Miniature Antenna Using Coupled Microstrip Lines Emulating Magnetic Photonic Crystals

Erdinc Irci*, Kubilay Sertel, and John L. Volakis
ElectroScience Laboratory, Dept. of Electrical & Computer Eng.,
The Ohio State University, Columbus, OH, 43212

Growing demand for smaller and multifunctional antennas with reasonably high gains and largest obtainable bandwidths (determined by the fundamental Chu-Harrington limits) is of recent interest in antenna design.

Towards this effort, artificial materials have been explored for antenna miniaturization, including negative index metamaterials and electromagnetic or photonic band gap materials in bulk or printed form. However, the perennial challenge of small bandwidth, particularly as the antenna size is reduced, continues to be a major challenge. In a recent study (G. Mumcu, K. Sertel, and J. L. Volakis, 2008 IEEE Antennas and Propagation Society International Symposium, San Diego, CA, USA) a combination of printed coupled/uncoupled microstrip (MS) line sections were used to emulate a unit cell of a degenerate band edge (DBE) photonic crystal for wave slow-down. Using these coupled lines in place of a single printed line, a loop is formed to realize an antenna with much lower resonance frequency. However, the demonstrated miniaturization is achieved at the expense of reduced usable bandwidths.

To increase bandwidth without affecting the size of the DBE antenna, in this work, we propose a new design utilizing the magnetic photonic crystal (MPC) dispersion. This is done by replacing the dielectric substrate of the coupled line sections with a ferromagnetic one. Nonreciprocal wave propagation is therefore realized with asymmetric dispersion characteristics of the periodic unit cell. As the dispersion diagram has non-zero slope at the resonant ($K = \pi$) frequency, higher bandwidths are achieved. Also, better matching can be achieved in presence of ferromagnetic substrates (with $\mu_r > 1$). Further, as the ferromagnetic substrate is used only for the coupled line sections, magnetic losses are minimized. In the presentation, we will detail the design process and compare gain, size and bandwidth performance with and without magnetic biasing of the ferromagnetic substrate.

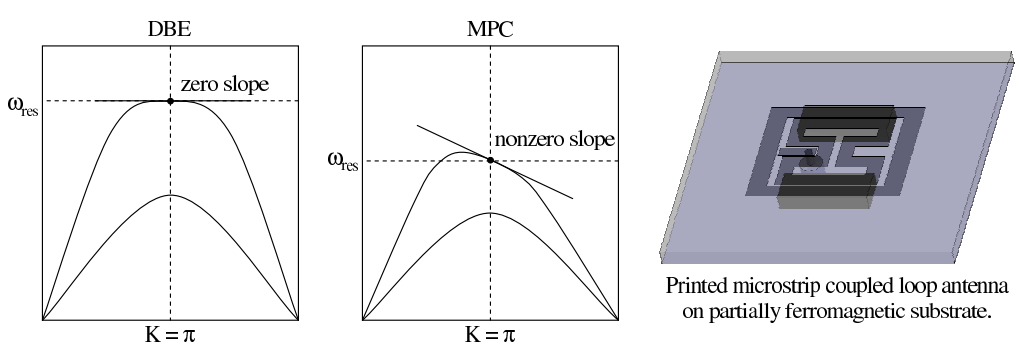

Figure 1: Dispersion diagrams of DBE/MPC antennas and proposed antenna layout.