Time-Domain Inversion with the IMSA-FBTS Approach

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Abstract: In this paper, the problem of localization, shaping, and reconstructing the dielectric permittivity of a dielectric target is addressed. The inversion technique processes the time-domain scattered field data to reconstruct with an increasing degree of accuracy the unknown scatterer by exploiting an iterative multiscaling procedure. Preliminary numerical results are presented to validate the time-domain multi-resolution multi-step approach.

Keywords: Microwave Imaging, Forward-Backward Time-Stepping Method, Iterative Multiscaling Method.

1. Introduction

Microwave imaging techniques based on inverse-scattering methodologies are aimed at localizing and reconstructing the dielectric properties of unknown scatterers from the measurement of the scattered field. An inverse scattering problem is usually very difficult because its nonlinearity, the ill-posedness, and the non-uniqueness of the solution [1]. Several inversion methods have been proposed in the frequency-domain by assuming a monochromatic illumination of the scenario under test [2-3]. Although frequency-based techniques have been successfully applied in different applicative domains (e.g., medical imaging and nondestructive testing) with satisfactory results [4-6], they present some drawbacks. More specifically, the use of higher frequencies enables an improvement of the spatial resolution achievable from the inversion, but it leads to higher multiple scattering effects [7] and a growing complexity in measuring the phase of the scattered field. On the other hand, the exploitation of single-frequency data only allows the collection of a limited amount of information. To properly address these issues, multiple acquisitions at different frequencies are necessary [7] or broadband probing fields should be adopted [8-9]. This latter is usually preferred even if it requires a time-domain field analysis with a non negligible computational burden (i.e., storage resources and computational time). As a matter of fact, the numerical solution of the inverse problem at hand needs the discretization of both the investigation domain (i.e., the area where the unknown scatters are located) and the region surrounding the transmitters and the receivers [10].

To limit the computational burden of time-domain inversions as well as enhance the spatial resolution, this work presents an innovative approach based on the time-domain application of the iterative multiscaling methodology [11].