# A Microwave Metamaterial with Integrated Power Harvesting Functionality

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We present the design and experimental implementation of a power harvesting metamaterial. Electromagnetic metamaterials can achieve exotic parameters not possible in naturally-occurring materials such as a negative or zero index of refraction. Nonlinear and active metamaterials have phase conjugating and wave mixing capabilities, and have been demonstrated in Radio Frequency (RF) limiting and harmonic generation devices.

Nonlinear metamaterials can also be used for power harvesting, which is the focus of this work. Power harvesters convert one type of energy to another, typically to a DC signal, and require a method to couple to the energy that will be harvested. Since metamaterials are designed to couple to various types of energy, such as acoustic or electromagnetic energy, they provide a natural platform for energy harvesting. Metamaterials also provide a flexible energy harvesting platform, due to their electrically small nature and ability to cover surfaces as a flexible sheet of cells.

A split ring resonator (SRR), which couples to an electromagnetic field magnetically, is chosen as the base metamaterial unit cell for this work. An SRR's function can be easily modified by placing circuit components across a gap in the resonant loop structure. Using a Greinacher voltage doubler with fast switching diodes and impedance-matching circuitry, an SRR cell has the ability to rectify an RF signal. To increase efficiency of the harvester, an array of power harvesting SRRs is made to span the width of a TEM (open) waveguide.

The power harvesting metamaterial designed in this work achieves a maximum efficiency of 36.8% at 900 MHz, and is suitable for a wide variety of applications that require power delivery to any active components integrated into the metamaterial.