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Editorial

Computational Electromagnetics for Industrial Applications

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1. Introduction

Nowadays, computational electromagnetics (CEMs) methods play an important role in the rapid modeling and design of electromagnetic (EM) systems and their industrial applications. Virtual prototyping based on computational electromagnetics is currently widely adopted in electrical and electronic systems design because of the high accuracy guaranteed by many numerical methods for the solution of Maxwell's equations in a wide range of frequency from DC to hundreds of GHz or even in the THz range. With the continuous increase of integration and complexity in EM systems and devices, numerical modeling and simulation methods play a key role in the design of electromagnetic systems. From this perspective, accurate and efficient algorithms and methods enabling an accurate and efficient analysis of complex EM problems are strongly requested. Furthermore, semi-analytical methods can also offer elegant and accurate solutions to complex EM problems. This special issue aims to promote cutting-edge research along this direction and offers a timely collection of works to benefit researchers and practitioners.

2. The Special Issue

This Special Issue consists of nine papers covering a broad range of topics related to the applications of EM waves, from the modeling of transmission lines and electromagnetic structures to imaging, from the high frequency characterization of wave guides and meta-surfaces, to machine-learning modeling of electromagnetic devices and field distribution along the earth's surface of a submerged line current at low frequency. The contents of these papers are briefly introduced in the following.

In the first paper [1], an analytical series-form solution for the time-harmonic EM field components produced by an overhead current line source is presented. The axial electric field is expanded into a power series of the vertical propagation coefficient in the air space leading to explicit expressions for the electric and magnetic fields.

The second paper [2] presents an extension of the formulation of wave propagation in transverse electric (TE) and transverse magnetic (TM) modes for the case of metallic cylindrical waveguides filled with longitudinally magnetized ferrite which are important for various industrial applications, such as circulators, isolators, antennas and filters. The proposed approach guarantees a considerable reduction of the computation time compared to a commercial software.

In the third paper [3], the addition translation theorem is used to analyze multiple scattering by two Perfect Electric Conducting (PEC) spheres. The proposed approach will allow to evaluate the scattering from macro-structures composed of spherical particles, i.e., biological molecules, clouds of airborne particles.

The fourth paper [4] presents a simple technique to identify material texture from afar, by using polarization-resolved imaging. It has been applied to both isotropic references (Teflon bar) and anisotropic samples (wood). Such a technique can be easily implemented into industrial environments, where fast and cheap sensors are required.

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The EM scattering may be a significant source of degradation in signal and power integrity of high-contrast silicon-on-insulator (SOI) nano-scale interconnects, such as opto-electronic or optical interconnects operating at 100 s of THz. The fifth paper [5] characterizes THz scattering loss in nano-scale SOI waveguides exhibiting stochastic surface roughness with exponential autocorrelation.

Paper [6] considers the calculation of magnetic flux density in the vicinity of overhead distribution lines which takes the higher current harmonics into account. Based on the Biot–Savart law and the complex image method, it allows to determine the contributions of individual harmonic components of the current intensity to the total value of magnetic flux density.

A machine learning (ML)-based regression for the construction of complex-valued surrogate models for the analysis of the frequency-domain responses of EM structures is presented in the seventh paper [7]. Relying on the combination of the principal component analysis (PCA) and an unusual complex-valued formulation of the Least Squares Support Vector Machine (LS-SVM) regression, a compact set of complex-valued surrogate models are trained and then used to obtain the frequency response of EM structures.

Dielectric metasurfaces have emerged as a promising technology for sensing applications and non-linear frequency conversion, and for their flexibility to shape the emission pattern in the visible regime. In paper [8], finite-size metasurfaces and beam-like illumination conditions are investigated in contrast to the typical infinite plane-wave illumination compatible with the Floquet theorem.

Finally, a numerical analysis on field distribution along the earth's surface of a line current source submerged in the ground is conducted in [9]. The potential of the extremely low frequency (ELF) technology in the envisioned long-distance communication techniques is investigated by the combined numerical methods of the Romberg–Euler method and Gauss–Laguerre method.

Conflicts of Interest: The authors declare no conflict of interest.

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