electronics

MDPI

Editorial

Diagnostics and Fault Tolerance in DC–DC Converters and Related Industrial Electronics Technologies

Antonio J. Marques Cardoso * and Fernando Bento *

CISE—Electromechatronic Systems Research Centre, University of Beira Interior, Calçada Fonte do Lameiro, P-6201-001 Covilhã, Portugal

* Correspondence: ajmcardoso@ieee.org (A.J.M.C.); fjfbento@ieee.org (F.B.)

The deployment of DC energy systems is an attractive alternative to conventional AC-based energy distribution systems, improving the efficiency of energy supplies and promoting renewable energies. Within DC energy systems, industrial electronics, particularly DC–DC converters, are the key technologies that establish the interface between the multiple individual units of DC energy systems. Semiconductors and electrolytic capacitors, as critical components of DC–DC power converters, are particularly susceptible to suffering faults, which have a critical impact on converter operation. Implementing diagnostic, prognostic, and fault-tolerant strategies that can effectively deal with the multiple failure modes prone in DC–DC converters is a challenging goal and is yet to be fully achieved. Accordingly, novel advancements in the diagnostics, prognostics, and fault tolerance of DC–DC converters and related industrial electronics technologies require further attention.

This Special Issue discusses emerging solutions suitable for leveraging the availability, reliability, and robustness of DC–DC industrial power electronics technologies.

In [1], Vella et al. compare the main parameters of GaN and SiC devices, measured with a dedicated and low-cost embedded system. It is shown that GaN devices achieve higher efficiency with respect to SiC devices in the considered range of switching frequencies. As expected, the on-resistance exhibited by GaN devices increases with frequency. On the other hand, GaN devices were revealed to be more sensitive to parasitic effects. Indeed, the high dV/dt resulting from the reduced switching times may introduce unwanted ringing phenomena.

The study developed by Yodwong et al. [2] proposes a novel open-circuit switch fault diagnosis method for a three-level interleaved buck converter in a hydrogen production system based on the water electrolysis process. Upon the diagnostic of a switch failure, the control algorithm is suitably modified to maintain hydrogen production despite the fault. The proposed fault diagnostic algorithm relies on the comparison between the shape of the input current and the pulse width modulation (PWM) gate signal of each power switch.

Mahdavi et al. [3] propose a fault-tolerant bidirectional DC–DC converter for battery energy storage solutions. The proposed method is extensible to multi-phase structures of interleaved bidirectional DC–DC converters through the use of only two power switches and n TRIACs to mitigate open-circuit faults on $2 \times n$ switches of n legs. A fault diagnostic strategy based on the evaluation of the inductors current is also proposed, which allows for the detection of switch open-circuit faults.

In [4], Das et al. present a harmonic compensation technique based on artificial intelligence, applying it to hybrid AC–DC interlinking converters. The suggested strategy, modeling techniques, stability analysis, and a thorough virtual impedance design are discussed in this work. By compensating for the harmonics and reactive power in both grid-connected and islanded modes, faster and more reliable harmonic correction is attained.

Aurangzeb et al. [5] developed a flux-coupled superconducting fault current limiter (SFCL) suitable for DC energy systems. The SFCL is built by connecting two coils in parallel and a superconducting element in series with the secondary coil. In the absence of a fault in

check for updates

Citation: Cardoso, A.J.M.; Bento, F. Diagnostics and Fault Tolerance in DC–DC Converters and Related Industrial Electronics Technologies. *Electronics* **2023**, *12*, 2341. https://doi.org/10.3390/electronics12102341

Received: 16 May 2023
Accepted: 22 May 2023
Published: 22 May 2023

the DC system, the voltage generated by the two parallel coils is zero because the magnetic fluxes generated by each coil are equal. In turn, the resistance of the superconducting element increases in the presence of a fault, preventing the mutual cancellation of magnetic fluxes and thus causing energy loss.

In [6], Nallolla et al. present an evaluation of the state-of-the-art concerning multi-objective optimization approaches applied to the design of hybrid AC/DC microgrids integrating renewable energy sources. The optimal solution should provide a minimum cost of energy, minimum net present cost, low operating cost, low carbon emissions, and a high renewable share. Based on the authors' evaluation, multi-objective genetic algorithms and multi-objective particle swarm optimization were found to be the most valuable and promising multi-objective optimization approaches for designing hybrid microgrids.

Andrade et al. [7] present a compilation, comparison, and evaluation of DC–DC buck-boost topologies that have been introduced in the literature over the past few years. Given their features, these converter topologies are suitable for the integration of fuel cells in low-voltage DC microgrids. Design considerations, such as current ripple, number of components, voltage stress, voltage gain, robustness, cost, and efficiency, are weighted to assess the potential interest of each topology.

The papers compiled in this Special Issue represent some of the most meaningful developments undertaken regarding more robust DC–DC converters and their related industrial electronics technologies.

Author Contributions: Conceptualization, A.J.M.C. and F.B.; methodology, A.J.M.C. and F.B.; software, A.J.M.C. and F.B.; validation, A.J.M.C. and F.B.; formal analysis, A.J.M.C. and F.B.; investigation, A.J.M.C. and F.B.; resources, A.J.M.C.; data curation, A.J.M.C. and F.B.; writing—original draft preparation, A.J.M.C. and F.B.; writing—review and editing, A.J.M.C. and F.B.; visualization, A.J.M.C. and F.B.; supervision, A.J.M.C.; project administration, A.J.M.C.; funding acquisition, A.J.M.C. All authors have read and agreed to the published version of the manuscript.

Funding: This work was supported by National Funds through the FCT—Portuguese Foundation for Science and Technology, under Projects UIDB/04131/2020 and UIDP/04131/2020.

Acknowledgments: The Special Issue Editors gratefully acknowledge all of the authors for their interesting contributions to the Special Issue. A special note of appreciation is addressed to the reviewers for their commitment and valuable comments made to the received submissions. Thanks to the Electronics Editorial Board for accepting, hosting, and sponsoring the organization of the Special Issue. Finally, the Special Issue Editors express their gratitude to Queena Cui, the Managing Editor in charge of the administration of the Special Issue, for their prompt assistance and patience.

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

References

1. Vella, A.; Galioto, G.; Vitale, G.; Lullo, G.; Giaconia, G.C. GaN and SiC Device Characterization by a Dedicated Embedded Measurement System. *Electronics* **2023**, *12*, 1555. [CrossRef]
2. Yodwong, B.; Sikkabut, S.; Guilbert, D.; Hinaje, M.; Phattanasak, M.; Kaewmanee, W.; Vitale, G. Open-Circuit Switch Fault Diagnosis and Accommodation of a Three-Level Interleaved Buck Converter for Electrolyzer Applications. *Electronics* **2023**, *12*, 1349. [CrossRef]
3. Mahdavi, M.S.; Karimzadeh, M.S.; Rahimi, T.; Gharehpetian, G.B. A Fault-Tolerant Bidirectional Converter for Battery Energy Storage Systems in DC Microgrids. *Electronics* **2023**, *12*, 679. [CrossRef]
4. Das, S.R.; Mishra, A.K.; Ray, P.K.; Salkuti, S.R.; Kim, S.-C. Application of Artificial Intelligent Techniques for Power Quality Improvement in Hybrid Microgrid System. *Electronics* **2022**, *11*, 3826. [CrossRef]
5. Aurangzeb, M.; Xin, A.; Iqbal, S.; Aymen, F.; Jasiński, M.; Jasińska, L. Utilizing Parallel Superconducting Element as a Novel Approach of Flux-Coupled Type SFCL to Limit DC Current in the System. *Electronics* **2022**, *11*, 3785. [CrossRef]

6. Nallolla, C.A.; P, V.; Chittathuru, D.; Padmanaban, S. Multi-Objective Optimization Algorithms for a Hybrid AC/DC Microgrid Using RES: A Comprehensive Review. *Electronics* **2023**, *12*, 1062. [CrossRef]
7. Andrade, P.; Alcaso, A.N.; Bento, F.; Cardoso, A.J.M. Buck-Boost DC-DC Converters for Fuel Cell Applications in DC Microgrids—State-of-the-Art. *Electronics* **2022**, *11*, 3941. [CrossRef]