Adaptive Impedance Matching for 5.8 GHz Passive Energy Harvesting Circuitry

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Introduction

- RFID technology is implemented in toll road payments, animal IDs, inventory systems, passports, and student IDs [1].
- Energy Harvesting (EH) circuits are used as an alternative to batteries for passive RFID tags.
- When designing the RFID tags, impedance matching is needed for maximum power transfer.
- EH circuits are inherently non-linear because of the diodes, making impedance matching challenging.

Motivation

- Conventionally, a microcontroller is modeled as a single load but exhibits varying load characteristics [2].

Varying Loads of the MSP430 Microcontroller

Mode	Frequency (MHz)	Current (mA)	Impedance (kΩ)
With SPI	8	1.8	1
No SPI	1	0.310	5.8

Table 1. Measured loads under different data modes at 1.8 V.

- SPI communication uses a higher clock frequency which increases the power consumption.
- RFID microcontrollers use SPI to control an RF switch for backscatter communication with the RFID reader.
- In order to match varying impedances of the microcontroller, single-stub matching is utilized to optimize the EH circuit.

Charge Pump Design and Implementation

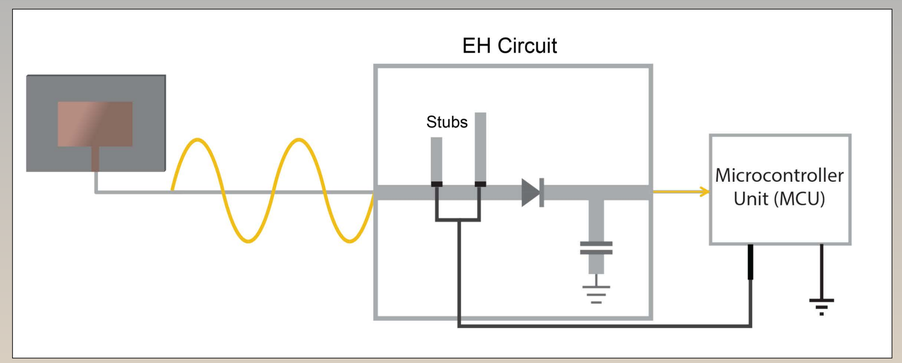

Figure 1. Charge Pump Design

Efficiency vs RF Power Input for Optimized and Non-optimized EH Circuits

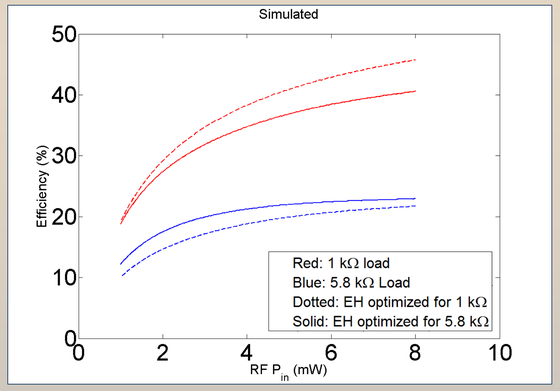

Figure 2. Simulated EH Efficiency

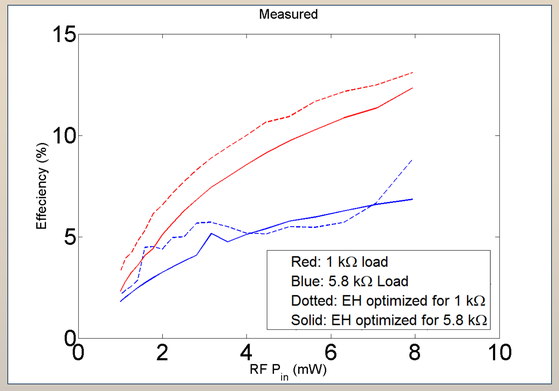

Figure 3. Measured EH Efficiency

Fabricated Energy Harvester Circuit

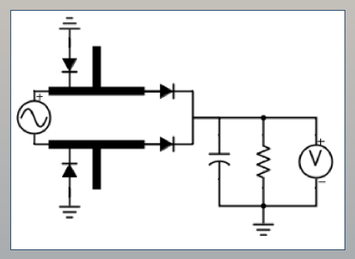

Figure 4. EH Circuit Schematic

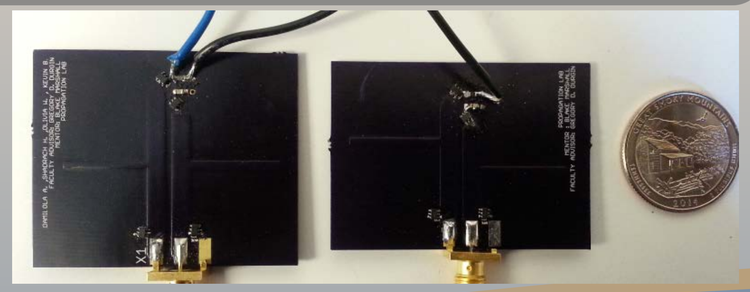

Figure 5. Printed EH Circuit Board

Conclusions

- Optimizing charge pump circuits to specific loads is a valid method of increasing the efficiency of the energy harvesting system.
- With higher efficiency, an increased range in our RFID system can be achieved.
- For the simulated data, the increase in efficiency of the 1kΩ load outperforms the increase in efficiency of the 5.8kΩ load.
- For the measured data, the optimized 1kΩ load outperforms the not optimized 1kΩ load.
- The difference between simulated and measured data is due to electromagnetic effects at 5.8 GHz.

Future Work

- Implement switching mechanism between optimized matching stubs.
- Characterize the different charge pump loads.
- Optimize circuit for three or more loads with multiple stubs.
- Transmit data packets via RF signal to microcontroller.

References

[1] M. J. Almada, L. Blanca-Pimentel, J. T. Block, J. L. Gonzalez, C. R. Valenta, G. D. Durgin, “Characterization of a 5.8 GHz 4-Stage Dickson Charge Pump with Resistive Loads,” The Tower, vol. 4, November 2011.
[2] El-Anzeery, H.M.G.E.-D.M., M.A.E.-A.S. El-Bagouri, and R. Guindi. "Novel Radio Frequency Energy Harvesting Model." (2012): Inspec. Web. 6 Apr. 2014.

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