Guest editorial: Modern electric machines and drives for wind power generation

1 | SUMMARIES OF ACCEPTED ARTICLES

Paper 1 entitled “Modern electric machines and drives for wind power generation: A review of opportunities and challenges” by Chen et al. provides a thorough review of modern electric machines and drives for wind power generation, with emphasis on machine topologies, operation principles, performance characteristics, as well as control strategies. The key features of electric machines and drives including their merits and demerits, such as torque/power density, efficiency, and cost, are compared and summarized. The major challenges and difficulties, which electric machines and drives for wind power generation are facing, are discussed.

Paper 2 entitled “A new parameter identification method of a dual-rotor flux-modulation machine based on an adaptive differential evolution algorithm” by Mao et al. proposes an adaptive differential evolution algorithm to identify the machine parameters by considering the magnetic saturation and cross-coupling issue at low rotational speed of dual-rotor flux-modulation machines. Both simulation and experimental results reveal the adopted adaptive differential evolution algorithm can identify the parameters more steadily and accurately than the conventional genetic algorithm.

Paper 3 entitled “Design and modelling of self-excited SRG and FM-SRG for wind energy generation” by Tefera et al. discusses the design and analysis of synchronous reluctance generator with a power rating of 2.1 kW. Various parameters of the designed machine are analysed through an analytical model and Ansys Electronics Desktop software, while experimental validation of the synchronous reluctance generator results is obtained through finite element analysis. The paper also proposes formulae to approximate the minimum values of the excitation capacitor requirement, for a self-excitation of synchronous reluctance generator with inductive load.

Paper 4 entitled “Comprehensive coordinated control strategy of PMSG-based wind turbine for system inertia support” by Zhu et al. proposes a comprehensive coordinated control strategy of permanent magnet synchronous generators (PMSGs) based wind turbines for the system inertia support. The comprehensive coordinated control strategy proposed in this paper can effectively give the system inertia support by realizing certain frequency regulation of wind turbines under various wind conditions and frequency fluctuations.

Paper 5 entitled “Performances characteristics and reliability assessment of self-excited induction generator for wind power generation” by Varshney et al. presents the performance analysis-based reliability estimation of a self-excited induction generator (SEIG) using the Monte-Carlo simulation (MCS) method with data obtained from a self-excited induction motor operating as a generator. The global acceptance of a SEIG depends on its capability to improve the system’s poor voltage regulation and frequency regulation. Hence, this paper deals with obtaining the minimum capacitor value required for SEIG excitation in isolated mode applications, including stand-alone wind power generation.

Paper 6 entitled “Reduced sensor operation and power quality improvement in grid-tied doubly fed induction generator using composite and twin frequency generalized integrators” by Das et al. presents strategy involving a reduction in the stator current sensor count for control of power converters, in a doubly fed induction generator (DFIG)-based wind energy conversion system (WECS). A composite generalized integrator phase-locked loop is presented to estimate accurately the stator flux amplitude and orientation angle, even at operating system irregularities such as unbalanced voltages, lower-order harmonics in the grid voltage, DC bias in sensing circuitry, and so forth.

Paper 7 entitled “Controller design for DFIG-based WT using gravitational search algorithm for wind power generation” by Bharti et al. describes the controller design aspects of DFIG-based wind turbine system (WTS) using gravitational search algorithm (GSA). The controller design schemes are optimized for accurate, reliable and stable operations of wind energy conversion System (WECS) using GSA. The proposed GSA technique is compared with the techniques already implemented in the previous research works including particle swarm optimization (PSO) and bacterial foraging optimization (BFO). The DFIG-based WTS’s output waveforms of voltage at dc-link, reactive power, and active power are improved using GSA based design technique.

Paper 8 entitled “Piezoelectric energy harvester converting wind aerodynamic energy into electrical energy for...
microelectronic application” by Sitharthan et al. develops a novel piezoelectric energy harvesting device for low power electronic devices. The developed Piezoelectric Energy Harvesting Systems consists of a cantilever with poles projecting outwards and the cantilevers one end is connected to the wind-catcher, and another end is connected to the torsional spring. The output voltage obtained from the Piezoelectric Energy Harvesting Systems does not affect any input frequency of the piezoelectric crystal.

Paper 9 entitled “Design and optimization of a bidirectional flux modulation machine for AC and DC power supplies” by Lin et al. proposes a novel power supply system that utilizes wind power to produce AC and DC power. A special designed generator based on bidirectional flux modulation effect is the key part of the proposed power supply system. The novel power system has a compact structure since the proposed generator has two electric port with contra-rotating rotors.

Paper 10 entitled “Design and optimization of deflection type dual-stator switched reluctance wind power generator” by Li et al. proposes a deflection type dual-stator switched reluctance wind power generator. The generator consists of an external generator and an internal generator, which can be coordinated to improve the efficiency of the generator. With the goal of reducing the loss of the generator core, Taguchi algorithm is used to screen out the parameter variables that has a great impact on the loss of the generator core. Based on the method of central composite design (CCD), the experimental sample data set is constructed and the rationality of the model is evaluated by analysis of variance and the optimal parameters of the generator are determined.

Paper 11 entitled “Design and optimization of a bidirectional flux modulation machine for AC and DC power supplies” by Lin et al. proposes a novel power supply system that utilizes wind power to produce AC and DC power. A special designed generator based on bidirectional flux modulation effect is the key part of the proposed power supply system. The novel power system has a compact structure since the proposed generator has two electric port with contra-rotating rotors.

Paper 12 entitled “Sensorless MRAS control of emerging doubly-fed reluctance wind generators” by Kashkooli et al. proposes a new model reference adaptive system-based estimation technique for vector control of real and reactive power of a brushless doubly fed reluctance generator without a shaft position sensor. Contrary to the existing model reference adaptive system observer designs reported in the brushless doubly fed reluctance generator literature, the reference model is entirely parameter-free and only utilizes direct measurements of the secondary currents. The current estimates coming from the adaptive model are obtained using the measured voltages and currents of the grid-connected (primary) winding, which has provided prospects for much higher accuracy and superior overall performance.

Paper 13 entitled “A modular and cost-effective HTS generator for large direct-drive wind turbines” by Kails et al. tries to improve an existing 10 MW HTS power generator. The authors propose to add an additional stator to the machine to increase the copper volume in the generator, resulting in a large increase in power density. Furthermore, with the additional inner stator, the overall current density in the individual stators can be reduced, leading to an increase in efficiency. The efficiency of the machine can be increased from 94.5% to 95% at a power output of 11.5 MW or through a further reduction of the current density in the stators an efficiency of 95.6% can be reached while maintaining a power output of 10 MW.

Paper 14 entitled “Reference voltage vector based-model predictive control for semicontrolled open-winding FSPMG with a novel zero-sequence current suppression strategy” by Zhao et al. studies a reference voltage vector based-model predictive control for semicontrolled open-winding flux-switching permanent magnet generator. In general, common dc bus is adopted in this configuration, thereby leading to zero-sequence current (ZSC). The concern of this work is put into proposing a novel ZSC suppression strategy, which is on the basis of the redundant vector pre-selection. Experimental results are presented to verify the correctness and effectiveness of the proposed method. Access full paper using following link: https://ietresearch.onlinelibrary.wiley.com/doi/10.1049/rpg2.12049

Paper 15 entitled “Electromagnetic and mechanical design of module dual stator brushless doubly-fed generator for offshore wind turbine” by Wang et al. proposes a direct drive module dual stator brushless doubly-fed generator with cage-barrier rotor having many outstanding merits. The fundamental structure, operation principle and power flow are presented. The electromagnetic design methods of the proposed generator including power distribution of inner and outer machines, the relationship of pole number, slot number and module number, and winding design are thoroughly investigated. To solve the problems in structure brought by module design and reduce the weight as much as possible, a mechanical construction applied for module DSBDVG is also proposed. Access full paper using following link: https://ietresearch.onlinelibrary.wiley.com/doi/full/10.1049/rpg2.12050

Paper 16 entitled “Novel rotor design of dual-stator brushless doubly fed generator based on surrogate model” by Wang et al. studies a dual stator brushless doubly fed generator. The different rotor structures are compared and analysed, and the position of non-magnetic ring is determined. In order to reduce the computational cost and improve the optimization efficiency, the surrogate model coupled with multi-island geometric algorithm (MIGA) is applied for the optimization of magnetic barrier layer of the cage barrier rotor. In addition, in order to reduce the effect of skin effect on the copper loss of cage bars of rotor, the different simulation models, whose cage bars have different layer number, are simulated and analysed.

Paper 17 entitled “A novel doubly-fed doubly-salient machine with DC-saturation-relieving structure for wind power generation” by Jiang et al. presents a doubly-fed doubly-salient machine with DC-saturation-relieving effect for wind power generation application, which possesses the advantages of
enhanced torque density, reduced torque ripple and improved power density. The key is that permanent-magnets are introduced into the stator slot openings to mitigate the saturation effect in stator core caused by DC field excitation, and relatively large excitation current can be fed into stator field windings, which contributes to improved power density of machine. In addition, with the armature winding artificially connected, the reluctance of all magnetic paths is kept the same, and the variation of self-inductance is compensated, and the torque ripple is greatly suppressed.

Paper 18 entitled “Design and analysis of a novel claw-shaped modular stator relieving-DC-saturation doubly salient machine with 3D complementary magnetic circuit” by Li et al. proposes a DC-excited doubly salient machine with claw-shaped modular stator and 3D complementary magnetic circuit for wind power generation application. The key is to artificially construct a 3D complementary structure to suppress torque ripple and employ auxiliary slot-opening PMs to relieve DC-saturation in the stator core and improve overload capability. The novel 3D complementary structure provides an alternative magnetic path for the main flux, so the flux leakages in the air gap at open-circuit position are effectively cancelled, and the flux in the yoke keeps relatively constant. Hence, the output torque ripple is suppressed.

2 | SUMMARY/CONCLUSION

There were a large number of articles submitted to this Special Issue with 18 articles being accepted by the Guest Editors for publication. The accepted articles are included as the collection on the following pages. The Guest Editors believe these articles will show their contributions over time, while they also hope these pieces of works will provide immediate effects to the readers.

Christopher H. T. Lee,
Kwok-Tong Chau,
Wenxiang Zhao

1 Department of Electrical and Electronic Engineering, The University of Hong Kong, Hong Kong, China Email: ktchau@eee.hku.hk
2 School of Electrical and Information Engineering, Jiangsu University, Zhenjiang 212013, China Email: zwx@ujs.edu.cn
3 School of Electrical and Electronic Engineering, Nanyang Technological University, 639798, Singapore

Correspondence
Christopher H. T. Lee, School of Electrical and Electronic Engineering, Nanyang Technological University, Singapore. Email: chtlee@ntu.edu.sg