDK baseboard on its own, or add shield boards to the IDK to incorporate additional sensor and actuator functionalities to the application design at their convenience.

Key System Specifications

- Inductive Generator: The Energy Required for Data Transmission is Created by the Mechanical Actuation of the Switch. Energy Generated: 300 μJ
- Miniature Design Combined with Extremely High Energy Output
- Long Mechanical Life (Minimum 1 million Switch Operations)
- Mono-stable/Momentary Design: Switching Mechanism Returns to Starting Position after Release (Pushbutton)
- (Optional) Bi-stable/Latching Design: Switching Mechanism with Two Rest Positions (e. g., On/Off Switch) Possible by Replacing Generator with ZF AFIG−00010
- Bluetooth 5 Compliant (RSL10 SIP)
- Dimensions: $23.6 \times 23.6 \times 21.2$ mm
- Temperature range: −40 to + 85°C
- No EMC Required due to Low Energy used by the Switch

Software and Tool Resources

- RSL10 Software Development Kit (SDK)
- Energy Harvesting Bluetooth Low Energy Switch Source Code
- *Beacon* Monitoring App (Android™ or IOS®) including Beacon Scanner, Beacon Manager, BLE Scanner, or CZBLEcontrol
- JTAG Programmer (e.g., SEGGER® J−Link™ Ultra+)

More Information

- RSL10 SIP Datasheet
- RSL10 Eddystone Beacon Application Note (AND9710/D)
- Getting Started with RSL10 (AND9697/D)

GETTING STARTED WITH THE ENERGY HARVESTING BLUETOOTH LOW ENERGY SWITCH

Eddystone Beacon Demonstration

The Energy Harvesting Bluetooth Low Energy switch board is preloaded with sample code that demonstrates the capabilities of the energy harvesting solution. After the switch is pressed, advertising packets are sent out every 20 ms until the harvested energy is consumed.
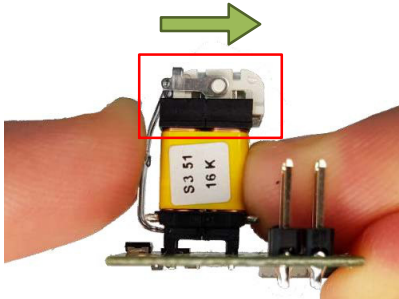

Figure 1. Pressing the Harvesting Switch

With every switch actuation, an Eddystone-URL frame is transmitted. This packet contains a link to www.onsemi.com/idk. The subsequent frames are Eddystone-TLM frames. These contain telemetry data like the supply-voltage, total number of packets sent since the press/release of the button and the associated up time. For more information on using the Eddystone beacon protocol for RSL10, refer to the Eddystone Beacon application note (AND9710/D).

NOTE: When the switch is used without an additional enclosure, it is important to ensure that the white plastic piece on top of the generator can move freely in the direction of the actuation (See Figure 1). If blocked, it can affect performance by reducing the amount of energy harvested.

The transmitted Eddystone-URL and TLM frames can be captured and displayed using a smartphone and one of the available beacon apps (listed above in Software and Tool Resources).
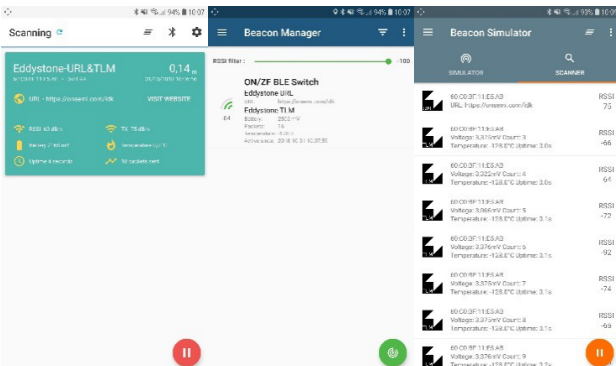
Figure 2. Examples of Beacon Monitoring Apps

The advertising packets sent by the energy harvesting switch can also be received by other Bluetooth Low Energy capable devices. This includes the RSL10 device itself.

Hardware Overview

The Switch device can be used straight out of the box by clicking the harvesting switch (Figure 1). This section describes additional methods to reduce the system form-factor.

Caution: When reducing the size of the device (as described below) certain functionalities of the reference design will no longer be possible (e.g., reprogramming the Bluetooth Low Energy device (see Figures 6 and 7), or using the harvester power source for powering another board (see Figure 12))

Removing of the Boards' Wings and Mounting into an Enclosure

If the smallest possible form factor is desired, the main functional part of the board, consisting of the ZF harvesting switch, energy storage, voltage clamping and the RSL10 System in Package (SiP) can be separated. All of this essential functionality is located on the central section of the evaluation board. The left and right wings of the board only contain mounting holes and the programming interface with programming power connector and a location for mounting different storage capacitors.

Important: The main programming interfaces are located on the wings. Once removed, re-programming is only possible by soldering the programming connections onto the board.

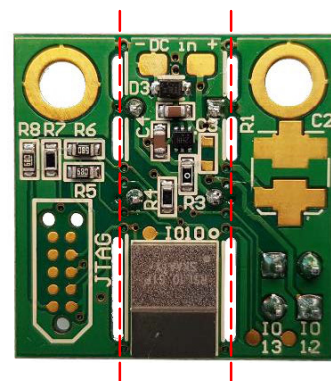The wings can easily be broken off along the axes shown in Figure 3.

Figure 3. Breaking Axes

Depending on the used enclosure, it might be necessary to smoothen the edges after breaking as shown in Figure 4. Figure 5 shows and example of the harvesting switch mounted in an plastic enclosure.
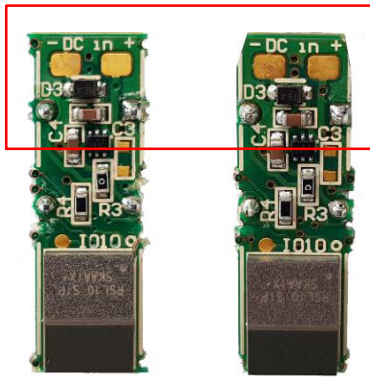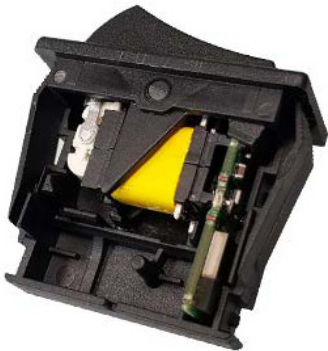
Figure 4. Smoothed and Un-smoothed Edges after Removing the Wings

Figure 5. Rocker Switch with Bluetooth Low Energy Module
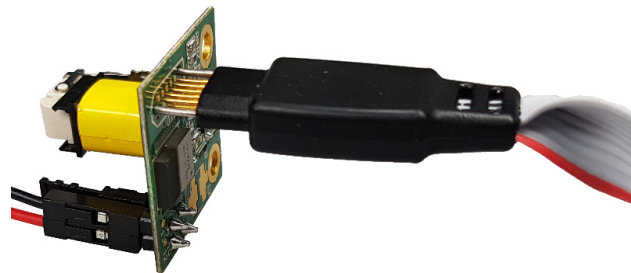
Programming the Harvesting Switch

The firmware of the switch can be customized in the RSL10 SDK. This can be used to add features like custom identification and authentication to further optimize security and/or convenience related aspects. In addition, the Bluetooth transmit power can be adjusted to further reduce power consumption or extend the transmission range.

Using the RSL10 Software Development Kit

The firmware featured on the Energy Harvesting Bluetooth Low Energy Switch RSL10 SIP can be updated using a JTAG Programmer like the SEGGER J−Link Ultra+ and the RSL10 Software Development Kit.

The board has a 10-pin JTAG/SWD interface that connects to a standard 10-pin needle adapter like the Tag-Connect TC2050−IDC. In addition, a 3.3 V power-supply and one jumper are required.

1. Connect a Jumper to the header marked "Prog" to ensure the RSL10 is in the programmable mode. The jumper needs to be connected before the board is connected to the programming power-supply.
2. Connect a 3.3 V power supply to the "Vout" header to supply the RSL10 during programming. Ensure to match the polarity marking on the board, as there is no reverse-polarity protection.

Figure 6. Power Connection and Programming Mode Jumper

3. Attach the needle adapter to the programmer pads on the backside of the switch reference design. Connect the needle-adapter to the J−Link programmer.

Figure 7. Connected Needle Adapter

4. Start the flashing process in the RSL10 SDK. For detailed instructions on how to use the RSL10 SDK please refer to the "Getting Started with RSL10" Guide ([AND9697/D](AND9697/D)).
5. Remove the needle adapter, programming power-supply and programming mode jumper.

Programming the RSL10 without Wings

If the wings of the board were removed, the 10-pin JTAG/SWD header, programming jumper and programming power supply header are not available. The central part of the board is equipped with test-points that enable programming.

Figure 8. Switch Reference Design without the Wings

The connections between the test-points on the switch reference design and the programmer and programming power-supply need to be setup in accordance with the following schematic:
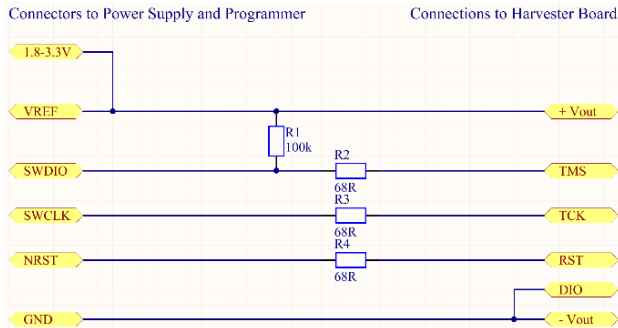
Figure 9. Connections for Programming the Board via Test-points
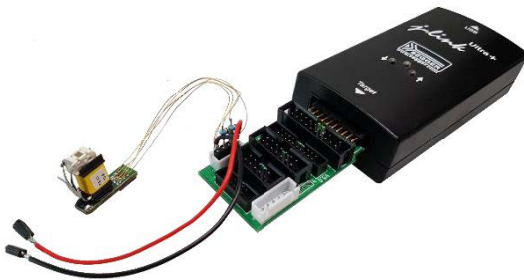
Figure 10. Example Programming Assembly using SEGGER J−Link Ultra+

With the connections in place, the RSL10 on the board can be flashed using the RSL10 SDK.

Using the Bluetooth IoT Development Kit (B−IDK)

The Bluetooth IoT Development Kit is a configurable node-to-cloud development platform that includes a baseboard, and a wide selection of shield boards for sensing and actuation. Using the B−IDK that is based on the RLS10, it is possible to control loads like a power LED, stepper or BLDC motor with the harvesting switch. The additional RSL10 SoC on the baseboard can be used to receive and process the advertising packets that are coming from the harvesting switch. For more information and additional sample projects, refer to the BDK−GEVK webpage.

Additional Configuration Options

The Energy Harvesting Bluetooth Low Energy Switch has additional options for testing and evaluating the capabilities of the energy harvesting circuitry as well as the RSL10 SIP module:

- Multi-capacitor Footprint (Marked C2 on Board):
  It can accommodate a variety of different capacitors for varying capacity and/or technology of the main storage capacitor (1206/1210 ceramic, SMD electrolytic/

polymer or 3528 Tantalum). By default, a 33 μF/10 V capacitor is used placed below the switch on the top-side of the board (marked as C1). C1 and C2 are connected in parallel, so C1 should be removed before other capacitors are evaluated using the multi-capacitor footprint.
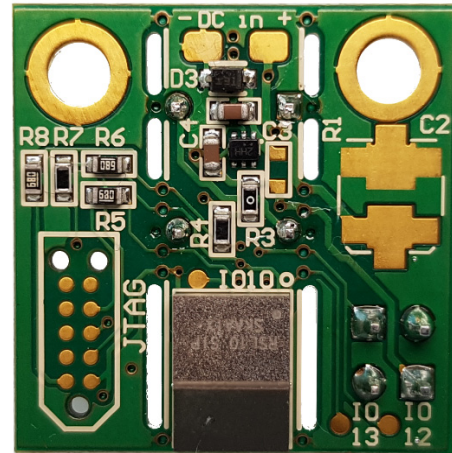
Figure 11. Bottom Side of the Switch Reference Design

- Adding additional circuitry like sensors to the RSL10's digital I/O. The digital I/Os are labeled IO10, IO12 and IO13, corresponding to the DIO10, DIO12 and DIO13 pins of the RSL10 SIP. They can be configured in the RSL10 SDK (simple input or output, SPI, I^{2}C, etc.). IO10 and IO13 have no restrictions concerning their use for a custom application.
  IO12 must not be connected to a pull-down. If a pull-down is detected on IO12 during startup, the RSL10 will not boot but will go to the programming mode.
- Using a different (harvesting) power source for the RSL10 SIP. An external energy source (1.4−5 V) can be connected to the "DC in" pads on the rear side. The voltage is stabilized by the on-board capacitors (C1 and the optional C2) as well as regulated and clamped to ensure a safe operation of the RSL10. Input voltage spikes will be clamped using the 6.2 V Zener-Diode (MM3Z6V2ST1G). Voltages greater than 3.3 V will be regulated using the NCP170 ultra-low quiescent current LDO.
- Use the switch as a harvesting-based power supply for an external MCU board like the RSL10 development board. To use the switch reference design in that way, resistor R3 needs to be removed to cut the power to the on-board RSL10 chip. The output voltage is connected to the header and test-points labeled as Vout on the top of the board. The output voltage is clamped at 3.3 V.
  If the RSL10 development board is used as an external MCU board as shown in Figure 12, the same firmware as for the harvesting switch itself can be flashed as it uses the same RSL10 chip. Using the evaluation board enables additional connectivity to more sensors, Analog inputs,

etc. for rapid prototyping. For optimal performance on the RSL10 development board the following jumpers need to be removed after the board was programmed: "VDD_AT", "VDDO", "3.3 V" and all three "SWD" jumpers. The "VBAT" jumper needs to be set to *"BATT"* and for the power-options *"VBAT EXT"* needs to be selected.

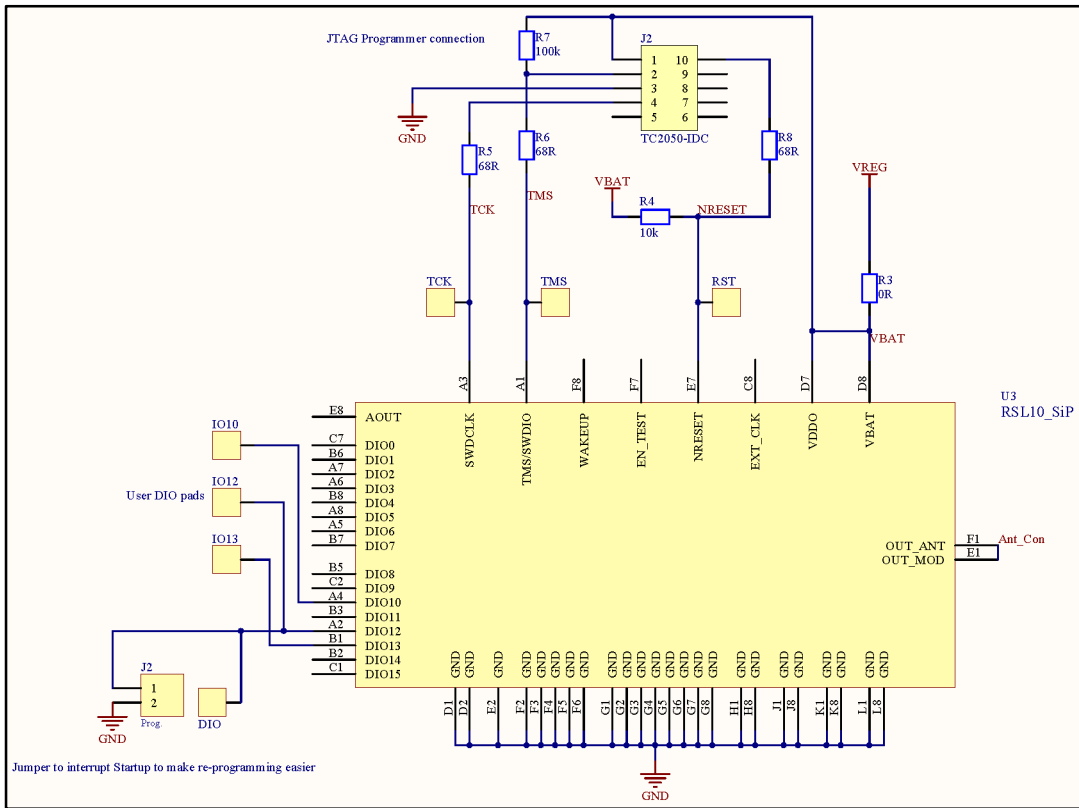The power consumption and other performance metrics are identical for the chip on the harvesting board and on the development board (assuming the above mentioned jumper configuration).
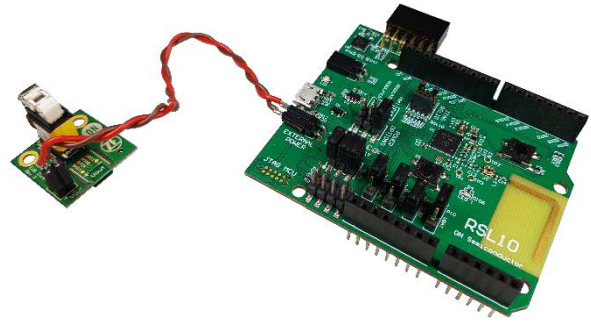
Figure 12. Switch Reference Design with Connected RSL10 Development Board
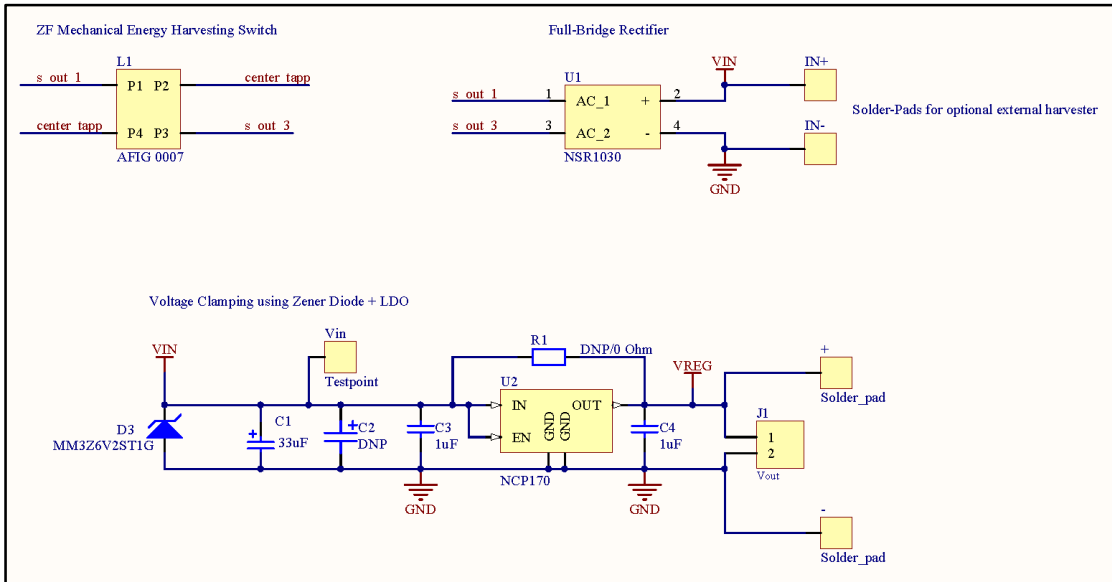
Figure 13. Bluetooth Low Energy Switch Power Supply Schematic

Figure 14. Schematic of RSL10 with Programming Interface

ADDITIONAL INFORMATION

TECHNICAL PUBLICATIONS:
Technical Library: www.onsemi.com/design/resources/technical–documentation
onsemi Website: www.onsemi.com

ONLINE SUPPORT: www.onsemi.com/support
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