Chapter 4
Study and Design of New Rectenna Structures for Wireless Power Transmission Applications

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ABSTRACT

This chapter presents many research works that have been carried out to deal with the problem of power supply to remote sensors. A 2.45 GHz voltage multiplier rectifier was validated to deliver 18V of output voltage with a conversion efficiency of 69%. Another rectenna was fabricated at 5.8 GHz of the Industrial Scientific Medical band and reach a measured voltage of 7.4V at 18 dBm. The third structure is about a series rectifier working at 2.45 GHz associated with a microstrip low pass filter which produces a supplying voltage of 11.23V. Added to the aforementioned results, the objective in this work is to design, optimize and realize two structures: A dual band patch antenna working at 2.45 GHz and 5.8 GHz, and a compact rectifier circuit at 2.45 GHz for the power supply of low-consumption devices. This rectifier has been designed using Advanced Design System. The bridge topology was employed on an FR4 substrate. A good matching input impedance was observed and high conversion efficiency was obtained. Simulation results have been validated through realization and measurements.

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INTRODUCTION

Electronics has undeniably evolved in recent years. Progress, particularly in digital electronics and circuit integration has led to more efficient, miniature and energy-efficient systems. Technological developments, combining advances in computing and digital technologies and their increasing integration into multiple objects, have led to the development of a new paradigm of systems qualified as cyber-physical systems. These systems are now being deployed on a massive scale due to the expansion of Internet of Things (IoT) applications. Cyber-physical systems are based, among other things, on the deployment of massive array of autonomous wireless communicating sensors, these have several advantages:

- Flexibility in the choice of location. They allow access to dangerous or difficult to access areas.
- Postage for cables that are heavy, bulky and expensive.
- Elimination of problems related to cables (wear, sealing, etc.)
- Easy deployment of sensor networks.

However, these wireless sensors require power autonomy to operate. Conventional techniques such as batteries or cells, ensure the operation of the sensors only for a limited time and require periodic change. This presents an obstacle in the case where wireless sensors are placed in a location where access is impossible. It is therefore necessary to find another way to permanently supply energy to these wireless sensor networks.

Wireless energy transmission (Shams & Ali, 2007) by RF wave and ambient RF energy recovery are very promising solutions for the sustainable power supply of portable communicating systems. Although the energy densities used in this case are relatively low compared to other micro-sources, RF energy offers superior performance in terms of mobility, flexibility and ease of deployment, which opens the doors to a very wide range of applications. Research on wireless power transmission began at the end of the 19th century when Hertz and Marconi noticed that energy could be transported from one point to another without the existence of any conductive means. The theoretical foundations of this phenomenon were established by Maxwell through equations established in 1862. At the beginning of the 20th century, Nikola Tesla (Tanuj Kumar Mandal, 2006) was already working on the “Wardenclyffe Tower”, the prototype of a transmitter for what he called “World Wireless System”, that would be able to provide wireless power to a remote receiver. Advances in wireless communications have greatly contributed to the development of wireless energy transmission techniques. The modern development of wireless transmission systems was largely stimulated by the advances in telecommunications and radar remote sensing that took place during World War II. It is the use of microwaves that relaunches the perspective of wireless energy transmission. In the 1960s, William C. Brown began experimenting with wireless energy transmission using microwave tubes such as magnetrons and klystrons (Brown, W. C., 1984). W. C. Brown was also the first to develop a rectifying antenna or “rectenna” in 1963 for the reception of electromagnetic waves and their conversion into direct voltage (DC). In 1964, as part of the RAMP Project, W. C. Brown’s team demonstrated an airborne platform flying at an altitude of 18 meters powered exclusively through a microwave beam from the ground (Brown, W. C., 1965).

Indeed, electromagnetic energy (Paris & Hurd, 1969) is nowadays omnipresent on our planet (Harrist, 2001), so using it as an energy source for electronic systems seems to be a plausible and feasible idea. This work is part of this concept, its objective is the design and manufacture of electromagnetic energy recovery systems for the supply of wireless sensor networks. The electromagnetic energy recovery circ-
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