Emerging Power Quality Problems and State-of-the-Art Solutions

ALTHOUGH the power quality problems, such as reactive and harmonic currents, distortion, and fluctuations in the supply voltage, are not new to power system and power electronics researchers, the ever-changing landscapes in power generation and distribution systems have given rise to additional power quality challenges. The growing interest in the smart grid concepts, vehicle to grid operation, inverter-based large-scale photovoltaic (PV) and wind integration, distributed generators (DGs) as ancillary service provider, multilevel inverters for high-power applications, and so on is making the power quality aspects more prevalent. This "Special Section on Emerging Power Quality Problems and State-of-the-Art-Solutions" of the IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS provides an insight on some of the newly emerging challenges and potential solutions to overcome those issues.

In item 1) of the Appendix, a dual tree-complex wavelet transform based control algorithm for a distribution static compensator to improve the power quality in a distribution system is proposed. In this technique, the distorted load current of each phase is decomposed into various frequency levels to extract the fundamental component, and thus the reference active power component is estimated.

In item 2) of the Appendix, a novel variable reactor based on a transformer with double-side energized windings is presented. A series power quality controller is developed that improves the utility impedance to harmonics instead of the fundamental current and plays the role of isolating the current harmonics. The proposed approach can reduce the passive filter size as it provides a very high impedance to harmonics.

In item 3) of the Appendix, control of a solar PV power generating system interfaced with the grid is discussed. A sliding-mode control approach is used for achieving maximum power tracking control of solar-PV array. Further, a Lyapunov function-based control approach is designed and modeled for the dc–ac inverter to serve the functions of an active power injection to the grid, balanced grid currents at unity power factor, and load currents harmonics compensation.

In item 4) of the Appendix, a harmonic and interharmonic controller for grid-tie converters for renewable energy sources is proposed. The control is based only on the measurement of the voltage at the point of connection of the generating unit. This paper also addresses the influence on the compensation performance of the line impedance between the generating unit and the point of connection.

In item 5) of the Appendix, a harmonic instability analysis method using state-space modeling and participation analysis in the inverter-fed ac power systems is presented. A full-order state-space model for the droop-controlled DG inverter is built in the paper. It is shown that the inner current controller, voltage controller, and time delay have an essential effect on harmonic instability in inverter-fed power systems.

In item 6) of the Appendix, a repetitive controller for voltage harmonic mitigation of voltage-source inverter (VSI) based islanded microgrids is proposed. An explicit analysis of the phase lead filters and a novel design method of the time advance unit in repetitive controllers, to ensure system stability, is developed in the paper.

In item 7) of the Appendix, a control strategy to achieve current harmonic sharing by directly controlling the inherent impedance of the inverter is proposed. A characteristic to dynamically control the harmonic output current of DG in proportion with its kVA rating is also developed. The proposed strategy improves the range of controllability of inverter impedance and achieves harmonic current sharing without affecting the voltage quality at different buses in an islanded microgrid.

In item 8) of the Appendix, the zero-sequence circulating current control in the multiparalleled three-phase VSIs is addressed. It is shown that the circulating current is not only susceptible to the mismatches of circuit parameters, but also influenced by the interactions of circulating current controllers used by other paralleled inverters. To eliminate these adverse effects, a coordinate control strategy for N-paralleled inverter is proposed based on the zero vector feed forward method with the space vector pulse width modulation (PWM).

In item 9) of the Appendix, a dual n-level modular multilevel converter (MMC) topology is proposed for open end stator winding medium-voltage (MV) induction motor drives. The control requirements of the proposed system are low-device switching frequency, minimal harmonic distortion of machine stator currents, elimination of common-mode (CM) voltages in machine stator windings, and maintaining floating capacitor voltages around their nominal value. Based on these requirements, an emerging modulation technique for MV induction motor drives, synchronous optimal PWM is developed in this paper.

In item 10) of the Appendix, a system for active suppression of parasitic dc bias from grid-connected power converters in ac grids is proposed. An optimum design of the dc-bias sensing reactor is devised in the paper, along with a robust, simple-to-use sensing algorithm that does not require calibration or tuning.

The reason for operational instability occurring upon neutral line disconnection and reconnection of active three-phase three-level neutral-point-clamped power factor correction rectifiers is revealed in item 11) of the Appendix. It is shown that neutral line disconnection/reconnection inverts the sign of the partial dc link voltages balancing loop; thus, reversing the sign of zero-sequence component created by the balancing loop controller eliminates the aforementioned drawback.

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In item 12) of the Appendix, an active CM duty cycle injection method to control the dc and low-frequency CM voltage in grounded systems interconnected by power converters is proposed. Using a two-stage bidirectional ac–dc converter as an example, the operating range of the proposed method is identified under different ac and dc voltages and alternative grounding schemes.

In item 13) of the Appendix, the analysis and design guidelines for an electronic on-load tap changer (OLTC) applied to a distribution transformer is presented. Experimental results, conducted on an electronic OLTC embedded in 5 kVA, 7.69 kV/220 V single-phase earth return distribution transformer, reveal an adequate voltage regulation within the transformer operation range and limitation of overlap current and voltage spikes.

The Guest Editors hope that the timely covered research topics in this Special Section will pave the way for new ideas and solutions to mitigate/compensate the emerging power quality problems.

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APPENDIX
RELATED WORK

1) R. Kumar, B. Singh, D. T. Shahani, and C. Jain, "Dual-tree complex wavelet transform-based control algorithm for power quality improvement in a distribution system," *IEEE Trans. Ind. Electron.*, vol. 64, no. 1, pp. 764–772, Jan. 2017.
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