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Editorial

Efficiency and Performance Optimization of State-of-the-Art "Multi-Phase, -Level, -Cell, -Port, -Motor" Electrical Drives and Renewable Energy Systems

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1. Introduction

This Special Issue was intended to consolidate the most recent advances in the field of power electronics for electric drives and renewable energy sources. The concerns about the on-going climate change and the need for environmental quality improvements and a reduction in CO_2 emissions has paved the way to increasing interest in new and innovative green (e.g., low-carbon) energy technologies. As they are becoming increasingly affordable, even more so than fossil fuel technologies in some cases, the investigation of efficiency and overall performance optimization in energy generation and consumption has become inevitable. The energy efficiency is of utmost importance when it comes to electrical machines, motor drives, and power electronics, as they are considered big consumers, but can also be found on the generation side.

With this in mind, and with the development of novel materials such as technologies based on a wide bandgap, which can increase efficiency, this Special Issue was oriented toward recent technological advances and performance optimization methods in the areas of power electronics, electrical machines, and multi-motor drives.

This Special Issue was closed on 20 October 2021, with five published papers. All in all, 17 authors from seven affiliations contributed to the excellent performance of this Special Issue. Author institutions belonged to four nations worldwide, distributed as follows:

- Italy: 3 institutions with 11 authors;
- Serbia: 1 institution with 3 authors;
- United Kingdom: 2 institutions with 2 authors;
- Chile: 1 institution with 1 author.

2. Contributions to this Special Issue: A Short Review

In the following, the papers published within this Special Issue will be briefly summarized, along with their main achievements. In ref. [1] is proposed a system for the dynamic modeling and control of a brushless doubly fed reluctance generator (BDFRG), considering specific conditions of operation, such as unbalanced grid conditions. The BDFRG is presented as a prospective replacement to the doubly fed induction generator for wind power applications, where aspects related to the cost, performance, and reliability are highlighted. As presented, the superior performance under unbalanced grid conditions is one of the greatest advantages of the BDFRG when compared with the doubly fed induction generator. In this paper, a novel control algorithm for the BDFRG is proposed, when used in wind generation systems and considering unbalanced operation. The validation was carried out by simulations considering a 1.5 MW BDFRG dynamical model, and the obtained results were compared with those of the conventional PI current control strategy.

In ref. [2], a comparative study between classical and model predictive control (MPC) applied to a single-phase modular multilevel converter (MMC) is presented. The mathematical model of the MMC is introduced and described in detail, based on the structure and range of parameters for classical control and optimal switching state MPC. The control methods are conceived and assessed considering virtual hardware-in-the-loop together with the MMC. The ac current, voltage balancing, and circulating current optimization are the defined control objectives. The analysis is performed considering steady-state and transient-state analysis, based on several criteria, e.g., the current reference tracking, the harmonic distortion, the voltage balancing, the number of control parameters, and the computational complexity.

In ref. [3], a design method for the cogging torque minimization of permanent magnet machines with a segmented stator core based on artificial neural network surrogate models is proposed. In this paper, a new methodology is suggested with the objective of minimizing the cogging torque of permanent magnet machines, which is based on the design of various individual shapes of the tooth tips over a topological optimization. As presented, based on the number of stator core segments, it is possible to define a formula for selecting the number of independent shapes to be designed. Furthermore, a heuristic approach based on genetic algorithms and artificial neural network surrogate models is presented, aiming to address topological optimization, as well as to identify the optimum tooth tip shapes. Simulation based on finite element methods is considered for validating the design formula and the effectiveness of the proposed method. A sensitivity analysis considering assembling and manufacturing tolerances is presented to prove the robustness of the recommended method.

In ref. [4], a variable structure control of a small ducted wind turbine in the whole wind speed range using a Luenberger observer is offered. The proposed variable structure control is for a variable-speed, fixed-pitch ducted wind turbine, equipped with an annular, brushless permanent-magnet synchronous generator. In terms of the power converter, a back-to-back structure is considered. The objective of the proposed control scheme is to optimize the aerodynamic power over the whole wind speed range, but taking into account the mechanical limits of the ducted wind turbine. A Luenberger observer is considered in the designed control scheme, aiming to estimate the aerodynamic torque, and a shallow neural network is considered for estimating the wind speed. A laboratory setup was implemented to verify the effectiveness of the proposed strategy, where a comparison with other solutions is also presented, permitting the evaluation of the performance of the proposal.

In ref. [5], a review of the low-voltage GaN FETs in motor control applications is offered, considering issues and advantages. The paper offers relevant recommendations for designers, aimed at the optimal use of GaN FETs, specifically for motor control applications, distinguishing the advantages, disadvantages, and main issues. An experimental evaluation is carried out considering GaN FETs in a low-voltage electrical drive, using two distinct boards to emphasize the switching behavior in various conditions of operation, as well as implementations, allowing the verification of the main technological characteristics related to motion control necessities. As analyzed and discussed in this paper, the fast-switching transients linked with decreased direct resistance influence the power losses; thus, a high switching frequency along with a clear decrease in dead time is feasible, permitting an improvement in the quality of the waveforms. Several experimental results are presented to support the main contributions of the paper.

3. Conclusions

All of the papers selected for this Special Issue have shown important insights and contributed to making this Special Issue successful in providing a platform for recent advances in the field of power electronics for electric drives and renewable energy sources, concerning both consumption and generation. Moreover, the importance of efficiency improvement with the usage of wide-bandgap devices has also been highlighted.

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