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EDITORIAL

Guest editorial: Modelling, methodologies and control techniques of DC/AC power conversion topologies for small- and large-scale photovoltaic power systems

Photovoltaic (PV) power generation has great potential to meet a majority of the global energy demand. The exploitation of solar PV energy is expected to increase further in the near future. To harvest solar energy and to meet the demand, power electronics and PV technologies play a major role. The power converters, especially the DC/AC inverters, are essential components in converting and controlling the PV energy to useful electric energy with high efficiency and reliability. The prior-art topologies and control techniques have found acceptance in various industries. This special issue aims to collect articles discussing high-efficiency DC/AC inverter circuit topologies with high power quality and novel control techniques that are highly flexible and less complex.

This special issue accepted 15 papers that were selected after a careful peer-review and revision process. The theme of the special issue is broadly divided into three categories as follows:

(i) Development and analysis of new power converter topologies.
(ii) Highly efficient and reliable grid-tied PV systems.
(iii) High-performance PV systems with advanced control techniques.

1 | TOPIC A: DEVELOPMENT AND ANALYSIS OF NEW POWER CONVERTER TOPOLOGIES

This special issue includes a review article on single-stage boost inverter structure by Sriramalakshmi et al. The review paper provides the comprehensive topological analysis of various single-stage boost inverters. Various performance indices like voltage stress, number of passive elements, voltage and efficiency are discussed.

A new switched capacitor topology with voltage boosting and reduced component count is presented by Bin Arif et al. The topology has a dual-DC source with three capacitors, and modulation strategy and capacitor voltage balancing are discussed. A maximum of 4.85% of total harmonic distortion (THD) is reported.

Deliri-Khatoonabad et al. discuss a diamond-shaped high step-up switched-capacitor inverter circuit with reduced voltage stress on the switch. The proposed topology generates a 17-level stepped waveform with a maximum output voltage gain of eight times higher than the source voltage. The total voltage stress on the switches is reduced, which leads to a reduction in the cost of the system. Access full paper using following link: https://ietresearch.onlinelibrary.wiley.com/doi/10.1049/pel2.12111.

Kumari et al. examine the new transformerless inverter topology for grid-tied PV applications. The proposed topology has the common ground that suppresses the leakage current and presents the analysis of common mode behaviour. The detailed loss and temperature analysis are discussed. Access full paper using following link: https://ietresearch.onlinelibrary.wiley.com/doi/10.1049/pel2.12041.

2 | TOPIC B: HIGHLY EFFICIENT AND RELIABLE GRID-TIED PV SYSTEMS

Shah and Singh address the harmonic compensation strategy for a 3-φ grid-tied solar energy conversion system with a leakage current attenuation feature. A novel algorithm is introduced to mitigate the harmonics in grid current. Also, the generalized integrator-based approach is introduced to ensure the harmonics suppression, power factor correction and leakage current alleviation. Finally, the grid current complies with IEEE std. 519 and the real-time controller-based results are discussed.

A new topology of single-phase transformerless inverters, which can be tied to the local grid as a low-scaled AC module system, is proposed by Barzegarkhoo et al. In order to inject a tightly controlled AC current into the grid, an adaptive hysteresis current controller scheme is discussed. A complete theoretical analysis, comparative study and the relevant experimental results are presented.

Jalan et al. introduce a novel active current co-efficient extraction (ACCE)-based control method for a three-phase grid-interfaced voltage source inverter (VSI). The proposed ACCE uses minimal mathematical operators to improve computational effectiveness. The proposed structure effectively confronts the

various power quality challenges while injecting the active power into the utility grid, and the results are investigated.

The intermittent nature of PV arrays introduces a power unbalance in the circuit. Elsanabary et al. propose an energy balancing strategy for the grid-connected modular multilevel converters (MMC)-based PV system to balance the power in the circuit. The energy balance has been achieved by controlling the internal leg current to inject the 3-φ balanced current to the grid, and low THD is reported.

3 | TOPIC C: HIGH-PERFORMANCE PV SYSTEMS WITH ADVANCED CONTROL TECHNIQUES

Mishra and Singh discuss the development of an efficient and reliable solar PV-fed water pump with a battery energy storage (BES). New control logic for BES is developed, which supports supply of water in all conditions. The control logic significantly improved the overall response of the system, and the performance of the presented scheme is examined and the results are discussed. Access full paper using following link: https://ietresearch.onlinelibrary.wiley.com/doi/10.1049/pel2.12084.

A novel control strategy based on sliding mode control for the single-stage boost inverter is proposed by Mohammad Hassani and Gholizade Narm. The main idea of this work is a combination of current-mode control and a new type of dynamic sliding mode control to improve the system's response in different scenarios. Furthermore, the proposed system has a fast and chattering-free response, provides an appropriate steady-state error, good THD, and its implementation is very simple. The comparison with conventional sliding mode control, simulations and laboratory experiments results report the proposed method's effectiveness.

The commercial solar PV plant (SPVP), and its integration into the low voltage network, is presented by Modi and Singh. The SPVP has a multi-functional operational capability. It directly feeds to the loads and the AC network with the power quality requirement as per the IEEE std. 519. The SPVP minimizes the line losses in the AC network by recouping the load reactive power requirement locally. An adaptive filter technique based on the maximum correntropy criterion is used for the power quality improvement (PQI). The hardware prototype mode was developed, and results are validated.

Thummalagunta et al. introduce a new hybrid quasi-switched boost multi-level-inverter circuit integrated with a reduced switch. Their paper presents a high gain and single-stage power conversion with low device stress, and the extension of the proposed is also presented. A control scheme is presented to ensure the grid operation, which provides a reliable electrical supply to the critical local loads. The proposed inverter has robustness and flexibility of control, making it more suitable for residential rooftop PV generation. A 500 W laboratory prototype and experimental results are reported. Access full paper using following link: https://ietresearch.onlinelibrary.wiley.com/doi/10.1049/pel2.12079.

A sparse quaternion-valued minimization (SQVM) based control technique of a two-stage grid supportive PV power system with power conditioning capabilities is proposed by Kumar et al. A new algorithm is used to mitigate the grid side converter, and it provides the reactive power compensation at the point of common coupling (PCC). Furthermore, the control offers to mitigate the DC offset error, harmonics current and improve the system's frequency response. Overall, the system loss is minimized by the incorporation of DC-link voltage in the control loop. The operation and control of the system topology are validated experimentally under various scenarios, and the results are discussed.

Wang et al. investigate the soft switching of the isolated three-port DC/DC converter topology for DC electric spring (DCES) applications. The boundary conditions are examined to evaluate the circuit parameters influence in zero voltage switching zone. The results are reported for both simulation and experimental.

4 | SUMMARY/CONCLUSION

All of the papers selected for this special issue show the further development on the performance of the PV system with various topologies and control techniques of DC/AC power conversion techniques. Remarkably, most of the articles have real-world validation and experimental results. However, many challenges are still open in this field that requires future research attention, such as power density, reliability studies and EMI issues. Future work can help unleash the potential of the DC/AC power conversion for PV applications.

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Prof Mekhilef has been listed by Thomson Reuters (Clarivate Analytics) as one of the Highly Cited (Hi.Ci) engineering researchers in the world in 2018, 2019 and 2020. He is actively involved in industrial consultancy for major corporations in power electronics and renewable energy projects. His research interests include power conversion techniques, control of power converters, maximum power point tracking (MPPT), renewable energy, and energy efficiency.

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Dr Yang was the Chair of the IEEE Denmark Section (2019-2020). He is an Associate Editor for several IEEE Transactions/journals and is a Deputy Editor for *IET Renewable Power Generation* for Solar Photovoltaic Systems. He was the recipient of the 2018 *IET Renewable Power Generation* Premium Award and an outstanding reviewer for IEEE Transactions on Power Electronics in 2018. He was the recipient of the 2021 Richard M. Bass Outstanding Young Power Electronics Engineer Award from the IEEE Power Electronics Society. In addition, he has received two IEEE Best Paper Awards. Dr Yang was named on the list of the World's Top 2% Most-cited Scientists (both in a single-year and the entire career) by Standard University in 2020. He is currently the Secretary of the IEEE Power Electronics Society Technical Committee on Sustainable Energy Systems.

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