

# Special Issue: Trends and Prospects in Applied Electromagnetics

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## 1. Introduction

With the rapid advancement of information technology, humans are living in an increasingly intricate electromagnetic environment [1–3]. Applied electromagnetics, a crucial branch of electromagnetics, serves as a link between theoretical electromagnetics and engineering requirements. It focuses on applying the fundamental theories and principles of electromagnetic fields and waves (characterized by Maxwell's equations) to address practical engineering issues, design diverse devices and systems, and develop novel technologies. These applications span a wide range of fields, including electrical engineering [4], communication engineering [5,6], railway transportation engineering [7,8], nondestructive testing and evaluation [9,10], and biomedical engineering [11].

In recent years, applied electromagnetics has witnessed significant progress in various domains, such as computational electromagnetics [12], Electromagnetic Compatibility and Interference (EMC&EMI) [13], electromagnetic nondestructive testing and evaluation [14], electromagnetic wave propagation [15], and bio-electromagnetics [16]. This Special Issue, entitled “Trends and Prospects in Applied Electromagnetics,” aims to present the latest research findings in applied electromagnetics.

## 2. Overview of Contributions

### 2.1. Electromagnetic Compatibility and Interference

Yang et al. [17] carried out an analysis of the mechanism and coupling paths of radiation interference in a high-speed PWM axial flow fan. An integrated and non-inductive filtering circuit was put forward. This circuit was designed to absorb the peak voltage that enters the windings and to determine the filter parameters. The findings indicate that the filtering method has been proven to decrease overall electromagnetic interference. The maximum peak reduction reaches 41.9 dB, and this method does not affect the desired signals. Tripathi et al. [18] developed a numerical model to explore the ability of bucky paper (BP), a porous membrane composed of a highly cross-linked network of carbon nanotubes, to enhance the electromagnetic interference (EMI) shielding properties of carbon-fiber-reinforced polymer (CFRP) composites. The numerical simulation results showed that the incorporation of BP significantly improves the EMI shielding effectiveness (SE) of CFRP composites above 2 GHz, attributed to its high conductivity within that frequency range.

To address the EMI generated by switching operations in high-voltage DC (HVDC) converter stations, Schneider et al. [19] proposed a finite-difference time-domain method to study the characteristics of single switching events. They utilized a realistic model of an HVDC converter station, with a particular focus on determining the influence of the valve hall on EMI shielding. The investigation revealed that the valve hall does not restrict high-frequency electromagnetic fields within the valve hall. Instead, it delays



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their exit through the bushings in the wall and spreads them out over time. Fortunately, incorporating electromagnetic absorbing materials into the design of the valve hall can significantly reduce the EMI outside the converter station.

## 2.2. Computational Electromagnetics

Tripathi et al. [18] explored a quantum tunneling-based equivalent electrical circuits and Monte Carlo method to predict the frequency-dependent electrical conductivity and EMI shielding effectiveness (SE) of the hybrid BP/CFRP composites. Damian et al. [20] described a simulation approach for the S (scattering)-parameters and the absorbed energy of polymeric nanocomposites with metallic inclusions (iron and aluminum, with two particle sizes) by considering the Nicolson–Ross–Weir procedure in infinite media. The results showed that due to higher conductivity, nanocomposites with Al particles could absorb a greater amount of energy compared to those with Fe particles in the composite materials, at both inclusion sizes. The significant reduction in transmission confirmed that for composites with added metallic powder, microwave energy was extensively absorbed by the materials. Yelkenci et al. [21] proposed a method to determine the matching media parameters that maximize the electromagnetic energy penetrating into a human arm modeled as a radially stratified cylinder. The accuracy of this approach was demonstrated by calculating the electric field amplitudes inside and outside the layers for the determined parameters. The numerical results indicated that when a matching medium was considered, the penetrating field increased by a factor of 1.3 to 13.96 compared to the case without a matching medium. Due to the nonlinear nature in energy harvesting, Abramovitz et al. [22] developed a clamped-type overhead line magnetic energy harvester equipped with a controlled active rectifier, which can generate a significant DC output power. Moreover, a piecewise nonlinear analytical model of the magnetic harvester was derived. This research presented a closed-form solution that takes into account both the nonlinearities of the core and rectifiers, enabling an accurate quantitative prediction of the harvester's key parameters.

## 2.3. Design of Key Electrical Devices

To mitigate electromagnetic interference (EMI) in radio frequency (RF) and Wi-Fi (wireless fidelity standard) 5 and 6E wireless communication applications, Lin et al. [23] devised an ultra-wideband common-mode (CM) filter for a gigahertz (GHz) data rate signal. This filter employed an asymmetrical magnified coupled DGS to generate a second-order transmission zero, thereby extending the suppression bandwidth. The results showed that the CM noise was suppressed by over 10 dB within the frequency range of 2.9 GHz to 16.2 GHz. In the time domain measurement, the proposed filter was able to block 62.3% of the CM noise magnitude. Fan et al. [24] put forward a new filtering switch with outstanding working performance, which was fabricated using an optimized coupled microstrip line. The switching device was connected to the microstrip circuit to achieve the filtering and shutdown functions.

To reduce the insertion loss, Liang et al. [25] proposed an ultra-wideband, low-insertion-loss, and high-precision 6-bit digital step attenuator (DSA). In the proposed DSA, a series inductive compensation structure (SICS) was designed to address the high-frequency attenuation values, and a small bit compensation structure (SBCS) was intended for large attenuation bits. Using the 0.25  $\mu\text{m}$  GaAs p-HEMT process, it exhibited the highest attenuation accuracy, the lowest insertion loss, the best IP1dB, and good matching performance within the 2–22 GHz range.

In addition, Karpuz et al. [26] developed a novel single/double-layer N-way Wilkinson power dividers (WPDs) by employing slow-wave structures to downsize them. Based on the proposed methods, two-, four-, and eight-way power dividers were designed and measured at the center frequencies of 2.03, 1.77, and 1.73 GHz. Leveraging meandered transmission lines, three- and five-way WPDs with new input/output port configurations were designed, enabling the input power to be halved at the next output port.

#### 2.4. Electromagnetics in Interdisciplinary

Aiming at the threat posed by the highly leaked magnetic field from electric vehicles (EVs) charging to humans, Okada et al. [27] investigated the suitability of spatial averaging methods for non-uniform exposure and made contributions to the smooth assessment in Wireless Power Transfer (WPT) systems. To enhance the identification accuracy of metal information, Xie et al. [28] proposed a metal material analysis model based on the discrete wavelet transform, using a Constant Phase Angle Pulse Eddy Current (CPA-PEC) sensor. The experimental analysis shows that the stability of the quantitative evaluation index of eddy current features reaches 97.1%, and the comprehensive accuracy error is less than 0.32%.

### 3. Conclusions

The articles compiled in our Special Issue spotlight the significant progress achieved in electromagnetic compatibility and interference, computational electromagnetics, the design of key electrical devices, and electromagnetics in interdisciplinary domains. These articles offer a valuable frontier perspective and technical guidance for applied electromagnetics.

Currently, applied electromagnetics still confronts numerous challenges. As the number of applied electrical devices continues to grow, the active and passive electromagnetic fields render the electromagnetic environment intricate. In the future, several valuable topics include how to control electromagnetic interference from passive sources to achieve electromagnetic compatibility, and how to utilize the active electromagnetic fields for the benefit of humanity. For instance, advanced electromagnetic materials such as metamaterials will be employed; higher accuracy and resolution electromagnetic nondestructive testing and evaluation are needed; new computational electromagnetics models will be established due to the application of new materials or novel electronic devices; EMC and EMI models, EMC standards, and EMC measurement methods can be developed to address the more complex magnetic environment; and an increasing number of artificial intelligence techniques will be introduced into electromagnetic applications.

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