Wireless Power Transfer System (WPTS)

SENIOR PROJECT PROPOSAL

Team members

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Project Advisor

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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

![High-Level Block Diagram of System #1](image1)

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

![High-Level Block Diagram of System #2](image2)

**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).

\[
\frac{P_{\text{rec}}}{P_t} = \frac{G_t A_t \lambda^2 R^2}{4 \pi R^2} = G_r \left(\frac{\lambda}{4 \pi R}\right)^2.
\] (1)

Where,

- \( P_{\text{rec}} \) = 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

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<th>Task/month</th>
<th>Jan 28</th>
<th>Feb 4</th>
<th>Feb 18</th>
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System #2 Schedule of Tasks

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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


[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