

Energy Harvesting Bluetooth® Low Energy Switch User Guide

Overview

The Energy Harvesting Bluetooth Low Energy Switch reference design is battery-free Bluetooth switch based on the RSL10 SIP, 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 × 23.6 × 21.2 mm
- Temperature range: –40 to + 85°C
- No EMC Required due to Low Energy used by the Switch



ON Semiconductor®

www.onsemi.com

EVAL BOARD USER'S MANUAL



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.

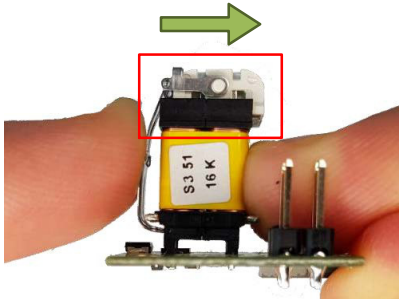


Figure 1. Pressing the Harvesting Switch

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).

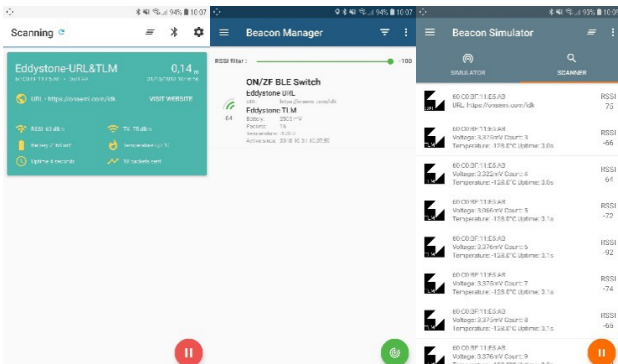


Figure 2. Examples of Beacon Monitoring Apps

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.

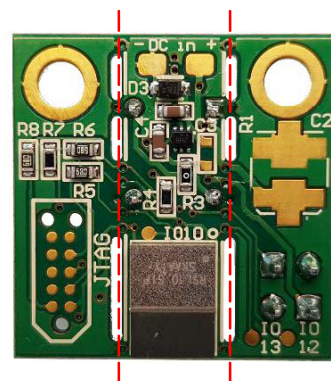


Figure 3. Breaking Axes

Depending on the used enclosure, it might be necessary to smoothen the edges after breaking as shown in Figure 4. Figure 5 shows an example of the harvesting switch mounted in a plastic enclosure.

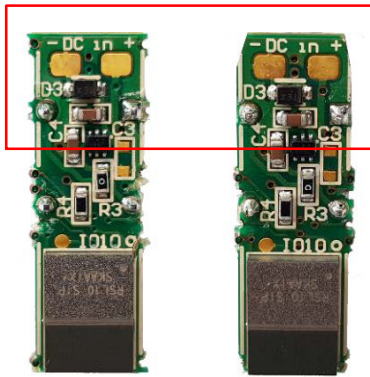


Figure 4. Smoothed and Un-smoothed Edges after Removing the Wings

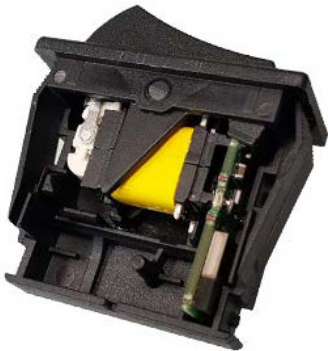


Figure 5. Rocker Switch with Bluetooth Low Energy Module

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.

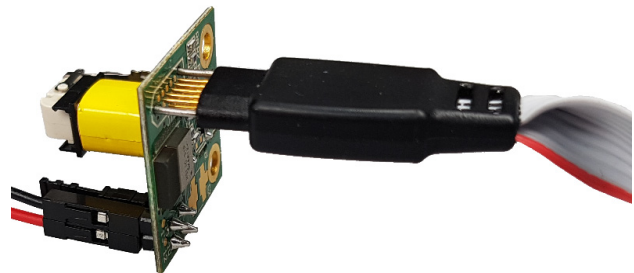


Figure 7. Connected Needle Adapter

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](#)).
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:

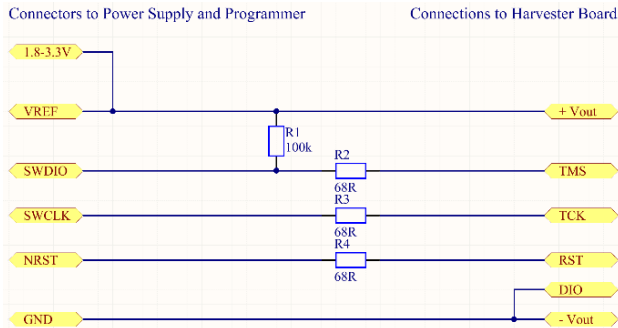


Figure 9. Connections for Programming the Board via Test-points

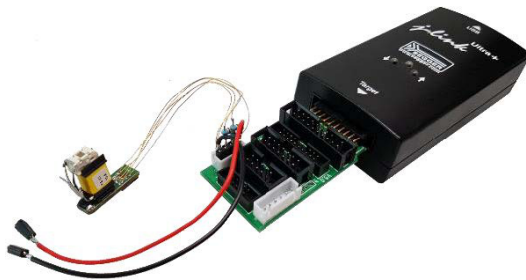


Figure 10. Example Programming Assembly using SEGGER J-Link Ultra+

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 μ F/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.

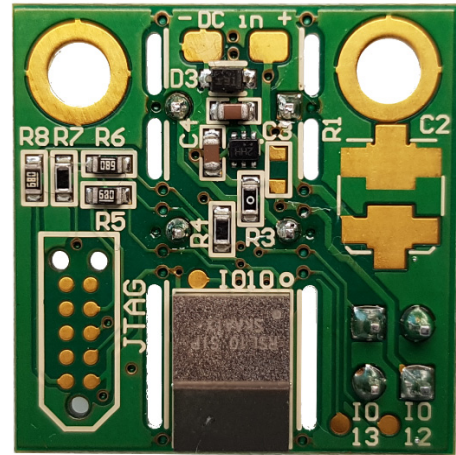


Figure 11. Bottom Side of the Switch Reference Design

- 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, I²C, 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).

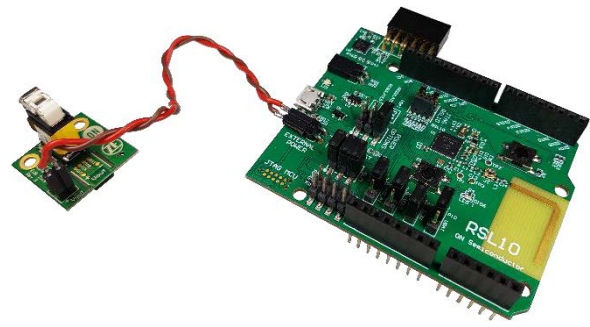


Figure 12. Switch Reference Design with Connected RSL10 Development Board

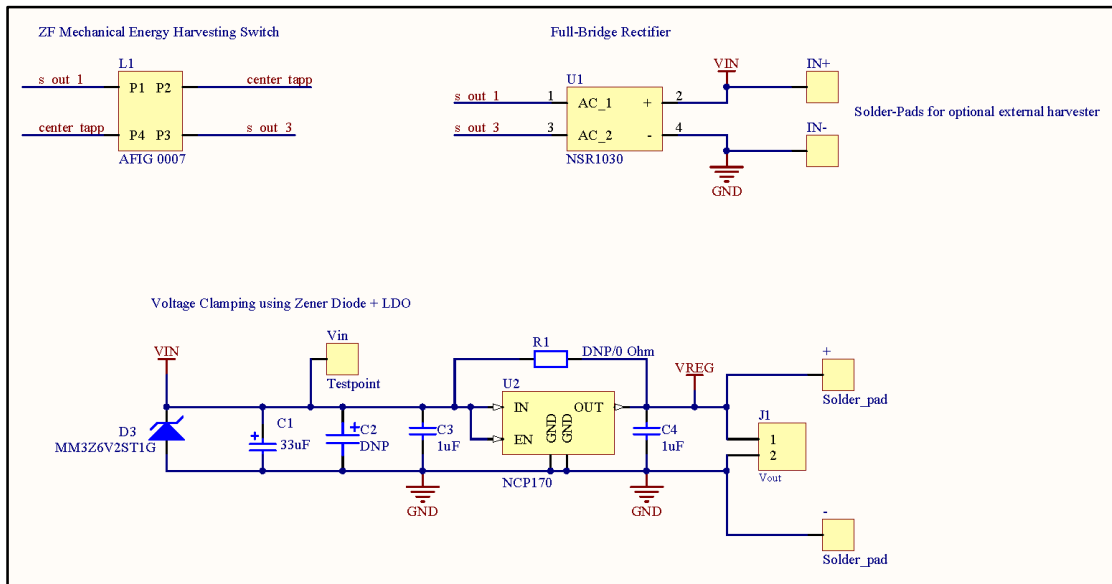


Figure 13. Bluetooth Low Energy Switch Power Supply Schematic

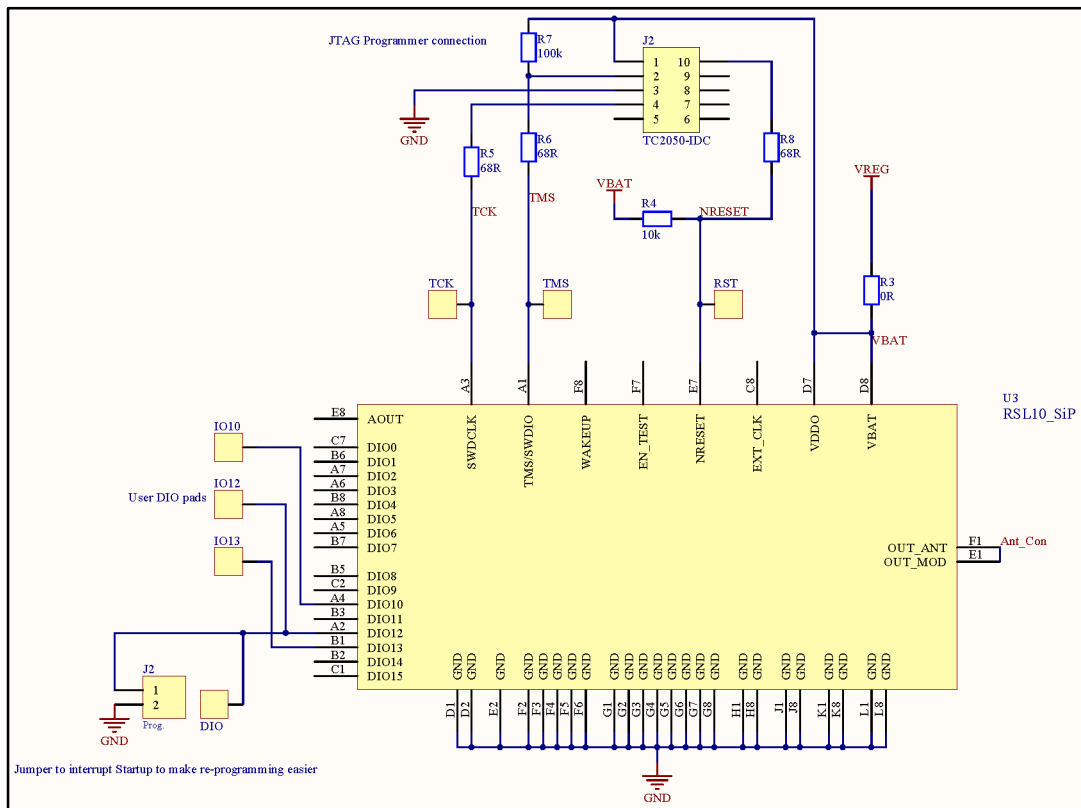


Figure 14. Schematic of RSL10 with Programming Interface

ON Semiconductor is licensed by the Philips Corporation to carry the I²C bus protocol.

Bluetooth is a registered trademark of Bluetooth SIG.

SEGGER is registered trademark and J-LINK is a trademark of SEGGER Microcontroller GmbH SEGGER Microcontroller Co. KG

ZF is a trademark of ZF FRIEDRICHSHAFEN AG.

All other brand names and product names appearing in this document are registered trademarks or trademarks of their respective holders.

onsemi, **onsemi**, and other names, marks, and brands are registered and/or common law trademarks of Semiconductor Components Industries, LLC dba "**onsemi**" or its affiliates and/or subsidiaries in the United States and/or other countries. **onsemi** owns the rights to a number of patents, trademarks, copyrights, trade secrets, and other intellectual property. A listing of **onsemi**'s product/patent coverage may be accessed at www.onsemi.com/site/pdf/Patent-Marking.pdf. **onsemi** is an Equal Opportunity/Affirmative Action Employer. This literature is subject to all applicable copyright laws and is not for resale in any manner.

The evaluation board/kit (research and development board/kit) (hereinafter the "board") is not a finished product and is not available for sale to consumers. The board is only intended for research, development, demonstration and evaluation purposes and will only be used in laboratory/development areas by persons with an engineering/technical training and familiar with the risks associated with handling electrical/mechanical components, systems and subsystems. This person assumes full responsibility/liability for proper and safe handling. Any other use, resale or redistribution for any other purpose is strictly prohibited.

THE BOARD IS PROVIDED BY ONSEMI TO YOU "AS IS" AND WITHOUT ANY REPRESENTATIONS OR WARRANTIES WHATSOEVER. WITHOUT LIMITING THE FOREGOING, ONSEMI (AND ITS LICENSORS/SUPPLIERS) HEREBY DISCLAIMS ANY AND ALL REPRESENTATIONS AND WARRANTIES IN RELATION TO THE BOARD, ANY MODIFICATIONS, OR THIS AGREEMENT, WHETHER EXPRESS, IMPLIED, STATUTORY OR OTHERWISE, INCLUDING WITHOUT LIMITATION ANY AND ALL REPRESENTATIONS AND WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, TITLE, NON-INFRINGEMENT, AND THOSE ARISING FROM A COURSE OF DEALING, TRADE USAGE, TRADE CUSTOM OR TRADE PRACTICE.

onsemi reserves the right to make changes without further notice to any board.

You are responsible for determining whether the board will be suitable for your intended use or application or will achieve your intended results. Prior to using or distributing any systems that have been evaluated, designed or tested using the board, you agree to test and validate your design to confirm the functionality for your application. Any technical, applications or design information or advice, quality characterization, reliability data or other services provided by **onsemi** shall not constitute any representation or warranty by **onsemi**, and no additional obligations or liabilities shall arise from **onsemi** having provided such information or services.

onsemi products including the boards are not designed, intended, or authorized for use in life support systems, or any FDA Class 3 medical devices or medical devices with a similar or equivalent classification in a foreign jurisdiction, or any devices intended for implantation in the human body. You agree to indemnify, defend and hold harmless **onsemi**, its directors, officers, employees, representatives, agents, subsidiaries, affiliates, distributors, and assigns, against any and all liabilities, losses, costs, damages, judgments, and expenses, arising out of any claim, demand, investigation, lawsuit, regulatory action or cause of action arising out of or associated with any unauthorized use, even if such claim alleges that **onsemi** was negligent regarding the design or manufacture of any products and/or the board.

This evaluation board/kit does not fall within the scope of the European Union directives regarding electromagnetic compatibility, restricted substances (RoHS), recycling (WEEE), FCC, CE or UL, and may not meet the technical requirements of these or other related directives.

FCC WARNING – This evaluation board/kit is intended for use for engineering development, demonstration, or evaluation purposes only and is not considered by **onsemi** to be a finished end product fit for general consumer use. It may generate, use, or radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to part 15 of FCC rules, which are designed to provide reasonable protection against radio frequency interference. Operation of this equipment may cause interference with radio communications, in which case the user shall be responsible, at its expense, to take whatever measures may be required to correct this interference.

onsemi does not convey any license under its patent rights nor the rights of others.

LIMITATIONS OF LIABILITY: **onsemi** shall not be liable for any special, consequential, incidental, indirect or punitive damages, including, but not limited to the costs of requalification, delay, loss of profits or goodwill, arising out of or in connection with the board, even if **onsemi** is advised of the possibility of such damages. In no event shall **onsemi**'s aggregate liability from any obligation arising out of or in connection with the board, under any theory of liability, exceed the purchase price paid for the board, if any.

The board is provided to you subject to the license and other terms per **onsemi**'s standard terms and conditions of sale. For more information and documentation, please visit www.onsemi.com.

ADDITIONAL INFORMATION

TECHNICAL PUBLICATIONS:

Technical Library: www.onsemi.com/design/resources/technical-documentation
onsemi Website: www.onsemi.com

ONLINE SUPPORT: www.onsemi.com/support

For additional information, please contact your local Sales Representative at www.onsemi.com/support/sales