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THE INFLUENCE OF SOFT ENCAPSULATION MATERIALS ON THE WIRELESS POWER TRANSFER LINKS EFFICIENCY

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ABSTRACT

As the era of Bioelectronic medicines (BEms) evolves, new technological challenges are generated, including miniaturized devices that are encapsulated with flexible materials and energized by wireless power transmission (WPT) techniques. Among them, magnetostatic, also known as inductive, and ultrasound (US) are the most viable candidates for shallow and deep applications, respectively. However, the conductive nature of the human tissue with high relative permittivity increases the parasitic components of the printed spiral coils (PSCs), while the acoustic impedance mismatch between the tissue and ultrasound transducers leads to power losses in the WPT link.

This study focuses on the influence of biocompatible, soft, polymeric materials, such as polydimethyloxane (PDMS) and Parylene-C, on the electrical behaviour of the aforementioned externally powered receivers. Unlike previous works, this investigation includes the high gas permeability property of polymers, predicting the electrical impact of moisture absorption. Analytical and simulation models are utilized to discriminate the effect of various packaging schemes and to relate their influence on the WPT link efficiency. Lastly, empirical measurements in air and saline aim to verify the proposed methods.

Early modelling results demonstrate that when a PSC is encapsulated with 50 μm PDMS and submerged into saline, its resonance frequency and quality factor are decreased by 3.6% and 34.2%, respectively. That renders the maximum theoretical WPT link efficiency to be reduced by 9%, compared to free-space propagation in air. Interestingly, when the coating thickness increases to 500μm, the WPT link efficiency drops only by 2.4%.

In the case of US, similar effects are predicted, yet the influence of the coating materials will be different. More specifically, their acoustic impedance decreases the US transducers' natural frequency of vibration and mechanical quality factor, due to the effect of added mass. In addition, when the coating thickness increases towards the wavelength of the incident US wave inside the material, the aforementioned effects become more evident.

The outcome of this study aims to address the contributing factors on the WPT link power losses from the electronics packaging perspective and to suggest on how the effect of the surrounding medium could be mitigated, improving the WPT link efficiency.