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*Editorial*

# Recent Advances in Power Quality Analysis and Robust Control of Renewable Energy Sources in Power Grids

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In modern power grids with a large share of distributed power production, achieving high-power quality is a challenging task. The integration of renewable energy sources (RES) into power grids has introduced various disturbances, such as harmonic distortions, voltage sags, frequency variations, voltage unbalance, etc., leading to power quality degradation. In particular, the variable nature of RESs may cause rapid voltage changes, and consequently, the protection system can cause the disconnection of power system parts.

To enable the flexible operation of RESs, voltage source converters, and associated control systems are necessary. Very often, several RESs with storage devices, loads, and voltage source converters are connected in so-called microgrids. Microgrids are an emerging concept, closely connected with power quality, novel control methods, the Internet of Things, cyber security, etc. They are designed to function either in grid-connected or standalone modes, depending upon their energy potential and grid code requirements.

Keeping in mind that about 30% of the world's electricity generation comes from RESs (including hydropower), problems and challenges of RESs' integration into power grids and the design of associated control systems are the focus of many researchers.

This Special Issue includes eight research papers in the field of power factor correction, supercapacitor parameters identification, pulse width modulation, disturbance analysis in renewable energy systems, the vibration analysis of a line-start permanent magnet synchronous motor, the backstepping control of neutral point clamped converters, a distributed level phasor measurement unit, and the optimization of PI controller parameters using the Gray Wolf algorithm.

In [1], the analysis of currents in the three-phase system from the viewpoint of the displacement power factor and the total harmonic distortion is performed. Different loads are selected for both the industry and the home sector, as follows: induction motors, inductive loads, compact fluorescent lamps, and capacitive loads. This analysis is carried out depending on the number of steps used for the power factor controller, the values of the capacitor banks, the values of AC reactors connected in series with all loads, and the LC shunt filters. For unbalanced electrical networks with slightly deformed loads, it is recommended to use high-performance power factor controllers with a large number of capacitor banks to perform the regulation of the reactive power independently on each phase. As opposed to this, for unbalanced electrical networks with high deformation loads, it is recommended to use a small number of power factor controllers with LC filters to control the reactive power independently in each phase.

The authors in [2] parameterize the Zubieta model for supercapacitors, which involves identifying seven parameters using a hybrid metaheuristic gradient-based optimization approach. The effectiveness of this method is compared to the particle swarm optimization and to the two new methods developed in this paper, both based on particle swarm optimization. Rigorous experimentation considering various types of input excitation provides results indicating that the two new methods show improvements of 51% and 94%, respectively.

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Grgić et al. [3] proposed two novel decoupled space-vector pulse-width modulation schemes for three-phase quasi-Z-source inverters. These schemes integrate dead time, and the shoot-through states are synchronized with the beginning of the zero-switching state. These novel schemes are designed to reduce switching losses and improve qZSI controllability. The obtained results indicate that the proposed pulse-width modulation schemes offer up to 6.8% greater efficiency and up to 7.5% reduced voltage stress compared to the closest competing pulse-width modulation schemes from the literature.

In [4], a condition monitoring strategy for the detection and identification of power quality disturbances in renewable energy generation systems is proposed. This strategy is based on the continuous wavelet transform and convolutional neural network. The proposed methodology is validated under a synthetic set of signals and a real set of signals acquired from a 30 MW photovoltaic system. The novelty of this work lies in the image processing that allows us to highlight the discriminant patterns through spectrograms into 2D images precisely.

Perez-Anaya et al. [5] deal with the vibration analysis of a line-start permanent magnet synchronous motor supplied with the voltage containing negative-sentence subharmonics. The results presented in this paper show the presence of unacceptable vibration for both no and full loads. For the full-load condition with voltage subharmonic values significantly less than those observed in real power systems, the maximal vibration velocity exceeds the threshold value of evaluation Zone D defined by the standard ISO 20816-1 Mechanical vibration—Measurement and Evaluation of Machine Vibration—Part 1: General Guidelines.

The modified backstepping methods to design controllers for neutral point-clamped converters interfacing with a DC/AC microgrid are proposed in [6]. These controllers are derived from the converter model and are designed to control the DC voltage and balance the two DC capacitor voltages in the neutral point-clamped converter. The proposed backstepping controller is free from high-frequency harmonics and ensures a very low total harmonic distortion (THD < 1.7%) of AC currents and very small steady-state DC errors (<0.5%). It also balances the two DC capacitor voltages, controls the power factor, and shows bidirectional power transfer capability.

A hierarchical multi-stage approach to restore system voltage when it exceeds the limits recommended by the IEEE 1547-2018 standard is proposed in [7]. This approach is based on a distributed level phasor measurement unit at local controllers and a phasor data concentrator at the central control unit. The proposed algorithm reduces unnecessary curtailment, leading to a more efficient voltage control system. The simulation results obtained using the IEEE 13-bus radial distribution benchmark system confirm the efficacy of the proposed control system for achieving coordinated voltage control and ensuring the accuracy of the communication interface. In addition, to demonstrate its scalability, the proposed coordinated algorithm was successfully applied to the IEEE 33-bus distribution network, showcasing its effectiveness across a larger system.

A control method to reduce the speed oscillations in a five-phase asynchronous motor drive at low speed is proposed in [8]. This method is based on the Gray Wolf optimization algorithm with the goal of the PI controllers' parameter adjustment. The proposed approach exploits the rapid optimization process of the Gray Wolf optimization algorithm under real-time working conditions to determine the optimal stator voltage levels that ensure the desired tracking speed at high torque with less ripple.

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