STUDY OF SLOW WAVE PROPAGATION IN A METAMATERIALS-BASED ELECTRONICALLY-CONTROLLED TRANSMISSION LINE

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Recently, left-handed metamaterials (LHM's) have been spotlighted due to their interesting natures, such as negative refractive index and backward propagation. A backward propagation of fast wave can be used for antenna applications. We recently proposed a backfire-to-endfire leaky-wave (LW) antenna by using a composite right/left-handed (CRLH) concept, in which lower frequencies operate in the left-handed (LH) region and higher frequencies operate in right-handed (RH) region. Despite its full-space scanning capability, it had a limitation in practical applications since a scanning angle is a function of a frequency. For this reason, we developed an electronically-controlled transmission line (TL) which is an extension of CRLH TL. The CRLH TL is represented by a series capacitance/ shunt inductance and a physically unavoidable series inductance/ shunt capacitance. In that sense, since propagation constant becomes a function of capacitive and inductive parameters, we can manipulate propagation constant by introducing varactor diodes to change capacitances. Therefore, the proposed structure, as a LW antenna application, is able to radiate backward to forward through broadside, by varying the bias voltages at a fixed frequency. In addition, it provides a beamwidth control capability with non-uniform bias distribution.

Since LW antennas radiate only in the fast wave region ($|\beta| < k_0$), we were mainly interested in this radiation region. In this paper, we investigate the electronically-controlled TL in the slow wave region ($|\beta| > k_0$). It is previously reported that a phase in the LH region is advanced, while a phase in RH region is delayed. The slow wave factor (SWF, $|\beta|/k_0$) is plotted versus a frequency or a bias voltage, from the measured S-parameters at different bias voltages. The SWF in the LH region is typically higher than the SWF in the RH region and the phase slope can be adjusted with capacitive and inductive parameters. In the proposed electronically-controlled TL (in effect, a phase controller), the SWF in the LH region is varied from 1 to 6 by tuning the bias voltage at a fixed frequency. It is observed that the range of SWF in the LH region decreases, as a frequency is lower.

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5. This is an invited paper organized by John Volakis and George Eleftheriades in "Metamaterials and other complex materials"