The design of high efficient resonator using multiple reactive loadings for wireless power transfers

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In recent several years, the techniques of wireless power transfer (WPT) have been researched for various charging applications such as smart phones, consumer electronics, and even electric vehicles, especially since the paper of WPT through magnetic resonance coupling was published by Prof. Soljacic at MIT in 2007. From the point of view of magnetic resonance coupling theory, both the quality factors of transmitter and receiver resonators should be high enough to realize high efficient WPT, and the coupling coefficients between the resonators should be high as well. However, it is difficult to implement high efficient WPT resonators surrounded by metallic components within the limited space in the compact multi-function applications. This paper presents a novel technique to design high efficient resonators using multiple reactive loadings for WPTs.

Conventionally, a multi-turn spiral coil was used in order to increase the intrinsic inductance of the coil for WPT, which carries out a high quality factor resonator at the same operating frequency. However, a simple multi-turn coil cannot easily adjust neither the current flow on the coil nor the magnetic field distribution over the coil. For example, in order to distribute both the current and the magnetic field uniformly over the resonator, a lot of coil design factors such as the line width, pitch, and gap between each line of the coil, etc. should be considered due to the mutual coupling between nearby the coil conductors and the proximity effect itself. The proposed method for high efficient WPT resonators utilizes multiple reactive components to drive the appropriate amount of current into a desired direction or to suppress the current in undesired direction. The equivalent lumped circuit model of a coil using the proposed method can be expressed as the connection either in parallel or in a combination of both series and parallel connections with loading multiple reactive components. The current on each branch can be adjusted through loading reactive component. For example, the improvement of simulated quality factor of a coil with 5 branches and loading reactive components with respect to a same size of one turn coil is about 32%. When placing the proposed receiver resonator on a transmitter resonator, the resonator coupling efficiency with multiple loadings is improved by 18.3% comparing to a same size of one turn coil. The proposed method could also be used to increase the tolerance of lateral misalignment for good performances between transmitter and receiver resonators.