RESOLUTION BOUNDS TO IMAGING WITH NEGATIVE-REFRACTIVE-INDEX TRANSMISSION-LINE LENSES

Anthony Grbic, George V. Eleftheriades
Dept. of Electrical and Computer Engineering, 10 King's College Road, University of Toronto, Toronto, ON M5S 3G4, Canada

Abstract Submission Form

2004 National Radio Science Meeting

Abstract: eleftheriades15557

Date Received: September 23, 2004

The perfect lens concept proposed by John Pendry in 2000 has captured the imagination of the scientific and technical communities alike [1]. Since then, numerous questions were raised concerning the issue of how close one can approach the perfect lens concept in practice. In a recent experiment, a negative-refractive-index (NRI) transmission-line (TL) lens was used to demonstrate imaging beyond the diffraction limit at microwave frequencies [2]. This experimental device consisted of a NRI region comprising microstrip lines loaded with series capacitors and shunt inductors. The so created NRI region was sandwiched between two dense microstrip meshes acting as parallel-plate waveguides. Using this NRI-TL lens, a resolution of $\lambda/6$ was achieved as opposed to the diffraction-limited resolution which would have been $\lambda/2$ [2]. Although the achieved resolution beats the diffraction limit, it does not correspond to perfect imaging. In this paper, we will discuss the practical resolution bounds of the experimental lenses in [2] due to material and mismatch losses.

A key result of our analysis is that the resolution is logarithmically bounded by the losses on the loading series capacitors. Specifically, the maximum resolved transverse wavenumber k_x is determined by,

$$R = \frac{k_x}{k_o} = \frac{\ln(Q_c)}{k_o d}$$

where $k_o d$ is the electrical thickness of the lens in radians and Q_c is the quality factor of the loading series capacitors.

[1] J. B. Pendry, Negative refraction makes a perfect lens, Phys. Rev. Lett., vol. 85, no. 18, pp. 3966-3969, Oct. 2000.

[2] A. Grbic and G.V. Eleftheriades, Overcoming the diffraction limit with a planar left-handed transmission-line lens. Phys. Rev. Lett., vol. 92, no. 11, pp. 117403 , March 19, 2004.

1. (a) George Eleftheriades
George V. Eleftheriades
Toronto, ON
M5S 3G4 Canada
gelefth@waves.utoronto.ca
(b) 416-946-3564
(c) 416-971-2286

2. B - Fields and Waves

3. (a) Metamaterials and Other Complex Materials for Radio Frequency Applications

4. I - Invited Paper, Program chair: John Volakis and George V. Eleftheriades

5. Metamaterials and Other Complex Materials for Radio Frequency Applications