Study of Reactive Loading for the Miniaturization of Folded Dipole Antennas

Sanghamitro Das* [(1)], Ashwin K. Iyer[(1)], A. Peter Annan[(2)], and Nectaria Diamanti[(2)]
(1) University of Alberta, Edmonton, AB, Canada, T6G1H9
(2) Sensors & Software Inc., Mississauga, ON, Canada, L4W2X8

Folded dipole antennas have found widespread use due to their moderate-to-high input impedance and wider-band frequency response compared to single dipoles, and are preferred in several applications such as VHF FM broadcast systems and as the driven element of Yagi antennas. Although they are typically operated at their half-wavelength resonance frequencies, several miniaturization techniques have been explored to make folded dipole antennas more compact at low frequencies. The simplest such techniques employ inductive loading, meandered or bent shapes (S. R. Best, IEEE Antennas and Propagation Magazine, Vol. 47, No. 4, Aug. 2005), and more recently, metamaterials (T. Kokkinos and A. P. Feresidis, IEEE Trans. on Antennas and Propagation, Vol. 57, No. 10, Oct. 2009). One application that may benefit tremendously from the use of miniaturized folded dipole antennas could be low-frequency ground-penetrating radar (GPR), where compactness and portability are crucial factors and low bandwidths/efficiencies due to miniaturization are usually addressed by using resistive loading and/or high input voltages.

In this work, we examine reactive loading of folded dipole antennas with the goal of creating usable resonances exhibiting electric-dipolar radiation patterns at frequencies much lower than their usual half-wavelength resonances. It is shown that inductive and capacitive loading may be used in conjunction to enable substantial miniaturization, such that the antenna retains a dipole-like radiation pattern with good matching but over expectedly narrow bandwidths. The bandwidths and impedance response of these miniaturized antennas when resistively loaded are then examined for their suitability in wider-band applications such as impulse GPR. Full-wave parametric studies were performed using Ansys HFSS for different reactive- and resistive-loading cases, as well as studies creating asymmetries to improve their radiation performance. Finally, we provide an equivalent-circuit model invoking even-/odd-mode analysis of the miniaturized folded dipole that allows the option of including reactive and/or resistive loading.