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Creating a State-of-the Art, Cost Effective Energy Harvesting Bluetooth® Low Energy Switch

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Introduction

As IoT rapidly grows into new markets such as MHealth, Agriculture 4.0, and building automation, new questions are being raised about the energy required to support its growth. Within the industry, we see a broad spectrum of power requirements. On one end, we have (relative to the number of IoT nodes) a small number of cloud servers with very high power requirements. These are running 100% of the time resulting in huge energy budgets. At the opposite end of the IoT ecosystem we have a huge number of end nodes with limited power demands and typically little up-time when they are active and demanding an energy source.

In June 2018, The World Material Forum 2018, held in Nancy, France, had a dedicated session titled: "Big Data/AI for Materials Efficiency". The paper presented by a Stanford Professor named Reinhold Dauskardt gave the following indicators:

"The Annual power consumption of US-only Data centers is estimated at 90 Billion kWh. This is equivalent to 34 nuclear power plant reactors of 500 MW, or exactly half of the nuclear power plant capacity of France (some 56 Reactors)."

Underlining the power demand of data centers/cloud computing server resources further is the statistic that in 2017 3% of worldwide electricity consumption was accounted for by data centers. That might be perceived by some as a low percentage, but driven by the world's insatiable hunger for the creation, consumption and movement of data, there is a kind of Moore's law that can be applied to the energy consumption of data centers, that is that it will double every four years. At this pace, if nothing changes, then theoretically, by 2037, computers will use more electric energy than the current worldwide production. Reinhold Dauskardt continued and then concluded: "A huge challenge ahead of us for the 20 next years, is to reduce the energy footprint of the IoT by designing objects that are connected to the Internet AND disconnected from the electric networks." They must be electric-friendly, autonomous and use any source of energy one could think about such as vibration, heat and light."

On the end-node side, as previously hinted, predictions give several tens of billions of nodes will be deployed by 2021. Each of them will have very low power consumption and combined with limited up-time, this can result in low individual energy budgets, which is good. But the dramatic proliferation still correlates to potentially very high global power consumption.

Combining Energy Harvesting and Bluetooth Low Energy

One source of alternative energy is to harvest dynamic energy from the movement and force applied to a button like an ON/OFF Switch. Application examples which can implement this technology include wall and lighting control, building automation, and asset tracking.

onsemi's RSL10 radio is a Bluetooth 5 certified System-on-Chip that supports Bluetooth Low Energy and has been awarded the industry's best EEMBC® ULPMark™ scores for power efficiency (1090 ULPMark CP @ 3 V; 1260 @ 2.1 V). Together with ZF, we have partnered to produce a Bluetooth Low Energy switch reference design for batteryless IoT applications that is entirely self-powered by a mere 300 μJ. With the Bluetooth Low Energy frame protocol being as short as 10 ms, a total energy budget of less than 100 μJoule is required. The comparison between the harvested 300 μJ and the required 100 μJ transmit budget is obvious.

The RSL10 Bluetooth Low Energy switch reference design implements a smart and low cost power supply schematic. Conventional transceivers need more than 2.5 V of power, substantially more than what is required using RSL10. Additionally, they require complicated implementation of energy harvesting consisting of expensive Buck/Boost converters, EMC radiating coils, and costly timing generation to limit radio-frequency interactions within tiny form-factor sensor nodes.

The RSL10 switch reference design removes these issues by enabling direct connectivity of the harvester to the transceiver using a low drop diode bridge with filtering capacitor.

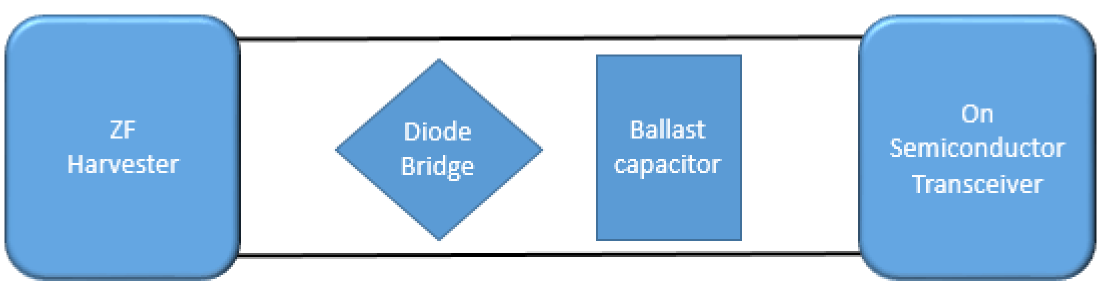

Figure 1. Simple RF Transceiver with Energy Harvester

With the compact design of the transceiver that we have been able to achieve it becomes easy to integrate every element in a small form-factor battery-less switch while supporting Bluetooth Low Energy (Bluetooth 5) transmission.

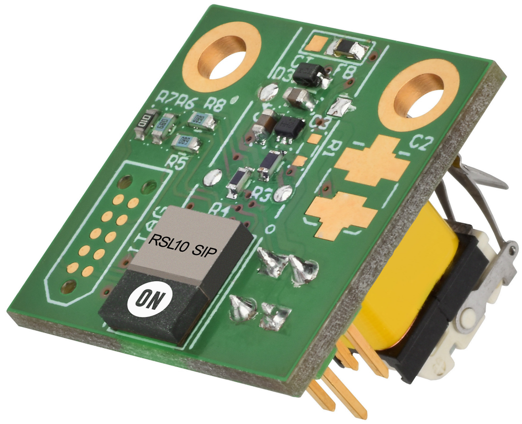

Figure 2. Energy Harvesting Bluetooth Low Energy Switch

This smart hardware design provides a reduced Bill of Materials (BoM), improved layout flexibility, and easier upgradeability after the application is released to market.

ZF Switch

In a world where the number of networks is increasing, requirements for information transmission are also changing. Transmission must be mobile and flexible, while using as little energy as possible. The solution is energy harvesting wireless switches from ZF. They are easy and effective to use, without any cables or batteries.

Due to its miniature construction, the high efficiency in the functional chain, and its long life expectancy of up to 1,000,000 switching cycles, the ZF wireless switch needs only a small amount of power for operation with no maintenance required – and can be installed in a tight space.

This environmentally friendly system has numerous advantages: You have the flexibility to install a switch without cabling in any location you want, where it will fulfil its function over the entire length of its service life without any maintenance or battery changes. In contrast to information transmission via cables, the self-powered wireless switch is also attractive for building services because it's easy to retrofit. For example, you can install new light switches in a freshly decorated room without having to cut any holes in the wall.

There are also numerous possibilities for use in industrial automation, particularly when the time it takes to lay cables is disproportionate to the application. Here again, the energy harvesting wireless switch serves as a cost effective, battery-less alternative to cable-based micro switches.

Technical Specifications:

- Inductive generator: The energy required for data transmission is created by the mechanical actuation of the switch. Energy generated: 2× min. 0.33 mWs
- 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)
- Bi-stable/Latching design: Switching mechanism with two rest positions (e. g. On/Off switch)
- Dimensions: 20.1 × 7.3 × 14.3 mm
- Temperature range: –40 to +85°C
- No EMC required due to low energy used by the switch

The Evolution of Energy Harvesting

As IoT continues to grow, it's clear that manufacturers will continue to seek new ways of improving energy efficiency and alternative sources of energy for entirely battery-less applications which provide lower maintenance, improved wireless range, simpler EMC transmission, and lower application cost. IHS Market is projecting a significant growth (CAGR of 57%) of the connected switches for home automation.

Application	2017	2018	2019	2020	2021	2022
Connected & Smart Home						
Home automation						
Plugs/switches	14,943	23,773	38,947	65,670	97,206	143,904

Figure 3. IHS MARKET Annual Shipment Estimations (Kunits)

Recent introductions by key DIY retail players in the fields of consumer lighting show the mega-trend of wireless switches. But they are Battery powered. And they suffer from short lasting life (3 to 6 months), despite all efforts made for improving performance.

Battery less implementation is definitely removing this restriction.

With an estimated 100 millions switches sold worldwide by 2021, the need for battery-less operations is getting critical for cost and maintenance reasons.

Together with ZF, **onsemi** is perfectly positioned to supply the perfect technology fitting the most difficult challenges ahead of us.

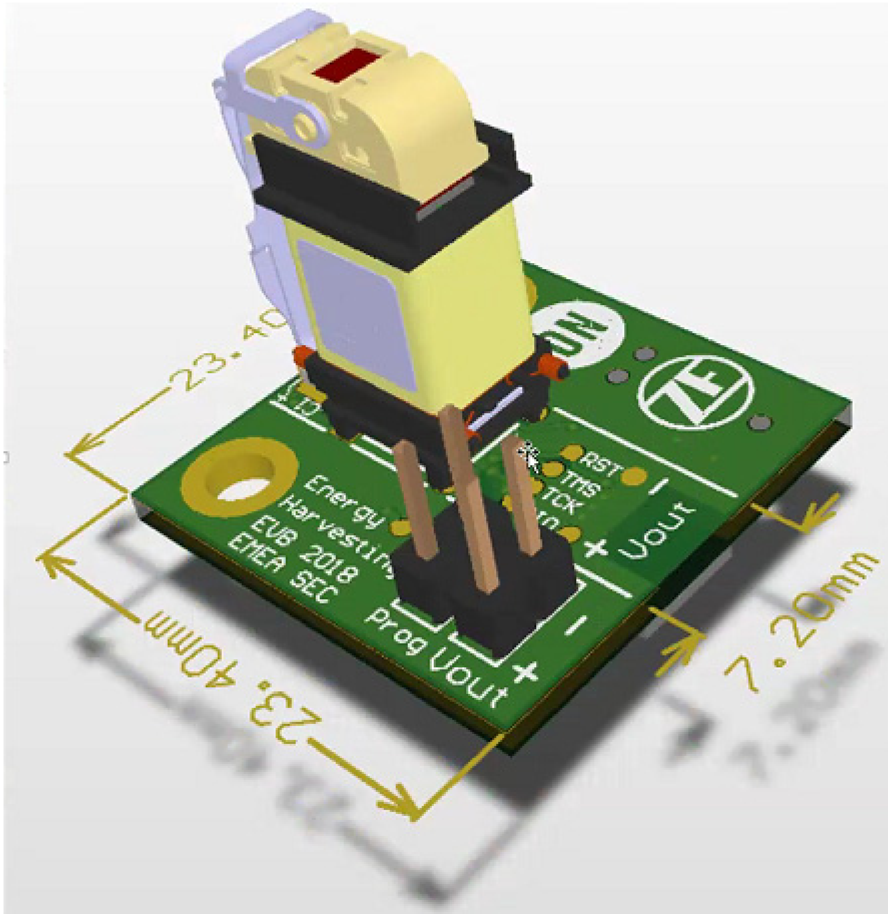

Figure 4. CAD Rendering of the Bluetooth Low Energy Switch

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