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Editorial

Special Issue: Advanced Technologies in Power Quality and Power Disturbance Data Application

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Power quality has been a rapidly growing area of research. In this Special Issue, we present twelve papers authored by a select group of experts in the area of power quality. These papers cover a wide spectrum of important problems and topics of current research interest. The topology of the static synchronous compensator of reactive power for a low-voltage three-phase utility grid is proposed in [1]. A voltage sag amplitude prediction method based on data fusion is proposed in [2]. A scheme that applies the cascaded H-bridge flexible fault current limiter to realize both voltage regulation and current limiting is proposed in [3]. A state machine-based droop control method (SMDCM) is proposed in [4]. A modified active voltage control algorithm is proposed in [5]. A flexible current-limiting device (FCLD) is proposed in [6]. A novel equivalent control method for voltage source inverters (VSIs) with disturbance observers (DOBs) is proposed in [7]. In [8], the authors use a particle swarm optimization algorithm (PSO) to determine the most suitable size and location of photovoltaic-based distributed generation (PVDG). A microgrid optimization scheduling strategy considering the integration of electric vehicles (EVs) is shown in [9]. An adaptive virtual inertia control strategy for a grid-connected converter of a DC microgrid based on an improved model prediction is proposed in [10]. An improved strategy based on variational mode decomposition (VMD) is proposed in [11]. A voltage sag loss assessment method based on a two-stage Taguchi quality perspective approach is proposed in [12].

In the following text, we comment on the main goals and results of these contributions.

In the first paper, "Cascaded Multilevel Inverter-Based Asymmetric Static Synchronous Compensator of Reactive Power", the authors propose the topology of a static synchronous compensator capable of asymmetric reactive power compensation in a low-voltage three-phase utility grid. It is implemented using separate, independent cascaded H-bridge multilevel inverters for each phase. Each inverter consists of two H-bridge cascades. The first cascade operating at grid frequency is implemented using thyristors, and the second one—operating at high frequency—is based on high-speed MOSFET transistors. The investigation shows that the proposed compensator is able to effectively compensate the reactive power in a low-voltage three-phase grid. Related results can be seen in [13–15].

In the second paper, "A Residual Voltage Data-Driven Prediction Method for Voltage Sag Based on Data Fusion", the authors propose a voltage sag amplitude prediction method based on data fusion. First, the multidimensional factors that influence voltage sag residual voltage are analyzed. Second, these factors are used as inputs, and a model for predicting voltage sag is constructed based on data fusion. Finally, the model is trained and debugged, which enables it to predict the voltage sag residual voltage accurately. The accuracy and feasibility of the method are verified using actual data from the power grid in East China. Related results can be found in [16–18].

In the third paper, "Research on a Non-PLL Control Strategy for a Flexible Fault Current Limiter and Its Application in Improving the FRT Capability of Microgrids", the

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authors propose a scheme that applies a cascaded H-bridge flexible fault current limiter to achieve both voltage regulation and current limiting at the point of common coupling (PCC). The d-q axis components are extracted without a PLL in a double synchronous rotating coordinate system by setting the angular frequency of the coordinate axis. To address the issue of the set frequency deviating from the grid frequency, a calculation formula for frequency correction is derived. Through iterative correction, the set frequency is adjusted without feedback control. A sequence decomposition and compensation control strategy for the CHB-FFCL is presented. Finally, through simulation analysis, the effectiveness of this strategy is verified. Related results can be found in [19–22].

In the fourth paper, "A State Machine-Based Droop Control Method Aided with Droop Coefficients Tuning through Infeasible Range Detection for Improved Transient Performance of Microgrids", the focus is to address the issues and the role of a droop controller's dynamics on the stability of microgrids. A small-signal stability analysis is conducted, thereby identifying an infeasible range of droop values. Accordingly, safe values for droop coefficients are defined using the state machine concept. The proposed SMDCM is compared with the conventional constant droop control method and the fuzzy logic-based droop control method in terms of frequency, power, and voltage characteristics under different power factor loading conditions. Related results can be found in [23–26].

In the fifth paper, "Modern Active Voltage Control in Distribution Networks Including Distributed Generation, Using the Hardware-in-the-Loop Technique", the authors prove that active approaches can greatly lower connection costs while boosting the capacity of connectable distributed generation when used in place of the passive strategy. In this article, a modified active voltage control algorithm is applied to an IEEE 33-bus system to test the robustness and reliability of the control algorithm under severe conditions. The simulations are carried out using the hardware-in-the-loop method. Real-time simulations are used to test data transfer and the reliability of the control algorithm's implementation. This analysis is based on a three-phase symmetric power system. Related results can be found in [27–32].

In the sixth paper, "Research on the Fault-Transient Characteristics of a DC Power System Considering the Cooperative Action of a Flexible Current-Limiting Device and a Circuit Breaker", the authors propose a FCLD that improves the operational ability of the DC system under asymmetric conditions. First, a rectifier provides a set-slope current to each cascade inductor, which enables the voltage of the inductor to be clamped. Second, a controlled current source is applied to generate inverse flux to block the inductor from magnetic saturation. The protection action time of the DC circuit breaker is reformulated. Finally, by considering the synergistic action of the current-limiting device and the circuit breaker, as well as the transient characteristics of the DC grid fault, the protection scheme of the multi-terminal flexible DC system is proposed. Related results can be found in [33–36].

In the seventh paper, "Utilizing Full Degrees of Freedom of Control in Voltage Source Inverters to Support Micro-Grid with Symmetric and Asymmetric Voltage Requirements", the authors propose a novel equivalent control method for VSI that incorporates DOB. The method leverages degrees of freedom of the VSI under symmetric and asymmetric microgrid voltage conditions by utilizing the mean-point voltage of the MG. This method enables the three-phase inverter to generate voltages as needed by the MG in response to changing loads in the microgrid circuits or phases. The method is also insensitive to disturbances because of the DOB, which is part of the controller. The proposed method is validated under both the balanced and unbalanced voltage demands of the microgrid. Related results can be found in [37–39].

In the eighth paper, "Optimal Location and Sizing of Photovoltaic-Based Distributed Generations to Improve the Efficiency and Symmetry of a Distribution Network by Han-

dling Random Constraints of Particle Swarm Optimization Algorithm", the authors discuss the use of a PSO algorithm. The goal is to determine the appropriate sizes of PVDG and find the best locations for PVDG. It is thus expected that this algorithm will provide an efficient and consistent solution to improve the overall performance of the power system. Placement and sizing of the distributed generation aim to minimize power losses, enhance the voltage profile, which brings symmetry to the voltage profile of the system, and provide maximum cost savings. The simulation results are successful, indicating its viability. Related results can be found in [40–42].

In the ninth paper, "Research on Optimal Scheduling Strategy of Microgrid Considering Electric Vehicle Access", the authors propose a microgrid optimization scheduling strategy considering the integration of EVs. Firstly, to reduce the impact of random integration of EVs on power system operation, a schedulable model of an EV cluster is constructed based on the Minkowski sum. Then, based on the wavelet neural network (WNN), the renewable energy output is forecasted to reduce the influence of its output fluctuation on the operation of the power system. Considering the operational constraints of each unit in the microgrid, the network active power loss and node voltage deviation are considered as the optimization objectives, and the established microgrid model is transformed equivalently using second-order cone relaxation to improve solution efficiency. Through network reconfiguration and flexible load participation in demand response, the economic efficiency and reliability of system operation are improved. Finally, the feasibility and effectiveness of the proposed method are verified based on the simulation examples. Related results can be found in [43–46].

In the tenth paper, "Adaptive Virtual Inertia Control Strategy for a Grid-Connected Converter of DC Microgrid Based on an Improved Model Prediction", the authors study an adaptive virtual inertia control strategy for a grid-connected converter of a DC microgrid based on an improved model prediction. Firstly, an adaptive analog virtual synchronous generator is introduced into the voltage outer loop by combining the inertial parameters with the rate of change of the voltage, realizing flexible adjustment of the inertial parameters. Secondly, the improved model predictive control is introduced into the current inner loop to achieve fast tracking of the reference current value and improve the dynamic performance of the control system. Finally, a system model is established based on Matlab/Simulink for simulation. The results show that the proposed control strategy can effectively improve the stability of DC bus voltage and the operational capability of the system under asymmetric conditions. Related results can be found in [47,48].

In the eleventh paper, "A New Method for the Analysis of the Broadband Oscillation Mode in New Energy Stations", the authors propose a method for analyzing the broadband oscillation mode based on VMD and Prony. This method can achieve improved decomposition performance through VMD, eliminating the dimensionality issues that are prone to the traditional Prony algorithm, which improves the identification accuracy. The amplitude, frequency, initial phase, and damping factor of the signal can be obtained, which helps better identify and analyze the broadband oscillation mode. Finally, the effectiveness of the proposed method is verified by analyzing examples and simulation data. Related results can be found in [49,50].

In the twelfth paper, "Research on Voltage Sag Loss Assessment Based on a Two-Stage Taguchi Quality Perspective Method", a voltage sag loss assessment method based on a two-stage Taguchi quality perspective method is proposed to perform a quantitative analysis of voltage sag economic losses. Initially, using the Taguchi quality perspective approach, single-index quality loss functions are separately established for voltage sag magnitude and fault duration. Subsequently, by introducing a comprehensive load tolerance curve, sensitivity parameters in the quality loss function are accurately calculated. This yields a

deterministic model for voltage sag assessment. Based on this, the relative impact of the two indices on voltage sag loss is evaluated using the quality loss function. Consequently, a comprehensive loss model under the influence of multiple indices is formed by integrating the two single-index evaluation models. The simulation results indicate that this method reduces the computational complexity of loss assessment through the consolidation process of intervals with similar sensitivity parameters. Related results can be found in [51–53].

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