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Selective magnetic field localization for safety enhancement in wireless power transfer applications

A. L. A. K. Ranaweera

Department of Physics, Faculty of Science,
University of Kelaniya, Sri Lanka
arunaran@kln.ac.lk

During the last decade wireless power transfer (WPT) has been immerged as one of the rapidly growing area of research. Wide range of its commercial applications such as charging pads, are appearing in market today. The operating principle of WPT is based on resonant inductive coupling which use evanescent magnetic field patterns. However, inherent magnetic flux leakage in it makes concerns on human safety. Therefore, there is a higher demand for selective wireless power transfer where only the intended receiver location is powered. To that aim, a mechanism is needed to precisely focus the magnetic field into the receiver location. The currently available WPT applications lack the precise spatial control of magnetic field. Therefore, in this study, novel method of magnetic field localization is proposed to reduce the magnetic flux leakage into the surrounding area other than the intended receiver location. Several methods have been reported recently for light localization in the deep sub wavelength scale using the capabilities of metamaterials. Metamaterials are a kind of artificially designed material which provides unique and exotic electromagnetic properties such as negative refraction, evanescent wave amplification. Metamaterials usually studied under effective medium approach has previously been successfully utilized in several applications including superlensing, sub-wavelength imaging beyond classical diffraction limit and wireless power transfer. Metamaterials shown to exhibit the well known hybridization bandgap above its resonance arising from the Fano type interference between continuum of plane waves and locally resonating unit cells. By creating a local cavity within the hybridization bandgap, it is possible to localize the magnetic field into the cavity location. Using this property, we propose a method to precisely localize the magnetic field on to surface of the metamaterial where the cavity is created. We utilize active metasurface which can be externally controlled to realize a local cavity within the hybridization bandgap. The proposed metasurface is fabricated with standard PCB fabrication process and experimental investigation is carried out to obtain the spatial distribution of magnetic field. To obtain experimental results, we place the fabricated metasurface in between Tx and Rx of WPT system which is connected to two ports of vector network analyzer. We use small loop coil as receiver loop to make the measurements non-invasive. Spatial distribution of magnetic field is extracted from the measured scarring matrix parameters using the Keysight 5063A vector network analyzer. The results indicated that the magnetic field can be precisely localized to the intended location. We believe that this can be used to improve the safety of wireless power transfer applications.

Keywords: Wireless power transfer, Metamaterials, Hybridization bandgap, Filed localization