Array of Non-Resonant Coils for Receiver Size Reduction in Wireless Power Transfer Applications

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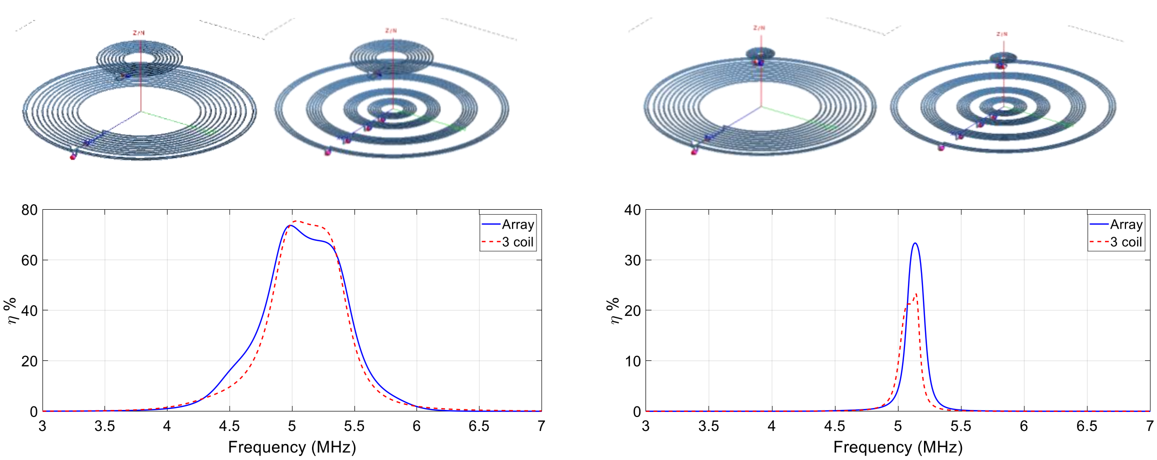
In Inductive Wireless Power Transfer (WPT) devices for biomedical implants, the size of the implanted receiver coil is a major concern. Although having large receiving area is useful to increase the mutual coupling with the transmitting coil (and, consequently, the overall efficiency), numerous implants (such as retina or hippocampus implants) require a very small form factor due to the limited available space. Further, the size of a foreign object inside human tissue is directly correlated to the probability to face tissue inflammation, damage, and cell death, especially for neuroprosthetic devices that directly interface with the neural tissue.

Typical 3-coil systems for biomedical implants found in the literature utilize a receiver of dimensions of the order of centimeters. To overcome this limitation, we propose a planar array made by concentric and non-resonant loops, able to focus the magnetic field. By replacing the transmitting coil with an array of N non-resonant concentric loops, the current amplitude for each array element can be independently controlled through a reactive load. In this way, it is possible to achieve focused magnetic field distributions and non-conventional behaviors for gain and efficiency as a result of the additional degrees of freedom given by the choice of the geometry and the current amplitude for each array element. Specifically, if the driver and the receiver are both maintained resonant at the same working frequency, the load for each array element can be expressed as:

$$Z_{ii} = \left(- \sum_{j=1, j \neq i}^{N} c_j Z_{ij} \right) \Big/ c_i , \qquad with \quad i = 1, 2, \ldots, N \tag{1}$$

where c_i is the i-th coefficient weighing the current amplitude for the array element i and Z_{ij} is the mutual impedance between the array elements i and j. We demonstrate that such a configuration achieves better efficiency compared to a standard 3-coil system when the receiver size is progressively reduced (Fig. 1). This result can pave the way towards safer and less invasive WPT devices for biomedical implants; further studies will be directed to apply the proposed solution to realistic scenarios.



(a) (b)

Figure 1. The focusing array configuration outperforms a traditional 3-coil system of the same external size (40 mm diameter) when the receiver diameter is progressively reduced from 15 mm (case a) to 5 mm (case b).