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Coil material and magnetic shielding methods for efficient wireless power transfer system for biomedical implant application

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ABSTRACT

In this paper, a passive shielding method is presented to minimize the magnetic field around the transmitting (Tx) and receiving (Rx) coil of wireless power transfer (WPT) system for biomedical implant application. Different conductive materials for coil construction, as well as dielectric materials for shielding, are being considered to improve WPT performance. Several cases of WPT coils have been examined using the simulation approach at 800 kHz and 6.78 MHz in the existence of a pacemaker casing with and without a magnetic shield. According to simulated results, it is found that high conductivity coils and high permeability shield materials are excellent materials for increasing the WPT system's efficiency. The results of the simulation method and physical measurement in Lab are validated using an analytical method. The efficiency obtained by using simulation method is very close to that obtained using the analytical method. The voltage gain obtained using an analytical and a simulation method at 800 kHz and 6.78 MHz is very close to the actual measurement in the lab. It is found that the WPT efficiency at 6.78 MHz is higher as compare to 800 kHz.

1. Introduction

Wireless Power Transfer (WPT) is a technique that allows a power source to send electromagnetic energy through an air gap to an electrical load without the need of wires. This technology is gaining popularity and may be used in a variety of fields, including industrial applications, consumer goods, and medicinal implants. In medical field, biomedical implanted devices are becoming more prominent. The main purpose of a wireless power transfer system is to transmit power more efficiently through human muscles to recharge a biomedical implant's battery. The coil and shield materials used in WPT are vital for improving efficiency (Haerinia and Shadid, 2020; Moore et al., 2019; Pokharel et al., 2021). This study has focused on selection of coil and shield material.

Magnetic shielding methods are commonly used to reduce magnetic fields (EMF noise) around the coils, reduce eddy current losses, enhance mutual inductance, coupling coefficient, and significantly improve WPT system performance. Various magnetic shielding methods for WPT system including, passive, active, and reactive resonant current loop methods have been developed and reported in the literature (Campi et al., 2016; Cruciani et al., 2019; Fadhel et al., 2019; Zhou et al., 2020).

According to Faraday's law, the magnetic fields generated by the primary (Tx) coil induce the voltage in the secondary (Rx) coil, which is located above the pacemaker's metallic enclosure. The exposed magnetic field in the pacemaker's metal casing induces the eddy currents. These currents generate magnetic fields in the opposite direction of the original field, leading to a reduction in net fields. As a result, overall WPT performance can be decreased (Maaβ et al., 2017).

The most common remedy to this issue is to isolate the pacemaker metal enclosure from the WPT system; however this is not really the most practical solution for recharging the pacemaker battery. Another solution to avoid eddy current in the pacemaker metal casing is to introduce a high permeability material that serves as a shield between the secondary (Rx) coil and the pacemaker metal casing. As a result, passive shielding using various permeability materials is used in this paper to examine the WPT performance.

According to the literature (Campi et al., 2016; Cruciani et al., 2019; Fadhel et al., 2019; Maaβ et al., 2017; Zhou et al., 2020), passive shielding method is more relevant and appropriate than other methods for biomedical applications. As passive shield methods are simple in design, less complex, and therefore can be easily fabricated. While other methods are mostly employed for portable devices like cell phones and battery charging for electric vehicles (EVs)(Cruciani et al., 2019).

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