MODIFIED LOG-PERIODIC DIPOLE ARRAY ANTENNA FOR WIDE BAND PULSE RADIATION

Peng Jin and Richard W. Ziolkowski*

Department of Electrical and Computer Engineering, The University of Arizona
1230 E. Speedway, Tucson, AZ 85721-0104 USA
E-mail: pjin@ece.arizona.edu, ziolkowski@ece.arizona.edu

The log-periodic dipole array (LPDA) is well known for its straightforward structure and nearly unlimited bandwidth expandability. Despite its wide frequency-domain bandwidth, the LPDA will cause significant distortion in wideband pulse radiation applications due to its inherent frequency dispersion properties. The LPDA dispersion phenomenon was discussed, for instance, in (C.M Knop, IEEE Trans. Antennas Propag., pp. 807-808, 1970). To address this problem, G.J Burke introduced a LPDA with modified distances between dipoles in 1990; P.S. Excell, A.D. Tinniswood and R.W. Clarde showed a LPDA with an independent feeding circuit in 1999, and T.W Hertel and G.S. Smith applied a pre-distortion pulse technique in 2003. In this presentation, inspired by the properties of metamaterials (MTMs) and their realizations, we are able to provide a different and more straightforward solution to the dispersion engineering problem of an LPDA.

An infinitesimal dipole is used for a dispersion free reference antenna. A fidelity function is defined to measure the likelihood between the received pulse in far field of LPDA antenna and this reference antenna. An LPDA with eight printed dipoles is analyzed using ANSOFT's High Frequency Structure Simulator (HFSS) and its far field is calculated based on the currents measured by the HFSS Field Calculator. A MATLAB analysis is also performed using Carrel's circuit model (R.L. Carrel, UIUC Ph.D. thesis, 1976). The two analyses give consistent results and both show the distortion in the received pulse compared to the pulse from the reference antenna. By introducing a modified circuit model for an LPDA antenna, we are able to analyze LPDA antennas modified with left-handed and right-handed phase shifters analytically with MATLAB simulations. The phase shifters are applied to adjust the phase centers of the LDPA elements such that in the far field, main beam direction, all of the phase centers are approximately adjusted to the same point. A differentiated Gaussian pulse is exploited as the excitation current source and the analysis frequency range is between 1GHz-4GHz (for an eight element LPDA) and 0.5GHz-4.5GHz (for a 10 element LPDA). Analyses have been performed for LPDA antennas with eight and ten elements. Significant fidelity improvements have been demonstrated for both cases. Because the distortion is more severe for an LPDA antenna with more elements, the improvement is more impressive for the LPDA with ten elements. These results will be reviewed in our presentation. Considerations on the process of finding the appropriate phase shifter values will also be presented.