COMPEL - The international journal for computation and mathematics in electrical and electronic engineering

271

Guest editorial: Electromagnetic modeling exploiting fields and circuits

I am delighted to introduce this special issue of *COMPEL (The International Journal for Computation and Mathematics in Electrical and Electronic Engineering)*, titled *Electromagnetic Modeling Exploiting Fields and Circuits*, featuring selected and expanded papers originally presented at the *28th Symposium on Electromagnetic Phenomena in Nonlinear Circuits (EPNC 2024)*.

The 28th EPNC Symposium was held from June 18 to June 21, 2024, at the Grand Hotel Bernardin in Portorož, Slovenia. It was organized by the University of Maribor, Institute of Electrical Power Engineering, Laboratory for Electrical Machines and Control (https://ime.feri.um.si/en/electrical-machines-and-control) (Slovenia), and the Poznan University of Technology, Faculty of Electrical Engineering (Poland). EPNC 2024 was further organized under the auspices of the Committee on Electrical Engineering, Polish Academy of Sciences and Committee on Electrical Engineering, PAS – Poznan Branch. Chairman of the International Organizing Committee was Assoc. Prof. Dr Martin Petrun.

The EPNC Symposium began in Poznań, Poland, in November 1972. Initially a local event, it became international over the last 17 editions. Early selected papers appeared in regular COMPEL *issues, but since EPNC 2004, they have been published as special issues. This marks the 11th consecutive special issue.*

The EPNC conferences aim to showcase the recent advances in the analysis, synthesis, optimization and inverse problems in nonlinear electromagnetics. The symposium provides a forum for discussion on applications of nonlinear phenomena in electrical engineering by field and circuit methods. These conferences offer renowned researchers, specialists and young PhD students a valuable opportunity to exchange ideas and experiences.

EPNC 2024 brought together researchers from ten countries, with 63 papers presented during the symposium. Two-page versions of presented papers were published in the conference proceedings and prepared in an electronic version. A limited number of seven extended papers, selected in a peer review process, was chosen by the EPNC 2024 Editorial Board and the COMPEL Guest Editor for publication in this special issue of COMPEL. The papers and the discussion at the symposium confirmed the recent trends in electromagnetism and electrical engineering. The papers in this issue illustrate the ongoing progress in electrical engineering, showcasing innovations in materials, measurement techniques, machine design and bioelectromagnetics.

Topics discussed at the EPNC 2024 symposium in Portorož included:

- Nonlinear Coupled Electromagnetic Phenomena;
- Nonlinear Devices and Systems;
- Electromagnetics for Energy; and
- Bioelectromagnetics.

The following paragraphs summarize the principal findings and insights from the extended papers featured in this special edition of COMPEL.

The paper *"Unbalanced magnetic pull in an 18-slot/8-pole dual three-phase machine under different modes of operation"* analyzes the emergence and impact of unbalanced magnetic pull (UMP) in an 18-slot/8-pole dual three-phase permanent magnet synchronous

COMPEL - The international journal for computation and mathematics in electrical and electronic engineering
Vol. 44 No. 3, 2025
pp. 271-273

0332-1649
DOI 10.1108/COMPEL-05-2025-654

machine (DTM) during postfault operation (PFO) and synthetic loading operation (SLO). Understanding UMP in these specific operating modes is crucial for ensuring the mechanical integrity of the electric drive. The study reveals that UMP arises due to interactions between field harmonics with differing spatial orders, specifically the 4th and 5th harmonics during PFO and SLO. The presence of both odd and even harmonics in the machine's field spectrum is a decisive factor in UMP generation. The authors found that while UMP increases bearing stress, it does not compromise the mechanical integrity.

The aim of the next paper titled *"The Optimization of Permanent Magnet Synchronous Motor Using Chimp Algorithm"* was to develop an algorithm and computer script for optimizing permanent magnet synchronous machines with self-starting properties. The authors found that the proposed optimization procedure, which incorporates the chimp algorithm, can be effectively applied to the optimal selection of parameters for various permanent magnet motors. The optimization algorithm was modified to achieve better convergence by introducing different types of parameter changes characteristic of the best-adapted individuals in the chimp troop. This developed optimization procedure was specifically adapted for optimizing line-start permanent magnet synchronous motors.

Another paper, titled *"Topology Optimization of a Non-linear Ferrite Core for Induction Heating in Injection Molding"* investigated recent progress in additive manufacturing methods that have alleviated manufacturing constraints on devices. This paper aimed to study the use of these algorithms in induction heating for injection molding. The study demonstrates that it is possible to significantly reduce the amount of ferrite without impacting efficiency. Additionally, the thermal performance of the proposed solution shows slight improvements compared to the original solution.

The paper entitled *"The Features of Two Approaches to Describe Magnetic Anisotropy in Non-Grain-Oriented Electrical Steels*" provides deeper insight into possible methods to take anisotropy of magnetic properties of nonoriented steels into account. The first approach, based on metallurgy and materials science, provides a straightforward way to compute variations in magnetic properties from measurements at three cutting angles of the samples. The second approach, rooted in electromagnetic theory, is more useful for electrical engineers as it determines relationships between vectors. The paper highlights the flexibility of the second approach, offering a lot of information on the relationships between the above-mentioned vectorial quantities. Findings indicate that the first model is simple and reasonably accurate, with discrepancies between measured and modeled values not exceeding 10%. The second approach, though more complex, provides insights into spatial dependencies between vectors. Discrepancies between model predictions and measurements were below 15%.

The paper "*Time-Stepping Algorithm for Hysteretic Lumped-Element Transformer Models*" addresses the challenges of precise numerical simulation environments for transformer models, particularly due to hysteretic core behavior. While assuming linear material laws allows for efficient and straightforward solution schemes in the time domain, it fails to incorporate saturation effects, inrush phenomena or hysteresis losses. This work focused on developing a time-stepping algorithm for a topologically correct lumped-element three-phase transformer model that includes hysteresis in the transformer core. The time-stepping algorithm achieves high accuracy within a few iterations and yields the transient response of the three-phase transformer models. Comparisons with inrush measurements demonstrate the algorithm's algorithm's practicability and additionally validate the transformer model.

The paper titled "*Accurate No-Load Behavior Prediction of Large Five-Legged Transformers Using Topological Transient Models*" proposes an approach for reproducing

the no-load losses and currents of large five-legged transformers when using their transient circuital models. This aim was achieved by employing topological transformer models based on a dynamic hysteresis model (DHM) and considering transformer capacitances. The study highlights the importance of accounting for transformer capacitances for accurate modeling of line currents feeding large transformers and demonstrates the possibility of representing these capacitances by equivalent per-phase elements. The findings contribute to a better understanding of processes in transformers with different core and winding configurations, promoting wider application of topology-correct models. The presented models can serve as independent tools or references for further developments. The method is supported by close agreement between calculated and measured data for two large transformers.

The aim of the last extended article, presented in the special edition of COMPEL, titled "*Impact of Material Property Variations and Sensor Positioning on the Coating Thickness Determination of Steel Sheets Using Eddy Current Testing*" was to investigate the reliable thickness, and more generally, the geometric and material parameter determination of thin electrically conductive and diamagnetic coatings on conductive and ferromagnetic substrates, e.g. steel, using eddy current testing. The study identified valid mesh rules are found for a very accurate finite-element analysis of eddy current problems with large air gaps. Moreover, the formulated hypotheses were confirmed by measurements.

These contributions highlight the diverse methodologies driving modern advancements and emphasize the importance of staying informed about emerging research.

We hope this special issue offers readers valuable insights and inspires further exploration in the field.

Martin Petrun
Faculty of Electrical Engineering and Computer Science,
University of Maribor, Maribor, Slovenia