Measurements through Rectenna System

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ABSTRACT

In this paper a rectenna system for wireless transmission of power is presented, describing the correlated tools for the measurement of electromagnetic fields, in order to optimize the system. The first part is dedicated to the benefits of the currently used systems based on rectenna technology as alternative to the traditional supply systems. After, the diverse structures of rectenna system and their operating modes are discussed. The major parameters of interest for a performance analysis of the rectenna, and the most appropriate tools for a correct measurement of the radiated and absorbed electromagnetic field by the rectenna are reported too.

Keywords: Electromagnetic Field, Measurement, Performance Analysis, Rectenna System, Wireless Transmission

1. INTRODUCTION

The gradual development of integrated circuits ever smaller and lower power consumption have lead to a great variety of wireless electronic devices. Often the size of such devices is particularly reduced, and the problem of how to supply them arises.

Although the technological development of batteries is addressed toward a reduction of their size and an increment of their life, the choice to use a battery is not always the best to supply such portable devices. For example in some cases, the substitution may be difficult or even impossible, and in this case the life time of the device would be solely determined by the battery life. Furthermore, the size of the instrument is strongly affected by the size of the battery itself (Tesla, 1904; Brown, 1984; Shinohara, 2006; Brown & Triner, 1982).

In this context, rectennas are introduced. The term “rectenna” is a contraction of the words “rectifying” and “antenna”, and it wants to indicate a particular antenna that uses a Schottky diode to convert the incident power at radio frequencies in continuous power. Schottky diodes are used because they are those that show a lowest voltage threshold among the diodes in commerce and so, they dissipate less power.

Typically, a rectenna includes an antenna and a circuit for the rectification, consisting of a diode (or more diodes), a small circuit for impedance matching, a capacity and a load resistor. The performance can vary depending

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on the type of used model; there are rectennas with a conversion efficiency of 30%, or those with higher performance, with a conversion efficiency of 80%. These changes of the performance depend on many factors, including the type of used antenna, the frequency and the configuration of the rectifier circuit. The principle on which rectenna is based is to exploit the electromagnetic waves already present in an environment in order to recharge, for example, a cell phone, a watch, or any electronic device instead of using a battery (McSpadden & Chang, 1994; Maten & Moll, 2005; Brown, 1986; Fujita et al., 1986).

Antennas are devices designed to radiate or capture electromagnetic energy. The radiated magnetic field in the vicinity of the antenna, i.e., at a distance less than some wavelengths, it is said induction field. The field at a great distance from the antenna is said radiation field, and it is characterized by an electric field $E$ and a magnetic field $H$ perpendicular to each other and to the direction of propagation.

In environments in which we live, many sources of electromagnetic waves are present: for example, the antennas for mobile phone, the Yagi-Uda or parabolic for transmitting/receiving radio or television and monopole antennas of the router wi-fi. This energy can be recycled by a rectenna, or rather, it uses energy already present in the environment, avoiding all the problems associated with the disposal of used batteries, and moreover saves money in the purchase of energy.

According to the specifications of the device to supply, the rectenna system can be constituted by different types of full-wave rectifiers, half-wave or hybrids.

In the rectifier circuit, the diodes are the main components which the conversion is entrusted to and therefore its efficiency. In the last years, apparatuses of straightening based on field-effect transistor are developed, called HEMT (High Electron Mobility Transistor) which allow a further increase in efficiency (Aoki et al., 1997; Xue Chin et al., 2005; Hagerty et al., 2000; Fujino & Ogimura, 2004).

1.1. Rectenna System

Rectenna devices are designed to work in the region of the far field of the transmitting antenna. The scheme of a rectenna is shown in Figure 1. To maximize the transfer of power, the characteristic impedance of the antenna is adapted to the rectifier, which is normally constituted by one or more Schottky diodes. The rectifier circuit generates a voltage which depends mainly on the level of input power and the load used in output.

A capacity is positioned in parallel with the load resistance. The values of the resistance and capacity are dimensioned to prevent the passage of the radio frequency signal to the output port. Generally, a diode rectifies the voltage more efficiently when the input power levels are higher.

If for a particular device it is not available the use of a battery, or an external power supply because a connection point is missing, the rectenna is presented as a good alternative solution in case the distances permit it.

Figure 1. Classical scheme of a rectenna
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