Lower Frequency Metamaterial-Inspired Magnetic-Based EZ Antennas

Chia-Ching Lin * *and Richard W. Ziolkowski*

Department of Electrical and Computer Engineering, The University of Arizona
1230 E. Speedway Blvd., Tucson, AZ 85721, USA
E-mail: cclin@ece.arizona.edu, ziolkowski@ece.arizona.edu

Many applications have been proposed that use metamaterials (MTMs), artificial materials having engineered electromagnetic properties, to obtain a desired, but unusual electromagnetic behavior. For instance, metamaterial-inspired efficient electrically small antennas have been proposed (A. Erentok and R. W. Ziolkowski, IEEE Trans. Antennas Propag., pp.691-707, 2008) which have led to an efficacious, electrically-small antenna design methodology and have drawn much attention. The main innovation of those designs was the introduction of an electrically small, resonant metamaterial-inspired parasitic element in the very near field of an electrically small radiator. The metamaterial-inspired parasitic structure provides the means for the antenna system to be resonant (reactive matching) and resistive matched to the source (e.g., 50Ω), without any external matching network. Inspired by the properties of MTMs and the ideas associated with this kind of antenna, we have extended the 3D magnetic-based EZ designs from their successful UHF frequency versions down to the VHF and HF frequency bands.

The resonance frequency of the magnetic-based EZ antenna is given by the expression: $f_0 = 1/(2\pi\sqrt{L_{eff}C_{eff}})$, where L_{eff} and C_{eff} are, respectively, its effective inductance and capacitance. Consequently, the basic design concept to lower the operating frequency of the magnetic-based EZ antenna is to change the capacitance of the metamaterial-inspired, resonant, near-field parasitic element. For the 3D case this means to change the capacitance of the extruded capacitively loaded loop (CLL) element, while for the 2D case it means to change the value of the lumped element capacitor associated with the CLL element. As a result, one could, in principle, scale the antenna design to other frequencies simply by changing these effective capacitance values. For instance, in the 3D case this can be accomplished by filling the capacitor gap with a dielectric slab. Based on this design concept, several 2D VHF antennas were built using Rogers 5880 Duroid™ board material having a 31mil (0.787mm) thick substrate and traces consisting of 0.5 oz electrodeposited copper (17μm thickness). Additionally, several 300MHz 3D antenna were fabricated by filling in the dielectric gap with a quartz dielectric spacer. Not only did the quartz spacer provide the desired lower capacitance, it also enhanced the mechanically stability of the fabricated structure. For both the 2D and 3D cases, the ka value was smaller than 0.5. Good agreement between the simulation and experimental results was obtained. A series of realizations and designs of the 3D antenna and the corresponding measured results will be explained and reported in our presentation.