Design of Dual-band Linearly and Circularly Polarized Microstrip Patch Antennas Using Uniplanar Metamaterial-Based EBGs

Stuart Barth, Braden P. Smyth, and Ashwin K. Iyer*
Department of Electrical and Computer Engineering, University of Alberta
Edmonton, Alberta, Canada

Advances in metamaterial (MTM) design have allowed for a high level of control in engineering specific dispersive properties through reactive loading of a host transmission-line (TL) medium. In particular, a uniplanar 1D MTM, rigorously modelled with multiconductor TL (or MTL) theory, has been shown to produce a large bandgap by employing the contra-directional coupling of a forward parallel plate waveguide (PPW) mode with a backwards or left-handed co-planar waveguide (CPW) mode. The resulting MTM acts as an electromagnetic bandgap (EBG) structure that not only has predictable dispersion characteristics, but is also highly miniaturizable and entirely printable. This work takes advantage of the above properties by integrating the MTM-EBG onto the radiating edges of microstrip patch antennas as a novel means of realizing dual-band behaviour, and has been successfully applied to both linearly and circularly polarized patch geometries.

The linearly polarized MTM-EBG patch exhibits two resonances: a high-frequency resonance when the MTM-EBG is in its bandgap region and a lower-frequency resonance when the MTM-EBG is in its passband region, as the patch appears to be electrically longer. Furthermore, the addition of a carefully designed MTM-EBG section onto the feed side of the rectangular patch allows for a high level of impedance matching at both frequencies. Measurements of both return loss and the radiation patterns agree well with full-wave simulation results.

A circular patch is also lined along the outer edge with a radial variation of the MTM-EBG, and the dispersive properties of the cells again allow for the design of two arbitrary operating frequencies, both of which exhibit circular polarization. The choice of the L1 and L2 GPS frequencies demonstrates a useful application for this antenna, and simulation results show that sufficient bandwidths are achieved at both frequencies for practical use.

In both cases, the resulting dual-band antenna follows a systematic design procedure, is fully uniplanar, and employs small enough reactive-loading values to be entirely printed. The novel method of design as well as the practical results, in good agreement with measurement, suggest many further applications of this MTM-EBG in multiband microwave devices and antennas, which shall be discussed at the conference.