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Design of an Ultra High Frequency Rectifier for Wireless Power Systems by Using Finite-Difference Time-Domain

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Abstract : There is a dispersed energy in Radio Frequencies (RF) that can be reused to power electronics circuits such as: sensors, actuators, identification devices, among other systems, without wire connections or a battery supply requirement. In this context, there are different types of energy harvesting systems, including rectennas, coil systems, graphene and new materials. A secondary step of an energy harvesting system is the rectification of the collected signal which may be carried out, for example, by the combination of one or more Schottky diodes connected in series or shunt. In the case of a rectenna-based system, for instance, the diode used must be able to receive low power signals at ultra-high frequencies. Therefore, it is required low values of series resistance, junction capacitance and potential barrier voltage. Due to this low-power condition, voltage multiplier configurations are used such as voltage doublers or modified bridge converters. Lowpass filter (LPF) at the input, DC output filter, and a resistive load are also commonly used in the rectifier design. The electronic circuits projects are commonly analyzed through simulation in SPICE (Simulation Program with Integrated Circuit Emphasis) environment. Despite the remarkable potential of SPICE-based simulators for complex circuit modeling and analysis of quasi-static electromagnetic fields interaction, i.e., at low frequency, these simulators are limited and they cannot model properly applications of microwave hybrid circuits in which there are both, lumped elements as well as distributed elements. This work proposes, therefore, the electromagnetic modelling of electronic components in order to create models that satisfy the needs for simulations of circuits in ultra-high frequencies, with application in rectifiers coupled to antennas, as in energy harvesting systems, that is, in rectennas. For this purpose, the numerical method FDTD (Finite-Difference Time-Domain) is applied and SPICE computational tools are used for comparison. In the present work, initially the Ampere-Maxwell equation is applied to the equations of current density and electric field within the FDTD method and its circuital relation with the voltage drop in the modeled component for the case of lumped parameter using the FDTD (Lumped-Element Finite-Difference Time-Domain) proposed in for the passive components and the one proposed in for the diode. Next, a rectifier is built with the essential requirements for operating rectenna energy harvesting systems and the FDTD results are compared with experimental measurements.

Keywords : energy harvesting system, LE-FDTD, rectenna, rectifier, wireless power systems
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