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Hemispherical Rectenna Arrays for Multi-Directional, Multi-Polarization, and Multi-Band Ambient RF Energy Harvesting

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OTHER INFORMATION

KEYWORDS

Ambient RF energy harvesting, multi-directional, multi-polarization, multi-band, rectenna, antenna, rectifier, impedance matching, hemispherical array, coupled-resonator monopole, GSM900, GSM1800, WLAN

CATEGORIZED AS

- ▶ **Communications**
 - ▶ Internet
 - ▶ Networking
 - ▶ Wireless
- ▶ **Energy**
 - ▶ Other
- ▶ **Semiconductors**
 - ▶ Assembly and Packaging
 - ▶ Design and Fabrication

RELATED CASES

2016-99E-0

SUMMARY

UCLA researchers in the Department of Electrical Engineering have developed a system that can receive RF waves in different frequency bands, from different directions, and with different polarizations to maximize energy harvested from ambient radio-frequency signals.

BACKGROUND

Harvesting radio-frequency (RF) energy from the surrounding ambient is potentially a sustainable and environmentally responsible source of energy. Majority of ambient RF energy is distributed across frequency bands for cellular data communications and WiFi communications. These ambient RF waves are also both multi-polarized and multi-directional. Thus, to maximize harvested energy output requires a system that can receive RF waves in different frequency bands, from different directions, and with different polarizations.

INNOVATION

UCLA researchers proposed and simulated a new system design using an array of rectennas (an antenna and a rectifier circuit) to achieve high power energy harvesting in different frequency bands, from different directions, and with different polarizations. This technology demonstrated experimentally an antenna element that operates at high-density ambient RF energy bands of 900MHz (GSM900), 1.8GHz (GSM1800), and 2.4GHz (WiFi). The designed system is estimated to be capable of delivering 7 - 12.5 uW DC power output in total.

APPLICATIONS

- ▶ Providing power sources:
- ▶ Low power consumer electronic devices
- ▶ GPS and RLTS tracking tags
- ▶ Wireless sensor networks
- ▶ Battery-based or battery-free remote sensors for HVAC control and building automation, structural monitoring, and industrial control

ADVANTAGES

- ▶ Maximizing the RF energy being harvested
- ▶ Operation at high-density ambient RF energy bands of 900MHz (GSM900), 1.8GHz (GSM1800), and 2.4GHz (WiFi).
- ▶ Capable of energy harvesting RF waves from different directions and with different polarizations
- ▶ Scalable to support more frequency bands
- ▶ The frequencies to harvest RF energy can be tuned individually by changing design parameters.
- ▶ Simple design
- ▶ Simplicity of overall design provides a nice aesthetic and mounting capability.
- ▶ The single-input antenna design allows for a simplified feeding system and reasonable efficiencies.
- ▶ The hemispherical ground plane provides shielding that reduce noise in the DC power output.

STATE OF DEVELOPMENT

The UCLA researchers have partially demonstrated experimentally the proof-of-concept product: a functional single antenna, and a single rectifier circuit operating in one frequency band (0.9GHz). A system level design has also been proposed that can be implemented in real world and system parameters have been estimated.

RELATED MATERIALS

- ▶ A Hemispherical Monopole Rectenna Array for Multi-Directional, Multi-Polarization, and Multi-Band Ambient RF Energy Harvesting
Bohan Zhang, Joshua Kovitz, Yahya Rahmat-Samii, University of California, Los Angeles, United States, TU-A5.3A.2, 2016 IEEE International Symposium on Antennas and Propagation and URSI/USNC National Radio Science Meeting

PATENT STATUS

Country	Type	Number	Dated	Case
United States Of America	Issued Patent	10,862,197	12/08/2020	2016-99E

ADDITIONAL TECHNOLOGIES BY THESE INVENTORS

► [Low-Profile Circularly-Polarized Single-Probe Broadband Antenna](#)

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