Multi-Directional, Multi-Polarization, and Multi-Band RF Energy Harvesting: Modeling and Development of a Hemispherical Monopole Array

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There is widespread interest in finding more sustainable and environmentally responsible sources of energy. One possible and attractive solution is to harvest from *ambient* RF energy and convert it to DC for wirelessly powering various applications, such as ultra-low power devices. This particular area has captivated researchers within the microwave and antenna community, and many efforts are being made to create effective modeling strategies in order to design efficient systems.

To harvest RF energy, a device called a rectenna is used, which comprises of an antenna and rectifier circuit. Their design is not trivial, and many environmental aspects should be considered. Recent RF frequency spectral surveys showed that the majority of available energy is contained within select bands of spectrum that correspond to popular communication channels such as GSM900, GSM1800, 3G, and WLAN (2.4 GHz). Furthermore, propagation effects like multipath propagation, scattering, random source orientations, and diffraction tend to make ambient radiation both multi-polarized and multi-directional. Based on these findings, it would be interesting to investigate a potential rectenna array designed to receive these frequency bands of interest as well as receive waves of multiple polarizations and incident directions.

In this paper, a hemispherical monopole rectenna array for ambient RF energy harvesting is investigated. In our design, a number of monopole-type antenna elements are arranged on top of a hemisphere-shaped metal dome. The currents from each element are rectified separately to DC before being combined together. To achieve selective multiband energy harvesting, a coupled-resonator monopole is designed. These monopoles can be densely arranged above a hemispherical ground plane for multi-polarization and multi-directional operation. We also discuss modeling approaches to further evaluate different configurations of the array for the *general* environment, where we consider how propagation characteristics affect an RF energy harvesting system. Integrating propagation models with full-wave solvers specifically purposed for RF energy harvesting can offer many interesting insights to consider for future concepts. Such a tool would be very useful for both active and passive RF energy harvesting systems.