Circuit Equivalence of "Growing Exponential" in Pendry's Lens

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Pendry in his paper (*Physical Review Letters*., vol. 85, No. 18, pp. 3966-3969, 2000) put forward an idea for a lens made of a lossless metamaterial with negative refractive index (also referred to in the literature as "double-negative (DNG) material), and he concluded that under certain parameter conditions such a lens can provide focusing with resolution beyond the conventional limit. In his analysis, the evanescent wave inside the slab of lossless DNG material is "growing", and thus it "compensates" the decaying exponential outside the slab. This issue of "growing exponential" has been the subject of debates among several groups interested in metamaterial research.

We have been interested to examine the issue of "growing exponential" in such a slab from the transmission-line viewpoint, and to analyze a set of distributed circuit elements representing evanescent wave interaction with a lossless slab of double-negative (DNG) medium. Considering the TM case as a case study, one can show that a TM evanescent wave in a conventional "double-positive (DPS)" medium can be treated with an equivalent transmission-line model with series capacitance and shunt capacitance, i.e., a C-C transmission line, while an evanescent wave in a DNG medium can be modeled as a transmission line with series inductance and shunt inductance, i.e., a L-L transmission line. So the equivalent TL model for the TM evanescent wave interaction with the DNG slab in Pendry's problem may consist of a finite segment of L-L line, representing the DNG slab for the evanescent wave, sandwiched between two semi-infinite segments of C-C lines, representing the outside DPS regions for the evanescent wave. We have analyzed such a lossless TL structure, and have examined the possibility of growing exponential term for the voltage and current distributions along a segment of this TL structure. Our analysis shows that under certain conditions the current in series elements and the voltage at the nodes may have the dominant increasing term in the L-L line segment and the dominant decreasing term in the C-C line segments, due to the suitable resonance in the lossless circuit.

In this talk, we will present some of the key features and results of our study on this TL analogy for evanescent wave interaction with metamaterials.