Structural Optimization of Wireless Power Transfer Using 3D-Printed Metamaterials

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When cables and wired power delivery present safety or practicality issues, such as in biomedical implants or robotics applications, Wireless Power Transfer (WPT) using metamaterials (engineered structures with internal properties that can enhance the range of WPT) offers a very promising alternative. However, printed circuit board (PCB) processes are usually used to fabricate the aforementioned metamaterial (MTM) slabs that are required to improve WPT efficiency. These processes typically cost approximately $0.20 per square centimeter, or approximately $100 for a basic 9x9 inch slab, which heavily limits widespread deployment. The purpose of this study was to determine whether a 3D-printed square spiral resonator MTM slab could replicate at least 80% of the capacity of a PCB-fabricated metamaterial at a significantly lower cost. Using 3D printing and hand wiring, a 4x4 array of 55x55 mm unit spirals, each with a 9-turn 30 AWG LC resonating circuit, was created for less than $10. An Analog Discovery 2 (AD2) was used to measure the Power Transfer Efficiency (PTE) between a transmitter coil and a receiver coil over nine distances (10–50 cm in steps of 5 cm) in three different scenarios: no MTM, MTM middle placement, and MTM front placement. The 3D-printed MTM slab exceeded the 80% capacity threshold at all tested distances, improving mean PTE by approximately 12.5 percentage points over baseline and achieving approximately 87.5% of the PCB benchmark performance. These findings show that industrial metamaterial performance can be meaningfully replicated for WPT enhancement using easily accessible and inexpensive fabrication techniques.

Awards Won:
Third Award of $1,200