Wireless Power Transfer System (WPTS)

SENIOR PROJECT PROPOSAL

Team members

Elie Baliss, Sergio Sanchez, & Tyler Hoge

Project Advisor

Dr. Prasad Shastry

Department of Electrical and Computer Engineering

BRADLEY
UNIVERSITY

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Project Summary

The project requires the development of two wireless power transfer systems. The two systems will be configured differently, however they will have the same function—harvesting wireless energy and converting it to DC power. System #1 involves the design of a transmitter and a receiver operating at 915 MHz, while system #2 only requires the design of a receiver operating at 2.4 GHz. The receiver of both systems, however, will be completely passive and will not require the use of any external power, besides that of the RF/Microwave energy.

Block Diagrams

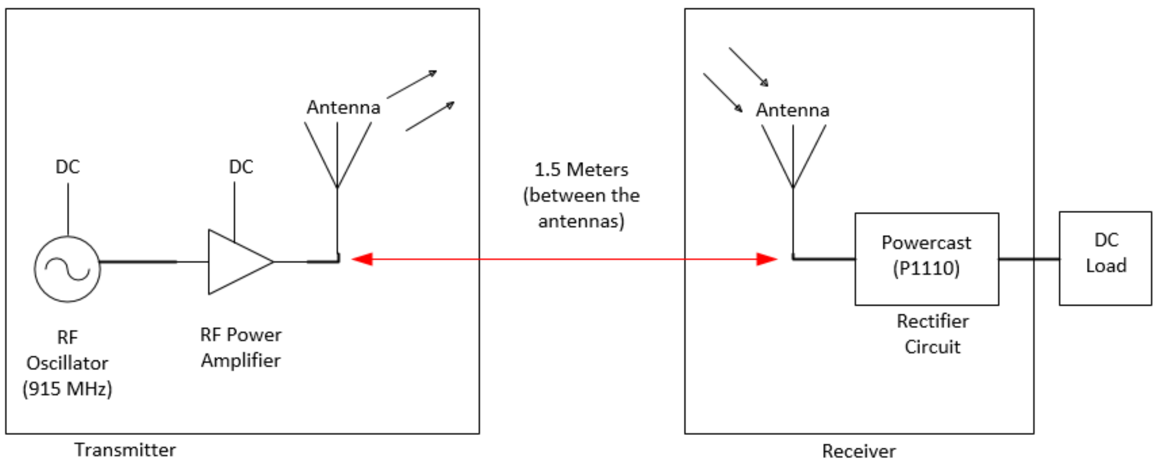

Fig.1. High-Level Block Diagram of System #1

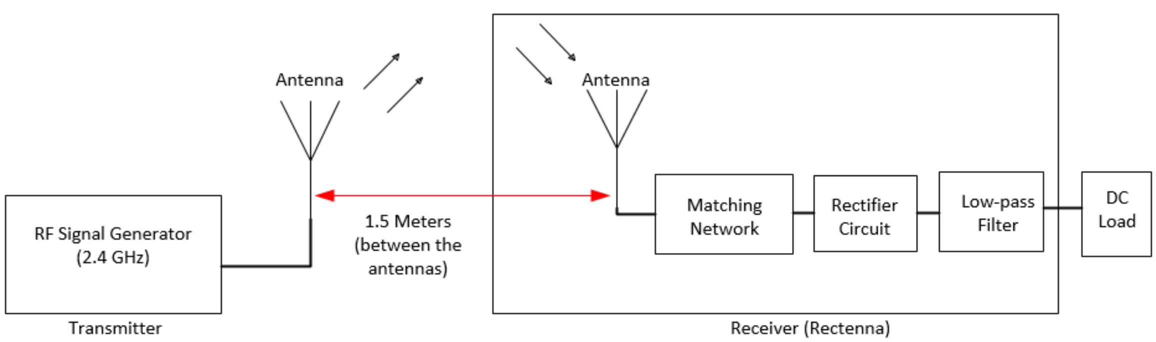

Fig. 2. High-Level Block Diagram of System #2

Functional Description

System #1 Transmitter:

An RF oscillator (ROS 1000PV) generates a continuous wave (CW) signal at 915 MHz. The signal is amplified by an RF power amplifier (HMC478SC70). The amplified signal is then emitted from an antenna (10dBi gain).

System #1 Receiver:

The transmitted RF signal is received by an antenna (6dBi gain). A rectifier circuit converts the received signal to DC voltage. The RF to DC conversion is accomplished by the P1110 Powercast rectifier module. The receiver circuit is expected to charge 1.2V, 200mAh, AA battery. The receiver will be tested using an evaluation board that is provided by Powercast. Aside from Powercast's evaluation board, a separate evaluation board will be designed by our group.

System #2 Rectenna:

A 2.4 GHz signal is captured by the antenna and converts it to DC via its built-in rectifier circuit. This system will utilize an RF signal generator as its transmitter. The output DC output power is yet to be defined.

Challenges

System #1:

- Maximizing power transmission distance
- Maximizing current produced from the receiving circuit
- Overall size limitation of receiver circuit

System #2:

- Rectifier topology to be used for a maximum RF-to-DC conversion efficiency
- Maximizing power density
- Reducing harmonics
- Overall size of rectenna

Functional Requirements

Specifications such as transmitted distance, power transmitted, and power received can be derived from Friis transmission formula **[5]** given in (1).

$$\frac{P_{rec}}{P_t} = \frac{\xi_t \xi_r A_t A_r}{\lambda^2 R^2} = G_t G_r \left(\frac{\lambda}{4\pi R}\right)^2 . \quad (1)$$

Where,

P_{rec} = power received [W]

P_t = power transmitted [W]

G_t = gain of transmitter’s antenna

G_r = gain of receiver’s antenna

Lambda = wavelength (speed of light/operating frequency) [m]

R = distance of power transmission [m]

System #1 shall:

- Transmit approximately 1.2 W of power at a distance of 1.25 meters
- Receive approximately 10 mW of power at a distance of 1.25 meters
- Have a 67% RF-to-DC conversion efficiency
- Transmitter antenna gain of 10dBi
- Receiver antenna gain of 3dBi
- Have dimensions not exceeding 4 in x 3 in for receiving circuit
- Power a 1.2V, 200mAh, AA battery

System #2 shall:

- Be designed for a high RF-to-DC conversion efficiency
- Have an antenna designed for optimal gain (approx. 3-5 dB gain)
- Be designed with matching networks to reduce power losses
- Be designed with a low-pass filter (LPF) to eliminate high-order harmonics

Schedule of Tasks

EE452 will run from 01/22/2014 until the week of 05/12/2014. Our team will put in work on both lab days, Tuesday and Thursday, if necessary.

Elie Baliss and Tyler Hoge will work on System #1, while Sergio Sanchez will work on developing the rectenna for System #2. We will work as a group to finish fabricating and designing both systems.

System #1 Schedule of Tasks

Task/month	Jan 28	Feb 4	Feb 18	Feb 25	Mar 4	Mar 25	Apr 10	May 1	Presentation day
Check parts ordered over break. Reorder if necessary									
Design Circuit									
Optimization									
Layout									
Simulation of Design									
Fabrication of circuit/Mounting components									
Final testing									
Preparation for Presentation									
Present Project									

System #2 Schedule of Tasks

Task/month	Feb 4	Feb 18	Feb 25	Mar 4	Mar 25	Apr 10	May 1	Presentation day
Design of microstrip & CPW antenna, & simulations								
Optimization								
Simulation of final design								
Layout								
Fabrication of passive antenna & mounting diodes								
Testing								
Project Presentation preparation								
Present Project								

Parts, Equipment, & Tools

RF Components

- RF Oscillator (ROS_1000PV)
- RF Amplifier (HMC478SC70)
- Rectifier Circuit (Powercast's P1110)
- Antenna on receiver (Powercast)
- Antenna on transmitter (To be determined)
- Connectors, cables, & circuit boards

Tools

- Vector Network Analyzer
- Agilent CAD Tools
- RF Signal Generator
- Anechoic chamber
- DC power supplies
- Spectrum analyzer

Bibliography & References

[1] Boaventura, Alírio, Ana Collado, Nuno B. Carvalho, and Apostolos Georgiadis. "Optimum Behavior." IEEE Microwave Magazine, 6 Mar. 2013, pp. 26-35.

[2] "Sony Develops Highly Efficient Wireless Power Transfer System Based on Magnetic Resonance." News Releases. N.P., 02 Oct. 2009. Web. 20 Sept. 2013.

[3] Nadakuduti,, Jagadish, Lin Lu, and Paul Guckian. "Operating Frequency Selection for Loosely Coupled Wireless Power Transfer Systems with Respect to RF Emissions and RF Exposure Requirements." (2013): 1-6. The Alliance for Wireless Power, 15 May 2013. Web. 22 Sept. 2013.

[4] Kesler, Morris. "Highly Resonant Wireless Power Transfer: Safe, Efficient, and over Distance." (2013): 1-32. WiTricity Corporation, 2013. Web. 20 Sept. 2013.

[5] Fawwaz T. Ulaby, Eric Michielssen, & Umberto Ravaioli, *Fundamentals of Applied Electromagnetics*, New Jersey: Prentice Hall, 2010.

[6] **Powercast products and technology are covered by one or more of the following U.S. patents and other U.S. patents pending:** 6,289,237 | 6,615,074 | 6,856,291 | 7,027,311 | 7,057,514 | 7,639,994 | 7,643,312 | 7,812,771 | 7,844,306 | 7,868,482 | 7,898,105 | 7,925,308 | 8,159,090