TAILORING DOUBLE NEGATIVE METAMATERIAL RESPONSES TO ACHIEVE ANOMALOUS PROPAGATION EFFECTS ALONG MICROSTRIP TRANSMISSION LINES

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In the past few years, there has been a renewed interest in using sub-wavelength structures to develop materials that mimic known material responses or that qualitatively have new response functions that do not occur in nature. These efforts include the realization of double negative (DNG) metamaterials, artificial materials whose effective permittivity and permeability are both negative. These DNG metamaterials exhibit an effective negative index of refraction that can be tailored to a specified frequency regime.

We have investigated the performance of microstrip transmission lines loaded with DNG metamaterials formed by embedding capacitively loaded strips (CLSs) and capacitively loaded loops (CLLs) in the substrate region. It has been demonstrated theoretically and experimentally that a suitable arrangement of these components in Roger's 5880 DUROID (ε_r=2.2) produces (theoretically and experimentally) a negative index of refraction in the X-band. Similar behavior has been demonstrated theoretically in an open waveguiding environment associated with a microstrip transmission line operating in the S-band.

The DNG metamaterial loaded microstrip transmission line problem will be reviewed in detail. Simulations based on Ansoft's High Frequency Structure Simulation (HFSS) tools will be used to characterize the S-parameter performance of this configuration. It will be shown that a matched metamaterial can be obtained that yields complete transmission in a specified frequency region (S-band). Furthermore, it will be shown that a transmission line lumped element model can be used to extract the effective permittivity and permeability in that regime. Cases will be shown that generate DNG values in the matching region and, hence, that have a negative index of refraction there. Potential applications to modify the shape of signals propagating along these DNG loaded metamaterial microstrip transmission lines will be described.