Loss-Reduction and Dispersion Control for Minimum Beam Squinting in Infinite-Wavelength CRLH Beam Forming Networks

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Over the past five years, metamaterial (MTM) have enabled a host of novel electromagnetic concepts and microwave applications (C. Caloz and T. Itoh, *Electromagnetic Metamaterials, Transmission Line Theory and Microwave Applications*, Wiley Interscience & IEEE Press, 2005).

One of these novel MTM concepts is the phenomenon of infinite-wavelength propagation (or resonance) occurring in composite right/left-handed (CRLH) MTMs at the transition frequency between the left-handed (LH) and the right-handed (RH) bands, which has allowed for instance, for the first time, true broadside radiation with efficient full-space scanning in a leaky-wave antenna (see ref. above). Recently, this concept of CRLH infinite-wavelength – or more generally of phase compensation along an artificial transmission line (TL) - has been applied to a series-type power divider having naturally all outputs naturally balanced both in phase and amplitude (A. Lai, K. M. K. H. Leong, and T. Itoh, "A novel n-port series divider using infinite wavelength phenomena," *IEEE MTT-S International,* June 2005; M. A. Antoniades and G. V. Eleftheriades, "A broadband series power divider using zero-degree metamaterial phase-shifting lines," *Microwave Wireless Compon. Lett.*, vol. 15, no. 11, Nov. 2005.) The fundamental benefit of such a divider is that the distance between the divider's outputs can be arbitrary, which may be useful to design sparse arrays with nonuniform spacings or to offer an alternative to conventional corporate feeding networks.

The present contribution presents an infinite-wavelength divider used as a serial CRLH beam-forming network (BFN) and implemented in CPW technology on a 2-mil thin substrate. This BFN will be integrated in tensioned membrane antennas for space applications. Two aspects are demonstrated. First, despite larger per-unit-length loss, the overall CRLH series BFN can exhibit a better power loss budget than that of a conventional corporate feeding network, due to the much shorter overall lengths to the antenna elements. Secondly, the CRLH dispersion curve of the BFN can be designed to minimize the beam-squinting of the complete array antenna. It should be noted that beam-squinting minimization requires minimization of the frequency dependence of the propagation constant ($\partial\beta/\partial\omega \to 0$, or $v_g \to \infty$) and not simply the suppression of dispersion ($\partial\beta/\partial\omega$ = const.), and clearly has limitations. However, the group velocity can be theoretically arbitrarily large (larger than c for instance) in a completely artificial structure. Various serial CRLH BFN architectures are presented and compared.