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Green Antennas: Design, Simulation, and Measurement of Printed Microstrip Patch Antennas for RF Energy Harvesting Applications

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Title of Research Proposal:
Green Antennas: Design, Simulation, and Measurement of Printed Microstrip Patch Antennas for RF Energy Harvesting Applications

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Project Summary:

Harvesting power from ambient radio frequency (RF) and microwave sources, which are everywhere nowadays, is a green solution for wireless power applications, from recharging batteries for wearable and biomedical implantable devices, small wireless sensors, and Radio-Frequency Identifications (RFIDs), to powering unmanned aerial vehicles. The ambient mobile and wireless networks provide recyclable RF signals, which can readily be used for aforementioned applications. For example, RF signals from Global Positioning Systems (GPSs), nearby mobile phones, Wireless Local Area Networks (WLANs), and many more, are all free sources for energy harvesting systems. Building blocks of a typical RF energy harvesting system are illustrated in Figure 1. Its pivotal component is the antenna. It receives the electromagnetic waves from the available sources in space and delivers to the rectifier block, where the RF signals are converted to DC power.

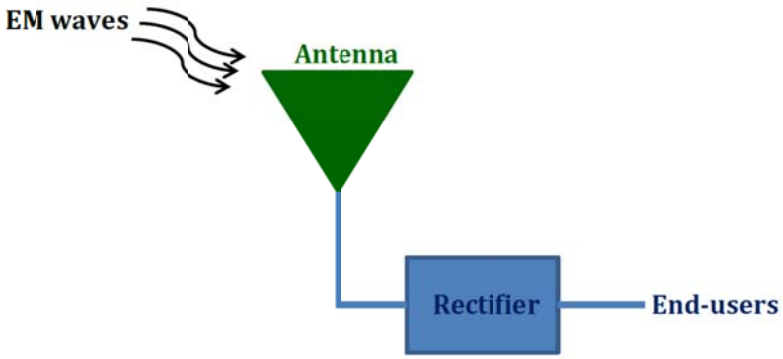

Figure 1: Building blocks of a typical RF energy harvesting system.

In this project, a microstrip patch antenna will be studied to harvest RF energy from ambient GPS signals. Such antennas are very popular candidates in most wireless applications with small power handling capabilities, due to their appealing features, such as low-cost, low-profile, light-weight, and easy to fabricate using Printed Circuit Board (PCB) technology. The patch is etched on a grounded dielectric slab and it is connected to a coaxial probe to deliver the received RF power to the rectifier. To be considered as a senior design project, the proposed antenna can be extended to its corresponding phased array configuration for further investigation.

Student Prerequisites:

EE 308 Engineering Electromagnetics; the selected student is required to have a firm grasp on the EM radiation concept covered in the EE 308.

Student Duties:

First, the student will design the proposed microstrip antenna at the frequency of 1 GHz, near the GPS frequency bands. The initial design will then be numerically investigated using the High Frequency Structural Simulator (HFSS), which is a commercial full-wave electromagnetic solver from ANSYS. The antenna parameters, such as radiation patterns, gain, and efficiency, are numerically investigated and finalized. Finally, a prototype antenna will be fabricated and tested using the available table-top antenna measurement set-up in the department of Electrical and Computer Engineering. Therefore, the student will learn the theoretical concepts and also gain pertinent hands-on experience throughout the project. A tentative workload expectation is listed in Table 1, over 10-12 weeks at 32-40 hours per week. The project has six phases in total. At the end, the student will submit a final written report of the project to the faculty mentor.

Table 1: A tentative schedule for the proposed project

Project phase	Time
Phase 1: Learn antenna design guidelines	1-2 weeks
Phase 2: Design the antenna	1 week
Phase 3: Numerical investigation	2-3 weeks
Phase 4: Fabrication	2 weeks
Phase 5: Measurement	2 weeks
Phase 6: Writing report	2 weeks

Mentor Supervision and Interaction:

The student will be fully supervised by the proposer, the faculty member at the ECE department. During phase 1, the faculty mentor will teach the student design guidelines of the proposed antenna structure. As such, they will meet every other day during this phase. There will be weekly meeting thereafter to advise the student and monitor her or his progress. During phase 4, while the prototype will be fabricated at the Machine Shop, the student will be trained by the faculty mentor, to use the antenna measurement set-up. The measurement process of the fabricated antenna will be supervised by the faculty mentor.