EFFICIENT ELECTRICALLY SMALL ANTENNA DESIGN USING A DIPOLE ANTENNA LOCATED NEAR AN EPSILON NEGATIVE (ENG) SPHERE

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A metamaterial-based electrically small antenna design using a shell of homogenous, isotropic double negative medium (DNG) was first introduced analytically in (R. W. Ziolkowski and A. Kipple, Application of double negative metamaterials to increase the power radiated by electrically small antennas, IEEE Trans. Antennas Propagat.,vol. 51, no. 10, pp. 2626-2640, October 2003). Different from the classical ideas; such as using passive or active lumped elements to obtain a matching network, a DNG shell medium was used as a distributed matching element to the electrically small dipole antenna to obtain large radiated power efficiency and large fractional bandwidth. A different design methodology that replaced the DNG shell with an epsilon negative (ENG) shell was introduced in (R. W. Ziolkowski and A. Erentok, Metamaterial-based efficient electrically small antennas, submitted to IEEE Trans. Antennas Propagat., June 2005). Here, we extend this concept by introducing an electrically small cylindrical dipole antenna antenna outside of an ENG sphere.

It will be shown that the antenna-ENG sphere system may have advantages over the previously presented dipole-ENG shell work for practical implementations. A finite element model, ANSOFTs High Frequency Structure Simulator (HFSS), was used as the computational electromagnetic (CEM) modeling tool for this investigation. The antenna-ENG sphere system was designed at 300MHz using an electrically small cylindrical dipole antenna with a length located next to an ENG sphere with a radius . The ENG sphere located at the origin and the front face of the antenna was placed a distance h from it along the y-axis. The resonant interactions of dipole-ENG sphere system were studied for different h values. A resonant dipole-ENG sphere system showed a 64dB radiated power gain at 300MHz agreeing with the previous dipole-centered-ENG shell results.

It will also be demonstrated that for a given electrically small antenna, the distance h can be optimized to produce an electrically small system with a zero input reactance and an input resistance that is matched to a specified source resistance and that these antenna resonances occur where the corresponding radiated power gains and radiation efficiencies are maxima. The radiation patterns of the dipole antenna do not show any degradation at the far-field region. The quality factor and the fractional bandwidth of this dipole-ENG sphere system and its comparison to the Chu limit with and without dispersion characteristics will be discussed.

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