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Electromagnetic Energy Harvesting by Using a Rectenna with a Metamaterial Lens

Authors : Ursula D. C. Resende, Fabiano S. Bicalho, Sandro T. M. Gonçalves

Abstract : The growing demand for cheap and clean energy sources have been motivated by the study and development of distinct technologies and devices able to provide different amounts of energy. In order to supply energy for small loads, the energy from the electromagnetic spectrum can be harvested. This possibility is particularly interesting because this kind of energy is constantly available in the environment and the number of radiofrequency sources is permanently increasing, due to advances in telecommunications services. A rectenna, which is a combination of an antenna and a rectifier circuit, is an equipment that can efficiently perform the electromagnetic energy harvesting. However, since the amount of electromagnetic energy available in the environment is very small, limited values of power can be harvested by the rectenna. Therefore, several technical strategies have been investigated in order to increase this amount of power. In this work, a metamaterial electromagnetic lens is used to improve the electromagnetic energy harvesting. The rectenna investigated was designed and optimized to charge a Li-Ion battery using the electromagnetic energy from an internet Wi-Fi commercial router model TL-WR841HP operating in 2.45 GHz with maximal output power equal to 18 dBm. The rectenna consists of a high directive antenna, a double voltage rectifier circuit and a metamaterial lens. The printed antenna, constituted of two rectangular radiator elements, was projected and optimized by using the Computer Simulation Software (CST) in order to obtain high directivities and values of S11 parameter below -10 dB in 2.45 GHz. The antenna was printed over a double-sided copper fiberglass substrate, FR4, with characterized relative electric permittivity $\varepsilon r = 4.3$ and tangent of losses $\delta = 0.01$. The rectifier circuit, which incorporates a circuit for impedance matching and uses the Schottky diode HSMS-2852, was projected and optimized by using Advanced Design Software (ADS) and built over the same FR4 substrate. The metamaterial cell is composed of two Square Split Ring Resonator (S-SRR) and a thin wire in order to operate with negative values of εr and relative magnetic permeability in 2.45 GHz. In order to evaluate the performance of the purposed rectenna two experimental charging tests were performed, one without and other with the metamaterial lens. The result obtained demonstrate that the electromagnetic lens was able to significantly increase the levels of electric current delivered to the battery, approximately 44%.

Keywords : electromagnetic energy harvesting, electromagnetic lens, metamaterial, rectenna
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