Stability Analysis of Non-Foster Circuit Loaded Artificial Magnetic Conductors

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The mushroom-type artificial magnetic conductor (AMC), originally presented by Sievenpiper et al., (IEEE Trans. Microwave Theory Tech., 47, pp. 2059-2074, 1999) has found numerous applications, e.g., underneath horizontally polarized antennas, between planar antennas for reducing the coupling between them, for reducing the E-plane edge diffraction from finite ground planes, and for suppression of noise in multilayer circuits. Recently the AMC loaded with negative-inductor non-Foster circuits (NFCs) was investigated for substantial reduction of the resonant frequency and for increasing its bandwidth (Gregoire et al., IEEE Antennas and Wireless Prop. Lett., 10, pp. 1586-1589, 2011). The objective of this work is to investigate the stability of the active circuit loaded AMC (AAMC).

The surface wave propagation in the AMC structure has been modeled in the form of a multi-conductor transmission line in the prior literature. In particular, it has been shown that each mode of propagation in the multi-conductor line can be considered as a combination of two pure modes, a backward wave mode propagating primarily within the surface and a forward mode that resides primarily on the surface (Ramprasad and Petras, IEEE MTT Symposium Digest, 2005). At the bandgap frequencies, the two modes couple resulting in no propagation. Their work demonstrates that a single transmission line representing the lower layer predicts the backward wave very accurately up to the bandgap frequency, and it provides a justification for using a single transmission line model for our stability analysis.

We used the commercial finite element code HFSS and method of moments code IE3D to determine the circuit elements of the transmission line model of a unit cell of the AMC structure along with the non-Foster loads based on the prior work by Gregoire et al. We employed the ABCD parameters of the unit cell consisting of a series impedance model of the gap between the conducting patches in parallel with the NFC load, a length of transmission line, and the via inductance. From this model, the propagation characteristics of the backward wave mode and the Bloch impedance have been determined. The stability of the structure has been investigated in the time domain and in the frequency domain for different termination conditions. We will present results of our investigation on the stability of finite and infinitely long AAMC structures.