Chapter

Introductory Chapter: Overview of Wireless Power Transfer Technologies

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1. Introduction

The idea of Wireless Power Transfer (WPT) is not a new concept. From the end of the 19th Century, Nikola Tesla was already experimenting with the possibilities. In recent years, the concept of WPT has gained increased popularity and has raised much excitement [1–3].

Following significant advancements in wireless data transfer over the past two decades, power is the last physical connection to be eliminated. However, the obsession with wireless power is not new.

2. History

The idea dates to 1888 in a work by Heinrich Hertz. He was able to demonstrate high frequency power transfer using a spark gap and parabolic reflectors at both the transmitting and receiving ends of the system.

The more famous wireless power transfer experiment was carried out later by Nikola Tesla in 1893 [1, 2]. He spent thousands of dollars and performed public demonstrations of wireless power transfer, which earned him the title of a mad scientist.

3. Motivation

The technological breakthroughs made possible due to WPT have been fostering an increased research activity, as well as the commercialization of numerous consumer products based on these concepts.

From a research and development perspective, there are two principal fields of investigation in WPT.

The first approach comprises the underlying mechanisms of power transfer, particularly by seeking knowledge about the possible scientific methods to wirelessly transmit energy from a point to another in space.

The second approach includes the development of individual circuit modules required in a functional wireless power transmission system. This includes circuit design considering the specifics of a particular WPT mechanism, ensuring that the module has the appropriate characteristics for that power delivery mechanism.

4. System overview

There are many different types of WPT such as electromagnetic, electrostatic, electromechanical, etc. In the case of electromagnetic wireless power transfer, the systems are generally broken down into two categories of far-field and near-field power transfer [4].

In such systems, the energy transfer is accomplished through electromagnetic radiation, which for omnidirectional propagation scenario results in poor efficiency. The range that is the far-field region of a transmitter depends on the frequency of operation.

The idea behind WPT is simple. According to the Faraday's law of induction when a varying magnetic field passes through a loop it will produce a potential difference across it. In other words, a loop can harvest an alternating magnetic field which then can be converted and stored as electrostatic energy [5].

Generating, the required magnetic field can be done through Amperes law. Amperes law states that when an electric current flow through a loop, let us call it the transmitter loop, it generates a magnetic field around it.

Now, if we place a second loop, let us call it the receiver loop, in the proximity of the transmitter, an alternating voltage will appear across the receiver loop. Hence effectively transmitting power through electromagnetic waves.

5. Methods

Radio Frequency (RF): RF-based WPT is established as a technology for the transfer of power over the order of tens of meters, however, the efficiency of such systems is much lower than other WPT methods.

Inductive Power Transfer (IPT): This method utilizes the concept that an electric current driven through a coil, by virtue of the produced magnetic flux, induces an electromotive force in an adjacent coil.

Magnetic Resonant Coupling (MRC): Magnetic resonant coupling is deemed as the potential breakthrough in WPT methods [6]. The underlying concept is that two resonator circuits tuned at the same resonance frequency, can experience power transfer at higher efficiencies, at greater distances, when compared with conventional IPT systems.

6. Conclusion

Recent advancements in the semiconductor integrated circuits and functional materials technologies have accelerated the demand for electronic devices such as the internet of things (IoT) and wearable sensors, which have low power consumption, miniature size, and high data transfer efficiency.

Wireless power transfer has become the alternative solution to current electronic devices that rely on bulky batteries to supply the power and energy.

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