Rotman Lens-Based Rectenna System for mm-Wave Harvesting (#8141)

*Scalable, high-gain, large-beamwidth approach operating in the 28-GHz band to enable 5G-powered Internet of Things (IoT) applications*

Inventors at Georgia Tech have developed a flexible Rotman lens-based rectifying antenna (rectenna) system capable for the first time of mm-wave harvesting in the 28-Ghz band. This novel approach addresses the tradeoff between rectenna angular coverage and turn-on sensitivity with a structure that merges unique radio frequency (RF) and direct current (dc) combination techniques, thereby enabling a system with both high gain and large beamwidth. The technology has been demonstrated to achieve a 21-fold increase in harvested power compared with a referenced counterpart, while maintaining identical angular coverage. This robust system may open the door to the emergence of passive, long-range, mm-wave 5G-powered radio-frequency identification (RFID) for wearable and ubiquitous IoT applications.

Operating just like an optical lens, the Rotman lens introduces differential propagation time delays to wavefronts that impinge onto various points of its surface. Tuning the shape of the lens according to geometrical-optics approximation results in a lens-shaped structure with one angle of curvature on the beam-port side and another on the antenna side. This enables the structure to map a set of selected radiation directions to an associated set of beam-ports. The lens is then used as an intermediate component between the receiving antennas and the rectifiers for 5G energy harvesting. This helps maintain a stable output with maximum efficiency regardless of the source location when the rectified products of each of the ports are dc-combined. Specifically, all the electromagnetic energy collected by the antenna arrays from one direction is combined and fed into one single rectifier, thereby maximizing its efficiency. The dc-combining circuit then sums up the dc power at all ports resulting from the rectification from different directions.

**Benefits/Advantages**

- **Large coverage**: Provides a unique combination of large angular coverage and turn-on sensitivity in both planar and bent configurations
- **Long-Range**: Promises the ability to power devices using 5G base-stations as far as 180m away from the lens
- **Broadband-flexible**: Demonstrates operation over more than 20GHz of bandwidth
- **Scalable**: Can be finely scaled in size to select the optimal tradeoff between size and harvested power

**Potential Commercial Applications**

This technology is poised to take advantage of the emergence of 5G networks and their associated high-allowed effective isotropic radiated power (EIRP), making many new services possible, such as:
• 5G-powered battery-less nodes for IoT applications
• Km-range passive mm-wave RFIDs

Background/Context for This Invention

The advent of 5G networks opens the door to myriad opportunities for the Internet of Things. In addition to the advantages of high transmitted power available at 5G, moving to mm-wave bands makes the realization of modular antenna arrays possible, leading to fine scaling of the antenna aperture. Unfortunately, large-gain antennas have been hindered by their inability to provide isotropic radiation. Alternative approaches have to follow a tradeoff between angular coverage and harvested power. Until now, no alternative approach has been able to do both simultaneously. Georgia Tech’s invention addresses these limitations with a scalable, high-beamwidth system that provides both high gain and wide angular coverage in the 28-GHz band for the first time.

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This technology enables dual combining (RF + dc) by the use of the Rotman lens between antennas and rectifiers.
Georgia Tech’s fully flexible, Rotman lens-based rectenna.
For more information about this technology, please visit:
https://industry.gatech.edu/technology/rotman-lens-based-rectenna-system-mm-wave-harvesting