Reflection, Refraction and Diffraction of Magneto-Inductive (MI) Waves in 2-D Metamaterials

Ekaterina Shamonina
University of Osnabrück, Germany

R. R. A. Syms
Imperial College of Science, UK

Laszlo Solymar
University of Oxford, UK

Waves capable of propagating on arrays of capacitively loaded loops (stacked axially or arranged in a planar configuration) were predicted in [1], treated in more detail for the two- and three-dimensional cases in [2] and proven experimentally in [3]. The aim of the present communication is to show that MI waves belong to the family of linear waves not only when propagation in a homogeneous medium is considered but also in respect of properties like reflection, refraction and diffraction, a set of phenomena which were already investigated for coupled waveguide arrays. The best testing place for examining these properties is a 2-D array for the reason that the phenomena are not there in 1-D, and a 3-D approach is unnecessarily complicated.

Answers are given to the following problems:
(1) The conditions under which it is possible to excite a wave possessing a single spatial frequency.
(2) The effect of an obstacle (an element with different parameters) in an otherwise homogeneous array when a wave with a single spatial frequency is incident upon the obstacle.
(3) Distortion of a spatial distribution impressed at one end of the array when it reaches the other (matched) end.
(4) The reflection and refraction at the boundary of two homogeneous media, i.e. when the arrays on the two sides of the boundary have different parameters.
(5) Analogy with transverse electromagnetic waves: the conditions for defining an equivalent wave impedance and refraction index.

It is also shown by using an alternative approach (an equivalent coupling coefficient is derived between any two 1-D waveguides instead of assuming coupling between individual elements) that the analogies between the properties of coupled capacitively loaded loops and those of coupled waveguides [4] are very close.

REFERENCES