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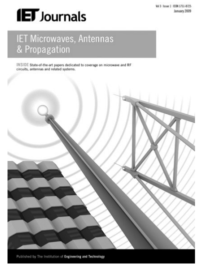
Published in IET Microwaves, Antennas & Propagation
Received on 22nd September 2012
Revised on 25th February 2013
Accepted on 18th March 2013
doi: 10.1049/iet-map.2012.0553



ISSN 1751-8725

Technique for inversion of an inhomogeneous bianisotropic slab through an optimisation approach

Ali Farahbakhsh, Davoud Zarifi, Ali Abdolali, Mohammad Soleimani

Department of Electrical Engineering, Iran University of Science and Technology, Tehran, Iran
E-mail: a_farahbakhsh@iust.ac.ir

Abstract: An electromagnetic inversion method is presented to reconstruct the constitutive parameters of an inhomogeneous bianisotropic slab. The measured co- and cross-reflection and transmission coefficients are used to extract the electromagnetic parameters profiles of the inhomogeneous bianisotropic media from the proposed method, using truncated Fourier series expansion and Gravitational Search Algorithm (GSA). GSA is used to improve the speed and accuracy of the optimisation process because of the complexity of inhomogeneous bianisotropic media, highly non-linearity of optimisation problem, and extremely large search space. Finally, the accuracy and robustness of the proposed reconstruction method are validated using some typical examples.

1 Introduction

Features of electromagnetic wave propagation in bianisotropic media have been intensively studied during the last few decades. Owing to the need for special electromagnetic properties, complex materials, such as bianisotropic media, classified as materials exhibiting magnetoelectric coupling, are considered. In these materials, there is a coupling between electric and magnetic fields which causes simultaneous production of electric and magnetic polarisations because of the electric or magnetic excitation [1]. This phenomenon is mathematically represented by magnetoelectric coupling tensors in constitutive relations. Bianisotropic media incorporates large variety of media, such as chiral or bi-isotropic media, gyrotropic chiral media, Faraday chiral media, anisotropic media, and gyrotropic media. Various applications utilising bianisotropic media have been proposed such as antenna radome [2], waveguides [3, 4] and polarisation transformers [5], microstrip antennas [6, 7], absorbers [8], backward wave media [9], and cloaking materials [10].

Electromagnetic scattering is one of the basic problems in the study of interaction of electromagnetic waves with bianisotropic media. If the structures of complex media are not in canonical geometries, the analytical analysis is limited. In this connection, many numerical methods have been extended to study the interaction of electromagnetic wave with complex media such as finite difference time domain [11, 12], and finite element method [13].

Analysis of the wave propagation and scattering from planar layered homogeneous bianisotropic mediums is rather straightforward. Rikte *et al.* introduced an efficient and robust method namely notation of propagators and wave splitting approach for analysing scattering from planar layered homogeneous bianisotropic media [14].

The problem of wave propagation in inhomogeneous media is important in many practical situations. Exact solution of the wave equation in such media is known for only a few particular profiles; and because of this, the wave propagation and scattering from inhomogeneous media has been intensively investigated and several approaches have been presented [15–22]. Recently, notation of propagator and wave splitting method is extended to analysis of inhomogeneous planar layered bianisotropic media [23]. An optimisation-based technique has been presented in [24] to simultaneously evaluate the permeability, permittivity and chirality parameter of a homogeneous bianisotropic slab from the knowledge of the transmission and reflection coefficients. In the present paper, a robust method is presented to reconstruct the constitutive parameters of an inhomogeneous bianisotropic slab via an advanced optimisation approach entitled Gravitational Search Algorithm (GSA).

The paper is organised as follows: The analysis of forward problem is reviewed in Section 2. In Section 3, applicability of the optimisation approach to reconstruct of inhomogeneous bianisotropic slab electromagnetic parameters is investigated. Section 4 is devoted to the verification of the accuracy of the proposed method. Finally, summary and conclusions are provided in Section 5.